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A THESIS REPORT ON

Assessing Bikeabililty of an Urban Road:

A Case of Kupondole-Jawalakhel-Lagankhel Road Stretch

By

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CERTIFICATE OF THESIS APPROVAL

This is to certify that they have read, and recommended to the Institute of Engineering for acceptance, a thesis report titled **" Assessing Bikeabililty of an Urban Road: A Case of Kupondole-Jawalakhel-Lagankhel Road Stretch"** submitted by **Mr. Gaurav Paudel (076-MSUrP-005)** in the partial fulfillment of the requirements for the degree of **Masters of Science in Urban Planning**.

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DECLARATION

I hereby declare that the thesis entitled "Assessing Bikeabililty of an Urban Road: A Case of Kupondole-Jawalakhel-Lagankhel Road Stretch", submitted to the Department of Architecture in partial fulfillment of the requirement for the degree of Master of Science in Urban Planning, is a record of an original work done under the guidance of Dr. Padma Bahadur Shahi, Institute of Engineering, Pulchowk Campus. Except for the material consulted, which has been properly referenced and acknowledged, all of the work in this thesis was done by me.

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ABSTRACT

From the perspectives of personal health, the environment, and the economy, using a bicycle as urban transportation within a city is a highly sustainable option. Despite this fact, cycling is still not a popular mode of transport in Kathmandu. Existing policies and practices seem unable to promote cycling in cities. Therefore, this study aims to access the bikeability of an urban road and obtain measures to promote it in an urban context.

To obtain the defined objective, the Kupondole–Jawalakhel–Lagankhel road stretch within Lalitpur Metropolitan City was selected as a study area. A literature review identified various built environment attributes influencing the bikeability of urban roads in the context of the Kathmandu valley. Then each attribute's influence level was calculated based on the perception survey with road users. Similarly, in order to assess the bikeability, assessment criteria for each attribute were defined. Finally, the selected road stretch's built environment attributes were assessed based on the defined criteria and categorized as "highly bikeable," "bikeable," and "low bikeable."

The study found that the current built environment of the road is not very conducive to cycling, and most people prefer motorized transport to bicycles. Aside from the built environment, there are other social and personal factors that influence bicycle use, such as a bicycle being considered a less desirable option than motorized transportation, bicycle-riding skills, and so on.

More specific and dedicated policies and guiding documents towards bicycle promotion need to be formulated. Furthermore, improving the built environment, in conjunction with programs such as awareness campaigns about the benefits of cycling, assisting people to learn to cycle, etc., can significantly increase the use of cycling in urban areas.

Keywords: Built Environment Attributes, Urban Bicycling, Perception Survey

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ACRONYMS

NMT: Non-Motorized Transport

NUDS: Nepal Urban Development Strategy

NRS: Nepal Road Standard

NURS: Nepal Urban Road Standard

NSTS: National Sustainable Transport Strategy

SDG: Sustainable Development Goal

JICA: Japan International Cooperation Agency

WHO: World Health Organization

UNRIC: United Nations Regional Information Centre for Western Europe

NSTS: National Sustainable Transport Strategy

LMC: Lalitpur Metropolitan City

MTMP: Municipality Transport Master Plan

AASHTO: The American Association of State Highway and Transportation Officials'

OAPEC: Organization of Arab Petroleum Exporting Countries

TU: Tribhuwan University

UN: United Nation

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CHAPTER 1: INTRODUCTION

1.1 Background

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. A higher share of cycling as a mode of transport in a also indicates a more sustainable transport system and is crucial in obtaining the Sustainable Development Goals (European Cyclists' Federation, 2016). Bicycles are safe, comfortable, and efficient in terms of economy, energy consumption and it also minimizes environmental pollution (Mat Yazid et al., 2011). From the national and organizational perspective, it even has benefits of reducing health care cost and the cost of transportation externalities i.e. air and noise pollutions, congestion, and climate change (Bauman et al., 2008). In the context of the developed world, cycling culture is highly preferred and practiced. Many countries in Europe such as in Denmark, Germany and Netherland, bicycling culture has been highly respected and encouraged. In Canada, there has been an increase of cyclist number by 42% in the period of 1996 to 2006 (Mayers & Glover, 2019). In Nepal, a number of national policy level documents such as National Urban Development Strategy 2017, Nepal Road Standard 2010 has emphasized the promotion of NMT and making the infrastructures cycle friendly.

