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Assessing Bikeability of an Urban Road: A Case of Kupodole-Jawalakhel-Lagankhel Road Stretch

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Abstract
From the perspective of personal health, the environment, and the economy, using a bicycle as urban transportation within a city is a highly sustainable option. This paper establishes various built environment attributes contributing on bikeability of an urban road in context of Kathmandu valley and assess the selected road stretch. First, various built environment attributes were identified. Then each attributes influence level was calculated based on the perception survey with road users. Finally, the selected road stretch's built environment attributes were assessed on the basis of the established qualitative evaluation criteria. It was found that, current built environment condition of road is not highly favorable for cycling and also, most people preferred motorized vehicle over bicycle. Beyond the built environment, there are other social and personal factors as well such as bicycle being considered as socially inferior option than motorized transport, lack bicycle riding skills etc. that influences the use of bicycle. Enhancing the built environment condition along with programs such as awareness campaign on benefits of bicycling, supporting peoples to learn bicycling etc. can significantly promote use of cycling in an urban area.

Keywords
Bikeability, Urban Road, Built Environment Attributes

1. Introduction

Bicycling is an important NMT[1] mode. In the history of transportation, the bicycle is still regarded as one of the simplest yet most practical modes of transportation. The cycle was first introduced to the world in around 1817 AD when German baron Karl von Drais first created a steerable two-wheeler machine, but the bicycle we know today only evolved in the 19th century. Using a bicycle as a mode of urban transportation within a city is a highly sustainable option from a personal health, environmental, and economic perspective. Bicycles are safe, comfortable, and efficient in terms of economy, energy consumption, and minimizing environmental pollution [1]. It even helps to provide an affordable transport option for the low income class. It also plays an important role to achieve goal 11 " Sustainable cities and communities" and goal 3 "Good health and well-being" of Sustainable Development Goals 2030. But, some of its cons, such as exhausting mode, insurance issues, high weather and environmental dependency, traffic accidents, etc., make people reluctant to prefer it over motorized modes of transport. Hence, built environment characteristics that limit these disadvantages of cycling increase the bikeability of any road in an urban context.

For the purpose of the study, a first literature review was carried out, and various built environment attributes influencing the bikeability of an urban road were identified. These attributes were then empirically tested and validated in our context through a survey. The selected study area was then assessed qualitatively on the basis of the selected attributes. Despite the plethora of advantages of cycling over motorized vehicles, the percentage of bicycle trips has decreased from 6.6 to 1.5 percentage during the period of 1991 to 2012 in Kathmandu [2]. Hence, the main objective of the study is to assess the bikeability of an urban road and identify ways to promote cycling in the context of Kathmandu. Its specific objectives are:

- To identify the built environment's attributes

[1] Non-Motorized Trasport

contributing to bikeability of an urban road of Kathmandu and undertake assessment.
- To recommend strategies to promote urban cycling in context of Kathmandu

2. Scope and Limitations

The study focuses on the determination of the bikeability of an urban road stretch. Because the urban road network is an essential component of a city's transportation, this study can be expanded to determine the bikeability of a larger urban area. The study depends on people's perception to obtain the influence of built environment attributes on the bikeability of an urban road as a primary data. Secondary data was from various national and international literatures and maps. The sample population has more representation of the age group 20–40; thereby the voice of that particular age group will be more prominent in the study.The bicycle considered for this study is the mechanical human powered bicycle only.

3. Literature Review

An individual's choice of particular mode of transportation depends on their perception towards that particular mode. This is especially true for NMT such as bicycle which demand physical effort and hence, a through understand of factors influencing individual's choice is necessary to obtain positive behavioral changes[3]. The condition of how suitable a particular path is for bicycling for an individual is termed as bikeability. Bikeability measures how well an area supports using a bicycle as a means of transportation and the conditions under which cycling occurs [4]. It is a degree to which a setting or environment is practical and secure for cycling as well as bicycle friendly [5, 6]. A positive correlation between bikeability and built environment attributes, such as cycle-friendly infrastructures, safety, weather, comfort, land use, pollution etc. has been evident from several studies [7, 8, 9, 10]. Various frameworks have been developed to determine the impact of the built environment on bicycling friendliness in a city. Hagen & Rynning in their 2021 paper has summarized these built environment characteristics influencing bikeability into 4 categories; Natural and place-specific condition, Infrastructure and traffic, Surrounding and activities and, Urbanity [8] .After reviewing 50 articles related to bikeability index, Arellana et al., (2020) has considered the factors i.e. directness and coherence, bicycle infrastructure, climate, safety, comfort and attractiveness security to identify the bikeability[11]. Similarly, Ito & Biljecki, (2021) has adapted 34 different characteristics of surrounding and categorized them into connectivity, environment, infrastructure, vehicle cyclist infrastructure and perception for assessing bikeability [6].