1.2 Need for Research

At the policy level, various initiatives have been taken to promote bicycling in cities i.e. NUDS, 2017 has mentioned the promotion of NMT as its activity for one of its intra-urban strategies. Similarly, NRS 2070 and NURS 2076 has also provided geometrical design guidelines for bicycle tracks to obtain user-friendly cycle lanes. However, very little research has been conducted to understand the ground-level situation of bikeability within the cities. Hence, there is a need for research in this particular field.

1.3 Importance of Research

This research will provide information on the condition of bikeability of our cities road. This will also provide evidence on to what extent the various attributes of the built

environment are contributing to obtaining a bicycle-friendly city. Therefore, this research will help planners and designers to understand the various attributes of the built environment of a city, which will help to promote the bicycling culture. This research will also enable policymakers to identify the policy gap and will support to undertake intervention to obtain sustainable urban mobility in cities.

1.4 Problem Statement

In Nepal, promotion of cycling to obtain sustainable transport system has been accorded well between policymakers, politicians, and academicians. This can be evident from the various international frameworks i.e. SDG, signed by Nepal as well as, cycling related concepts mentioned in multiple policy documents. NUDS, 2017 has mentioned the promotion of NMT as its activity for one of its intra-urban strategies. Similarly, NRS 2070 has also provided geometrical design guidelines for bicycle tracks to obtain user-friendly cycle lanes. However, at the ground level, of the total trip generated in Kathmandu, the bicycle trip has decreased from 6.6 % to 1.5% during the period of 1991 to 2012 (JICA 2012). This shows that the policy interventions as well as practices has been inadequate to promote the use of bicycle as a desirable mode of urban transport. Promoting bicycle as a preferable mode of transport within a city can support the overall sustainable development of the city.

1.5 Research Objective

The main objective of the study is to assess the bikeability of an urban road and identify the ways to promote cycling in context of Kathmandu.

The specific objectives of the study are:

- To review existing policies and practices related to bicycle.
- To identify the built environment's attributes contributing to bikeability and undertake assessment
- To recommend the strategies to promote urban cycling in context of Nepal

1.6 Limitation of the study

The limitations of the study are:

- The study depends on the primary data (people's perception) to rank the built environment attribute's influence on Bikeability
- Bicycling considered for assessing bikeability is for manual bicycle only (e-bike/scooters was not be considered)
- Findings and conclusion of the study are based on the selected study area (Kathmandu Valley), hence, might not be 100% relevant to other urban area

CHAPTER 2: LITERATURE REVIEW

2.1 Bicycling:

Bicycling is an important NMT mode. In the history of transportation, the bicycle is still regarded as one of the simplest yet practical modes of transportation. Cycle was first introduced in the world in around 1817 AD when German baron Karl von Drais first created a steerable two wheeler machine. Known by the various name "velocipede", "hobby-horse" "running machine" etc. in is early time, the bicycle we know today only evolved in 19th century. However, the first cycle was introduced in Nepal in the early 20th century. During the initial time it was considered a symbol of prosperity and could only be afforded by wealthy people. But later, with the increases import of motorized vehicles, and social influence by various foreign projects and investment, the cycle culture slowly declined. Rapid motorization after 1990 significantly reduced the cycling. But, with the rising health and environmental concern, since last decade, more people seem interested in cycling, at least in Kathmandu valley (Prashant Khanal, 2021).

2.1.1 Benefits of cycling:

Cycling can be used for recreation, fitness, sport, and transportation. The advantages of cycling can be seen in a variety of areas, from the healthy lifestyle to pollution-free communities. Cycling has many advantages, including:

Health: From the heath perspective, cycling can be an important way of undertaking physical activity. WHO has recommended minimum of 150 minutes of physical activities per week (WHO, 2010). Despite of this major proportion of populations fail to achieve the recommended level (Götschi. 2016). Integrating cycling the daily activities can help to achieve the level of recommended physical activity.

Pollution: Particularly, air pollution can result in a variety of health problems, including cancer, asthma, and skin conditions. Bicycling significantly lowers the quantity of air pollution in the community because bikes are propelled by muscle force rather than fuel, which helps to minimize the amount of pollutants in the air. Further, it also reduces the noise pollution in the street, unlike motorized vehicles.

Economic benefits: Being a mechanical device, use of cycle over motorized vehicle naturally reduces fuel consumption and hence helps to save vast amount of capital. Average automobile cost is very high compared to the cost of operating a bicycle. As per Nepal Oil Corporation, in fiscal year 2077/2078 Nepal has imported 591700 Kl of petrol and 1696202 KL of diesel and as of 2022/07/17 has an estimated loss of RS 14.8 and 21.92 per liter of petrol and diesel respectively. Hence, increased use of cycle as a mode of transport can help significantly in our country's economy.

Social benefit: The improvement of social interactions, livability, convenience, gender parity in transportation, and a sense of attachment and community belonging can all be addressed by cycle-supportive surroundings. Campaigns to raise awareness of cycling as an essential social element that assists to promote daily cycling. Improved urban cycling also boosts street activity, which acts as a natural type of surveillance by allowing people to observe various potentially bad street behaviors. Thus, a reduction in crime can be one of cycling's significant societal advantages.

Equity: Cycling is the most cost-effective mode of transportation for all income categories, particularly for students, because of its low price.

2.1.2 Cons of Cycling

Despite of having plethora of advantages, cycling also has some downsides when comparing to motorized transport. One of the major risk is from weather condition. Unlike in a car or bus bicycle rider are easily affected by weather condition such as heavy rain, sun etc. Beside this, pollution also have relatively greater impact. Being as mechanical device, it is only feasible for certain small distance. Further, as its safety features are inferior to the motorized transport, there is always a high risk of injury when getting in an accident. Also, its challenging in bicycle to carry passengers or other goods.

2.2 Bicycling and SDG

Cycle, being most affordable and healthy mode of transport it can support in number of goals of targeted by SDG. Promoting bicycle helps to achieve the majorly 2 goals (Goal 3 and Goal 11) of sustainable development goals. Cycling promotes physical activity, which lowers the risk of heart disease and other side effects of inactive lifestyle. Cycling

can be used in place of individual motorized transportation to enhance air quality and road safety. By making cycling safe, we can lessen the number of people killed and injured in traffic accidents worldwide. Hence, it helps in attaining, Goal 3 “Good health and well being”. In relation to the Goal 11 “Sustainable cities and communities” cycling is also accessible, safe, non-polluting, healthy, and supports a sustainable economy and makes cities and human settlements more inclusive, secure, resilient, and sustainable. It is highly resilient because it is essentially independent from sophisticated high-tech technologies. Also, modern communication and technologies, can integrate cycling into cities' Intelligent Transportation Systems. The sustainable transport system of a city is where there is higher the modal share of active transportation i.e. walking & cycling and public transport.

Further, the United Nations Regional Information Centre for Western Europe (UNRIC) has also defined how other goals can be attained through promoting cycling as a mobility option.

Goal 1: No poverty

Cycling is a cost-effective and straightforward means of transportation that provides access to employment, markets, schools, and community events in both urban and rural regions.

A person can reduce the cost of transportation for their household by using a bicycle, which is frequently the only technologically feasible inexpensive means of transport for people and goods. For people who would otherwise have to walk to work, cycling can more than reduce their commute time and increase their access to job prospects, schools, marketplaces, and communities. Additionally, there is a significant likelihood that jobs associated to cycling will lead to economic growth. Cycling investments present excellent chances for sound national, regional, and global poverty-reduction strategies.

Goal 2: Zero hunger

For many small-scale food producers, cycling can offer safe, egalitarian access to land, resources, markets, knowledge centers, financial services, and non-farm work opportunities. Cycling also guarantees improved access to food markets and

communities and by increasing the access to the wider area to those who cannot afford alternative mode of transportation.