4. Methodology

Ontologically, the study deals with the reality that is socially constructed. The bikeability of an urban road depends on how people perceive the existing built environment along the road. So, it falls under the post-positivist paradigm. A mixed-method approach will be used to assess bikeability. After selection of the study area, various built environment attributes affecting bicycle friendliness will be selected through a literature review. A questionnaire survey was conducted with the road users in the study area to validate the indicators and identify their level of influence on bikeability. For the study, a judgement sampling method was be used. Map and field studies were done to collect built environment related data. Finally, the bikeability of the study area was assessed qualitatively on the basis of established built environment attributes.

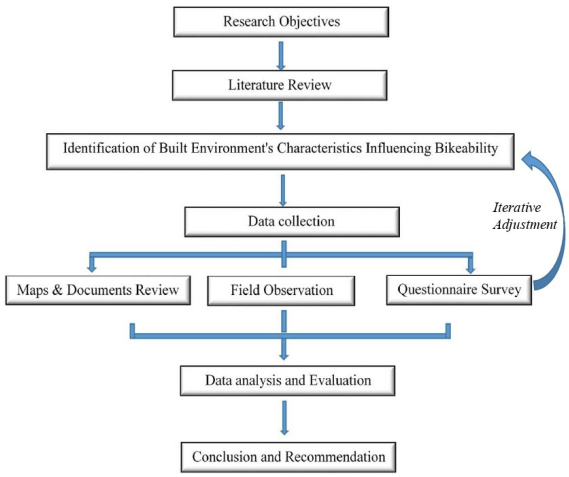

Figure 1: Research framework

5. Study Area

The study area selected is the road stretch Kupondole-Jawalakhel-Lagankhel which is located in the Lalitpur Metropolitan City of Bagmati Province.

The total length of the selected stretch is 3.15 km. Lalitpur Metropolitan City has selected this stretch to implement its first master plan to achieve a cycle city. Hence, this stretch was selected considering the various infrastructures constructed in favor of bicycle use. The selected road stretch for the study passes through ward no. 10, 3, 4 and 5 of the LMC. Along the route, there are a number of significant locations serving as popular destinations for the people, i.e., Pulchok campus, Lalitpur Metropolitan City office, Alka and Patan Hospital, Labim mall, central zoo, UN house, Bhatbahteni, a number of banks, Gurudwara etc. Furthermore, this road also serves as a route for the world-heritage site of Patan Durbar Square as well as cultural and historic residential areas in the vicinity. For the purpose of detailed investigation and the presence of differences in built environment features, this road stretch is further divided into 3 small sections.

Stretch 1 (S1): Kupondole to Hariharbhawan road, with a length of 1 km. This is denoted by the red path in the figure.

Stretch 2 (S2): Hariharbhawan to Jawalakhel road, with a length of 1 km. This is denoted by the blue path in the figure.

Stretch 3 (S3): Jawalakhel to Lagankhel road, with a length of 1.35 km. This is denoted by the yellow color path in the figure.

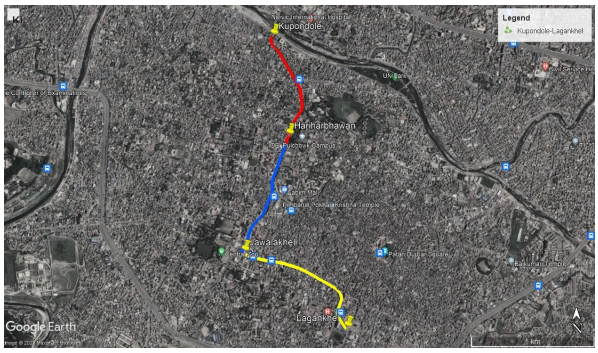

Figure 2: Study Area

6. Data Collection

The data collection was done using google form.