Goal 5: Gender equality

Women and girls can use bicycles to get to places like water, markets, schools, and occupations that would be otherwise inaccessible by other methods of transportation or by walking. Safe cycling infrastructure promotes gender equality by increasing the use of riding among women and girls.

Goal 7: Affordable and clean energy

Cycling makes transportation networks more energy-efficient since it is the most effective way to move people and commodities using renewable human power. Additionally, when combined with public transportation and logistical networks, cycling provides an excellent solution for the first and last miles. People have access to an affordable and energy-efficient means of transportation when there are favorable cycling conditions.

Goal 8: Decent work and economic growth

If cycling industry sector (i.e. cycle manufacture factories, repair shops, etc.) can be promoted through increases share of cycle in the cities, it can increase the job opportunity and economic growth of a country.

Goal 9: Industry innovation and infrastructure

Cycling makes it possible for people to transition from using personal motor vehicles to a combination of active transportation (walking and cycling) and public transportation. This supports government to build sustainable transport infrastructures with focus on more equitable and affordable access.

Goal 12: Responsible consumption and production

The ability to move around as commuters, shoppers, and tourists, as well as the production, consumption, and delivery of commodities in a sustainable manner is made possible by the mobility of people and goods by bicycle. Bicycle deliveries can be used for 50% of all deliveries of commodities in many urban areas. In addition, promotion of cycle tourism can help to create options for sustainable tourism.

Goal 13: Climate action

The bicycle gives the chance for immediate climate related actions and supports to decarbonizing city and transportation.

Goal 17: Partnerships for the goals

Common goal of attaining sustainable global development can bring together civil societies and experts working for the promotion of cycling. This can enhance global partnership. In order to promote cycling, they develop and support successful governmental, public-private, and civil society collaborations.

2.3 Bikeability

The word "bikeability" is relatively a new terminology. This has been repeatedly used in number of article but have not been yet included in a reputed dictionary. Oxford dictionary has defined the term bikeable as "suitable or safe for cyclists". On that basis, bikeability can simply be understood as suitability for cycling. Bikeability measures how well an area supports using a bicycle as a means of transportation and the conditions under which cycling occurs (Nielsen & Skov-Petersen, 2018). Reggiani et al. (2022) defines bikeability as the degree to which a setting or environment is practical and secure for cycling. It can be considered to be an extent to which environment is bicycle friendly (Ito & Biljecki, 2021).

2.4 Bikeability and built environment

A positive correlation between bikeability and built environment attributes, such as cycle-friendly infrastructures, safety, comfort, land use, etc. has been evident from several studies (Bauman et al., 2008; Hagen & Rynning, 2021; Winters et al., 2010). Understanding the relevance of built environment, various initiatives ranging from constructing separate cycling paths, to reducing motorized traffic flow have been taken around the world to promote bicycling culture (Mayers & Glover, 2019). In order to be a preferred mode of transport it need to be significantly better than other modes in terms of comport, economy etc. Various frameworks have been developed to determine the impact of the built environment on bicycling friendliness in a city. (Hagen & Rynning, 2021) has summarized these built environment characteristics influencing bikeability into 4 categories namely, Natural and place-specific condition, Infrastructure and

traffic, Surrounding and activities and, Urbanity. Natural and Place specific preconditions comprises of location and role of the area in its region and city, topography and weather condition. Infrastructure and traffic considers cycling infrastructure, cycling facilities at destinations, traffic volumes, speed level, traffic safety, intersections, and accessibility by public transport and car. Urbanity involves the density, proximity, urban structure and permeability. Surroundings and activities considers the attributes of Arellana et al., (2020), after reviewing 50 articles related to bikeability index, considered the following factors to identify the bikeability.

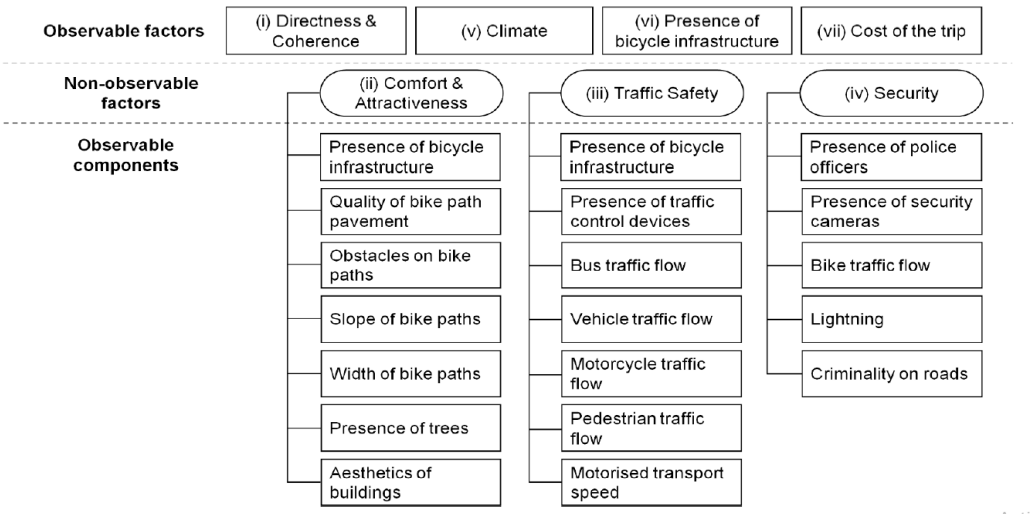


Figure 1: Arellana's built environment attributes

Bikeability Index of Dresden analyses the bikeability of area by considering a grid of 100m x 100m and assessing them based on following hard components:

1. Bicycle infrastructure (bike paths and lanes);
2. Existence of structurally separated bike paths;
3. Green area and water surface;
4. Topography;
5. Land use;
6. Bicycle facilities;
7. Traffic load

Ito & Biljecki (2021), has considered the various characteristics of surrounding in order to access the bikeability using street view imagery and computer vision. After

reviewing multiple of article the authors have developed five categories with 34 indicators for assessing bikeability:

a. Connectivity: measured through number of intersections with lights, intersections without lights, and cul-de-sacs
b. Environment: slope, the number of POIs, land use mix, AQI, and pixel ratios of greenery, buildings, and water
c. Infrastructure: type of road and pavement, the width of the road, number of transit facilities, and presence of potholes, street lights, bike lanes, street amenities, utility poles, bike parking spaces, sidewalks, crosswalks, and curb cuts
d. Vehicle cyclist interaction: the number of vehicles and speed control devices and the presence of on-street parking and traffic lights/stop signs
e. Perception: attractiveness for cycling, spaciousness, cleanliness, building design attractiveness, safety as cyclists, beauty

After the series of literature review, 18 different factors/attributes were extracted to be used to assess bikeability of urban road of Kathmandu valley. These factors were further broadly categorized into 3 categories namely, Natural Preconditions, Infrastructure and traffic, and Surrounding. All these attributes are described in detail below:

1. **Natural Precondition**

   Natural preconditions are the various existing natural situation in which a city is built. They govern the overall development of infrastructures with in a city and shapes the city.

   - **Topography**

   Topography in this study refers to the land form of the road. It could be flat terrain or the slope surface. Since bicycling is a mechanical device, it requires human labor to function. When the terrain is steep, it requires more work to be done to ride bicycle uphill due to gravity where as in the flat surface it is relatively easier to pull it. Similarly, steep downhill also makes it uncomfortable to control speed of the cycle. Flat roads with minimal slope is more appealing to cycle than the steep hills.

- **Weather condition**

Stable weather conditions helps people to predict or decide which mode to choose for traveling. Weather condition such as rainfall, temperature and humidity majorly dictates on the place bikeability. Too high or freezing temperature makes it hard to cycle. Similarly, higher humidity affects the cycling negatively*(Miranda-Moreno & Nosal, 2011)*. Most cyclist preferred the temperature ranges of Cycling was found to prefer relatively lower temperatures (29.5-31.5°C), lower humidity (52.3-62.7%), and no recent rain at least within the last 60 minutes (Meng et al., 2016).. Phung and Rose (2007) also mentioned the temperature of approximately 28 degrees Celsius is comfortable riding temperature range.

2. **Infrastructure and Traffic**

This category consists of various road and bicycle infrastructure, characteristics of traffic using the roads and their interaction with each other.