6.1 Questionnaire Survey

The questionnaire comprised two sections. The first section was on the demographic and travel behavior of respondents. The second section focused on various attributes of the built environment considered to contribute to bikeability. These responses were collected on the 5 point Likert scale.

6.2 Sample characteristics

For sample collection judgmental sampling was used. The calculated influence level of the attributes started to stabilize after 160 responses. So, the survey was limited to 202 repondents. Of the total respondents, 32% of the total were female and 68% were male. The majority were from the age group of 20–30, followed by 30–40 years. In total, 46 respondents own bicycles. But, among them, 26 people preferred private motorized transport, and only 10 people consider bicycles as their preferred mode of transportation.

7. Results

7.0.1 Attributes Identification

On the basis of in-depth literature review different factors/attributes of built environment were extracted to assess bikeability of urban road of Kathmandu valley. These attributes were validated through survey with the respondents. During questionnaire survey various other attributes were also suggested such as presence of water bodies along the route. But, these were discarded due to significantly low number of respose in survey and low relevency in the study area. 18 different built environment attributes were selected and were further broadly categorized into 3 categories as mentioned in Table 1 below.

7.0.2 Analysis

Respondents responded to each attribute's influence level on bikeability on a 5-point Likert scale, ranging from 1 to 5, namely, 1." No Influence," 2."Limited Influence," 3."Moderate Influence," 4." High Influence," and 5."Very High Influence." To obtain the quantitative equivalence of the responses, each response was scored between 0 to 1. A constant increment of 0.25 was assigned to the responses such that a value assigned for "No Influence," "Limited Influence," "Moderate Influence," "High Influence," and "Very High Influence" responses were 0, 0.25, 0.50, 0.75, and 1.00 respectively. Finally, the overall influence level of each of the attributes was calculated using the assigned value and total percentage of responses for each attribute obtained from the survey. The calculated influence values are provided in table 2.

Table 1: Categorized Built Environment Attributes

NATURAL CONDITIONS
• Topography • Weather
INFRASTRUCTURES and TRAFFIC
• Presence of bicycle lane • Width of bicycle lane • Continuity of bicycle lane • Separation of cycle lane from motorized traffic • Speed of motorized vehicle • Bicycle related traffic sign and road markings • Bicycle activated intersections • Connectivity with other destination & alternative routes • Presence of bicycle parking facility • Presence of bicycle repair workshops
SURROUNDINGS
• Mixed land use • Pollution • Safety concern • Obstructions in the route • Maintenance • Aesthetic and green surrounding

Table 2: Built Environment Attributes Influence Level

Attributes	**Influence Value (0-1)**
Natural conditions	
Topography	0.63
Weather	0.68
Infrastructures and traffic	
Presence of bicycle lane	0.80
Width of bicycle lane	0.78
Continuity of bicycle lane	0.77
Separation of bicycle lane from motorized traffic	0.82
Speed of motorized vehicle	0.72
Bicycle related traffic signs and road markings	0.75
Bicycle activated intersections	0.76
Connectivity	0.75
Presence of bicycle parking	0.73
Presence of bicycle repair workshops	0.70
Surroundings	
Mixed land use	0.61
Pollution	0.69
Safety concern	0.78
Obstructions in the route	0.70
Maintenance	0.72
Aesthetic and green surrounding	0.69

7.0.3 Bikeability Assessment

A comprehensive qualitative evaluation criteria, as mentioned in table 3, was developed for each attribute based on a review of the literature. Map studies and field studies were used to verify the defined criteria, while secondary data was gathered from document studies and official government websites i.e DoHM [1] website. Data on traffic accidents and other criminal activities was gathered from the traffic police and the Nepal police department. On the basis of defined criteria, the bikeability of each section was determined on a 3 point scale: ”Highly Bikeable”, ”Bikeable” and ”Less Bikeable” as showen in table 4.