- **Presence of bicycle lane**

Bike lanes are used to mark off open road space for cyclists' preferential use. Bicyclists can ride in bike lanes at their preferred speed regardless of how fast or slowly the traffic around them is moving. Additionally, compared to when riding on sidewalks, bike lanes encourage cyclists to ride on the road where they are more likely to be spotted by drivers entering or exiting the road. Normally, bike lane is provided in the same direction, motor vehicle area traveling.

- **Bicycle lane width**

Since the bicyclist comfort and desire of lateral separation from other vehicle affected by speed, volume and type if vehicle traveling adjacent to them, comfortable width is very crucial for bicycle riding. As per Nepal Urban Road Standard (NURS) a minimum of 2m width is necessary for one-way cycle lane. AASTHO has recommended the bicycle in most of the circumstances to be at least 5ft (1.5m).

- **Continuous bicycle lane**

In order for any bicycle lane to be functional, it should run continuously along the entire network or route. Imagine when riding bicycle, the lane mysteriously

disappeared at certain point in the road. Discontinuous bicycle lane naturally causes dilemma among the cyclist while riding bicycle. Evenness of cycle path has strongest effect for children and their parent in order to choose particular route *(Ghekiere et al., 2015)*. Continuous or evenness of the lane hence dictates the bikeability of any route.

- **Separation of cycle lane from motorized traffic**

Separation of cycle lane from motorized traffic creates lateral distance between the two. This also enhance the safety from collision and traffics accidents and hence decide the bikeability of any road section (Ghekiere et al., 2015; Mertens et al., 2014; Wegman et al., 2012; Winters et al., 2013). Cycle lane can be separated from the motorized traffic in multiple of ways. Painting is the simplest form of separation. Use of the road marking can also be used to sperate it with either discontinues or solid line. Cycle could also be separated using physical means such as bollards, hedge, median island, railing etc.

- **Speed of motorized vehicle traveling adjacent to the bicycle lane**

Speed of traffic next to the bicycle lane is associated with the safety, both perceived and real (Llorca et al., 2017; Wegman et al., 2012). Low motorized vehicle speed strengthens the safety feeling while cycling through mixed traffic and especially, when there is no separation between cycle lane and road (Ghekiere et al., 2015; Hagen & Rynning, 2021). Higher vehicular speed more than 30km/hr is associated by low cycling for transport and unpleasant environment for cyclist

- **Bicycle related traffic signs and road markings**

For the purpose of informing cyclist and restricting motorists of the restricted nature of bicycle lane. As per AASTHO, these markings should be placed after every intersection/ signalized driveway. Properly installed traffic sign and markings helps cyclist for way finding and drive safely.

Figure 2 Typical Way Finding Signs

(Source: AASTHO Bicycle Facilities Guide , 2012)

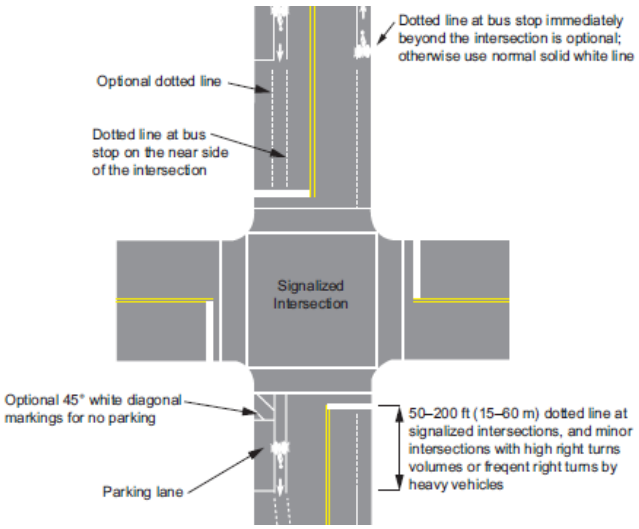


Figure 3: Typical Road Marking and way findings signs

(Source: AASTHO Bicycle Facilities Guide , 2012)

❖ **Bicycle activated intersections**

Intersections are generally hardest places for cyclist. At intersection, various actions such as left and right turn, crossing street, waiting for the light etc. creates conflict with other road users. Providing signs, light, road markings and provisions such as advance green supports to reduce these conflict and render intersection more safe and comfortable. For example, bike box helps cyclist by them providing more visibility and supporting them in taking 90-degree turn.