Table 3: Bikeability Assessment Criteria

Attributes	**High Bikeability Conditions**	**Low Bikeability Condition**	**References**
Natural Conditions			
Topography	Relatively flat landscape with slope less than 3%	Presence of steep slope more than 5%	[12]
Weather	Avg. temperature 25°C, Humidity: (52.3%–62.7%), low precipitation, and relatively predicatable weather condition	Very high or very low temperature and humidity and unpredictable weather conditions	[13, 14]
Infrastructures and traffic			
Presence of bicycle lane	Presence of bicycle lane	Bicycle lane not available	[15, 16]
Bicycle lane width	more than 2m for one way lane	less than 1.4m for one way lane	[11, 17]
Continuity of bicycle lane	Bicycle lane continuity along the entire route	Disconnected bicycle lane along the route	[8]
Separation of cycle lane from motorized traffic	Proper separation of cycle lane from motorized traffic by bollards, island etc for improved safety	No separation of bicycle lane from motorized traffic	[18, 15, 16]
Speed of motorized traffic	Motorized vehicle speed traveling adjacent to bicycle less than 30 km/hr	Motorized vehicle speed traveling adjacent to bicycle higher than 30 km/hr	[8, 19]
Bicycle related traffic sign and road marking	Proper traffic signs and road marking for cyclist	Lack of traffic signs and road markings for safe travel and convenient way findings	[8]
Bicycle activated intersections	Intersection designed with priority to cycle with road markings and bike box with advance green	Intersections with high priority to motorized vehicles	[8, 20]
Connectivity	Well connected cycling network with alternative routes	No connection with other street with bicycle related infrastructures for choosing alternative routes	[8, 21]
Bicycle facilities	Sufficient availability of bicycle parking and repair centers	Lack of Functional bicycle facilities	[8]
Surroundings			
Land use along the street	Mixed land use providing multiple options for activities and destination choices for the cyclist	Land use without variety of options for multiple of activities and destination choices for the cyclist	[8, 22, 23]
Pollution	No pollution in the street	Highly polluted environment and litters in the street	[21, 18]
Perceived safety	Low crime rate, traffic and non-traffic accident and availability of street light at evening and night	High crime rate, traffic and non-traffic accident, and street light not available for evening and night	[8, 10]
Maintenance	High focus on maintenance of the cycle related infrastructures	Extremely low focus on maintenance of the cycle related infrastructures	[8, 10]
Aesthetic and green surrounding	Pleasant surrounding with open spaces, abundant greenery and, historic buildings	motorized vehicle oriented environment with no open spaces, greenery and pleasant surrounding	[21, 22]

8. Discussion

The selected road stretch assessment showed that most of the built environment attributes along the road were only ”Bikeable” and ”Less Bikeable”. Some of the attributes, such as the presence of a bike lane, made all three sections highly bikeable, but poor maintenance of the same lane has rendered it less bikeable. The natural conditions of the area were not found to be unfavorable. Concerns about safety, which were also perceived to have a high influence on bikeability, were found to be satisfactory. This was

[1] Department of Hydrology and Meteorology

Table 4: Bikeability Assessment

Attributes	Kupondole to Hariharbhawan Stretch	Hariharbhawan to Jawalakhel Stretch	Jawalakhel to Lagankhel Stretch
Natural conditions			
Topography	Bikeable	Bikeable	Highly Bikeable
Weather	Bikeable	Bikeable	Bikeable
Infrastructure and traffic			
Presence of bicycle lane	Highly Bikeable	Highly Bikeable	Bikeable
Bicycle lane width	Less Bikeable	Less Bikeable	Less Bikeable
Continuity of bicycle lane	Bikeable	Highly Bikeable	Bikeable
Separation of cycle lane from motorized traffic	Less Bikeable	Less Bikeable	Less Bikeable
Speed of motorized traffic	Less Bikeable	Less Bikeable	Less Bikeable
Bicycle related traffic signs and road marking	Bikeable	Bikeable	Bikeable
Bicycle activated intersections	Bikeable	Bikeable	Less Bikeable
Connectivity	Less Bikeable	Bikeable	Less Bikeable
Bicycle Parking facilities	Less Bikeable	Less Bikeable	Less Bikeable
Bicycle Repair workshop	Less Bikeable	Highly Bikeable	Less Bikeable
Surrounding			
Land use along the street	Highly Bikeable	Highly Bikeable	Bikeable
Pollution	Bikeable	Bikeable	Bikeable
Perceived safety	Bikeable	Bikeable	Bikeable
Obstructions in the route	Less Bikeable	Less Bikeable	Highly Bikeable
Maintenance	Less Bikeable	Less Bikeable	Less Bikeable
Aesthetic and green surrounding	Bikeable	Bikeable	Less Bikeable

because of the lower incidence of severe accidents, low crime rates, and the presence of street lights and CC cameras. Even though no permanent obstructions were seen along the route, the culture of parking motorized vehicles in the cycle lane and picking and dropping passengers in places other than bus stops created substantial obstructions while cycling in the lane along all 3 sections. Improving this scenario will significantly improve the bikeability of the road. The route's mixed land use has provided the cyclist with multiple destination options in a short distance. Further improvement of the surrounding aesthetic and providing more open and green spaces along the route can encourage cycling by providing a pleasing environment for them. Attributes related to infrastructure and traffic were found to have the highest level of influence on bikeability of the sections surveyed, but these factors were found to be very poor along all three sections. Since the bicycle lane available was the shared lane, it was not separated from the motorized vehicle by any means such as islands, bollards, or railings. The speed limits were also not defined along the road section. This rendered the route less bikeable. Bicycle-related facilities such as bicycle parking and bicycle repair work shops need to be provided in order to promote the use of bicycles. In the survey, 68.3% of total respondents were willing to cycle if the built environment conditions were improved, and 27.6% responded as "may be". This shows a highly optimistic scenario for promoting cycling by enhancing built environment attributes. But, when asked for the reason for not using bicycle 21% of 170 put forward social reasons such as bicycles being a less prestigious mode of transport and a less cool option than motor vehicles. Also, 13% responded that it was time-consuming. Personal reasons such cycle considered to be a hectic mode and lack of riding skills also prevails among the people as 8% confessed not having any riding skill. Various reasons i.e. age or other physical disabilities and limitation might have rendered people unable to use bicycle. This shows that there are also these underlying social and personal issues which will still hold back cycle use even when the built environment and physical attributes of an area are made cycle friendly.

9. Conclusion and Recommendations

This research examined people's perceptions and identified the various built environment attributes that dictates the bikeability of an urban road. The study also assessed the bikeability of the Kupondole-Jawalakhel-Lagankhel road stretch on the basis of established criteria of assessment for each attributes. The major conclusions obtained from the study are:

- Built environment attributes related to infrastructure and traffic conditions have a greater influence on the bikeability of an urban road followed by surrounding and natural conditions.
- The current built environment of the study area is not highly favorable for cycling.
- People are willing to cycle more, if the built environment is made more safe, appealing, and cycle-friendly.
- People have false perceptions of cycling as a socially inferior mode of transportation than motorized vehicles.
- Personal characteristics such as bicycle riding skill, age and physical disabilities also was found to limit people from using cycle despite of their interest in bicycling.

Due to poor maintenance, though there is availability of the cycle lane, it is almost unnoticeable in many locations. So, the lanes and road markings should be timely and properly maintained. If needed, the road markings should be painted at frequent intervals. Along the studied road, the cycle lane width was limited to 1.2 meters only. At least a minimum width of 1.4 meters as mentioned in NURS and, if possible, more than 2 meters should be maintained for

comfortable passage of the bicycle. The most influential attribute, "separation from the motorized traffic," should be given high priority, and bollards or metal rails should be installed along the existing lane to separate it from adjacent motorized vehicle traffic. This will also enhance the safety perception of bicycle users. Further, the continuity of the existing lane as well as its connectivity with other routes or networks was also found to be very poor with minimal options. So, the established cycle lane should be continuous along the route. While establishing the cycle route, a complete network should be established rather than just a linear route. This helps users take shortcuts and alternative routes while bicycling.

A national document providing more specific guidelines for bicycle related road infrastructure design, bicycle lane classifications, minimum grade, speed limit, traffic signals and markings, operation, and maintenance is needed. Awareness campaigns should be emphasized so that the city residents will be aware of how, in developed countries, even rich people use bicycles to travel within the city. Use of influential personnel such as celebrities and leaders in awareness campaigns could also scale up the level of influence. An e-bike could be promoted and made easily available for those who find cycling hard to operate and physically uncomfortable. Proper provisions should be made to help people learn to cycle. Also, bicycle riding skills as well as its positive benefits should be integrated into school level education so that the future generation will be more equipped and enthusiastic about using bicycles. Additionally, the method used in the study could be used to qualitatively determine the bikeability conditions of other areas as well. These actions will certainly contribute to create a more bikeable city and, hence, promote bicycling culture in an urban context.

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