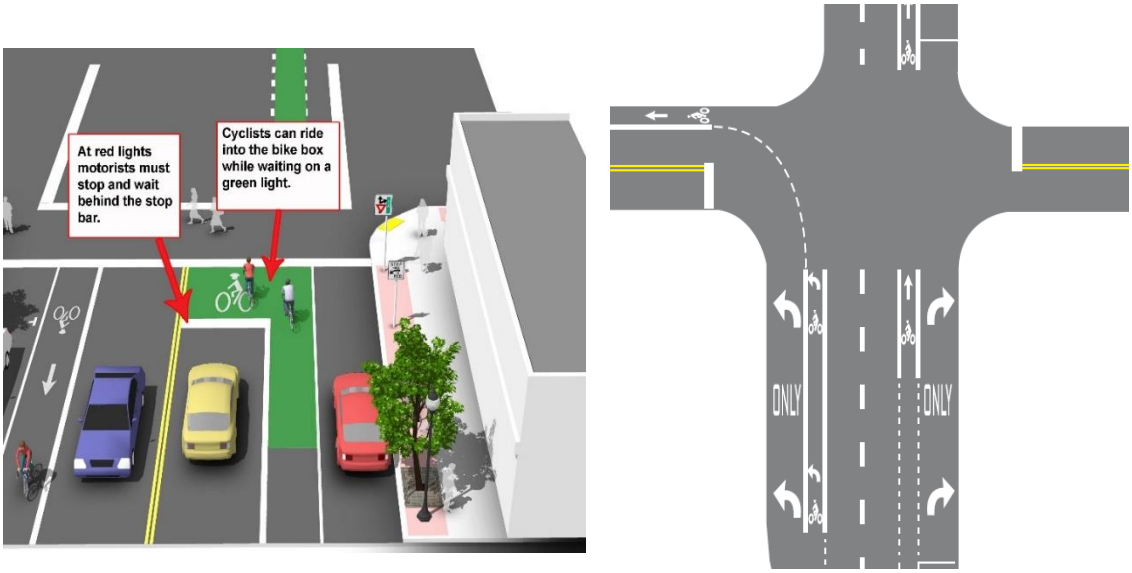


Figure 4: Bicycle activated intersections

❖ **Connectivity**

Number of roads connected through junctions, roundabout and intersections increases the connectivity of the any particular road. Connectivity with the other bicycle network through these roads support the cyclist to choose the multiple for destinations as well as use shortcut to travel and hence freedom of movement during cycling.

❖ **Availability of bicycle parking facility**

Whenever we travel to any destination-using bicycle, we need parking place that support-parking bicycle in safe way. Bicycle parking facility could be permanent or temporarily allocated. But, either type, should have infrastructure suitable and safe to park any type of bicycle.

❖ **Availability of bicycle repair workshops**

Bicycle, being a machine it can cause mechanical problems at any time. Hence easy accessible repair workshop motivates the selection of bicycle as a mode of transport.

3. Surrounding

❖ **Land use**

Land use means the how human make use of land. It varies from agricultural, economic, industrial, commercial, and educational to cultural. Mixed type of

land use provides multiple destination and purpose options for people to travel (Hagen & Rynning, 2021). Options for multiple activities and function in a small distance also encourage people to use bicycle more. Hence, the stretch of road providing more option and purpose to travel can be considered more bikeable.

- **Pollutions**

While commuting in cities major form of pollution we come across are, air, water and noise pollution. Majorly in the road while traveling in bicycle, air pollution and noise pollution bothers the most. Trashes and rubbishes stacked in the street or nearby also creates highly unfavorable environment. Pollution free environment creates a healthy and motivating situation for active mobility (Merten et al., 2016; Winters et al., 2013).

- **Safety concerns/perception**

Safety is crucial for any activity. We prefer to do those things which are relatively safer to carry out than other. Similarly, for cycling in any road safety while driving matters a lots. Ma et al., (2017), in their research mentioned that those who perceived their surrounding more bikeable also believed that it was due to less crime rates in that particular area. Roads with minimum numbers road accidents, crime rate and availability of street light and cc camera renders the road more preferable to use while cycling.

- **Obstruction in the routes**

Obstruction in the cycling route be due to the various reason. Some obstruction are permanent such as raised manhole covers, potholes, trees and their roots, electric pole. Temporary obstacle could be due to parked vehicles, encroaching by motorized vehicle while driving or passenger picking up and dropping, pedestrian waking in bicycle lane etc.

- **Maintenance**

Road being a public good gets used a lot and hence need frequent maintenance. Number of infrastructures directly related to cycling such as pavements, road markings, sign post etc. needs frequent maintenance. Proper and timely

maintenance keeps the road more bikeable (Ma et al., 2017**:,** Hagen & Rynning, 2021)

- **Aesthetic and green surrounding**

Open spaces and greenery along the road creates an pleasant environments to any commuter. Façade of the building as well as building with cultural and historical features adds diversity along the route and also supports to create aesthetic environment to support cycling. Motorized vehicle oriented environment are not appealing for bicycling (Chen et al., 2017)*;* Merten et al., 2016).

These attributes were further tested through peer review and were also verified through survey.

2.5 Existing National Documents Review:

2.5.1 Nepal Urban Road Standard

In order to attain uniformity in road section in urban area Nepal urban road standard was published and approved officially in 2076 /10/10 BS. Lane system is identified according to toad types and NURS also aims to design pedestrian. It focuses the promotion of NMT and pedestrian friendly roads. Classification of road is done into four sub categories as arterial road, sub-arterial road, collector road and local road. It has particularly defined the required minimum width of the cycle track to be 2m and additional 1m for each additional lane. Separate cycle track should be providing for cycle traffic more than 400 per hour or motor vehicle traffic more than 200 per hour.

For improved efficiency of the cycle track following points has been mentioned:

- Continuity to allow for reasonable speed
- A smooth surface material, asphalt or concrete paved blocks are to be avoided
- Manhole cover should be avoided and if unavoidable should be on the same level of riding surface
- Continuous shade through tree cover
- Elevated carriage way
- 0.6m buffer between cycle track and parking area or carriageway

- At property access points, the cycle track remains at the same level and vehicle access is provided by a ramp in a buffer

Width of Cycle track	Capacity in number of cycles/hour	
	One-way traffic	Two-way traffic
Two lanes (3 m)	250-600	50-250
Three lanes (4 m)	> 600	250-600
Four lanes (5m)	---	> 600

2.5.2 Nepal Road Standard, 2070

NRS 2070 was prepared before Nepal Urban Road Standard. Like NURS it has also provided the guideline for cycle track. As per it:

- All roads with ADT more than 4000 PCU and bicycles travel more than 1000 nos/day bicycle tracks should be constructed. The minimum width should be 1.2m for each lane in each direction of travel.
- There should be at least 1m gap between road edge and cycle or should be separately constructed.

2.5.3 National Sustainable Transport Strategy (NSTS) (2015-2040)

NSTS has identified poor infrastructure and lack of bicycle lane as key issue in urban transport sector. In relation to the promotion of NMT it has set targets to:

- minimize motor vehicle ownership
- minimize per capita CO2 emission from transport sector
- increase share of NMT in total trips

For this it has set forth strategic actions, which are:

- Invest for pedestrian and Non Motorized Transport (NMT) infrastructure in Kathmandu, NMT lanes in urban areas
- Making provision for bicycle stands
- Dedicated bicycle lane in national highways

2.5.4 Periodic plans:

Starting from the 10th plan provision related to cycling has been directly mentioned. In this plan it has been mentioned that the area of heavy traffic, road widening with cycle lane will be provided. Footpath and bicycle lane needs to be provided where possible is mentioned in 12th plan. Similarly, the current 15th plan has emphasized on multisector coordination, construction and establishment of cycle lanes.

2.5.5 Lalitpur Metropolitan City's Making Lalitpur Cycle Friendly City

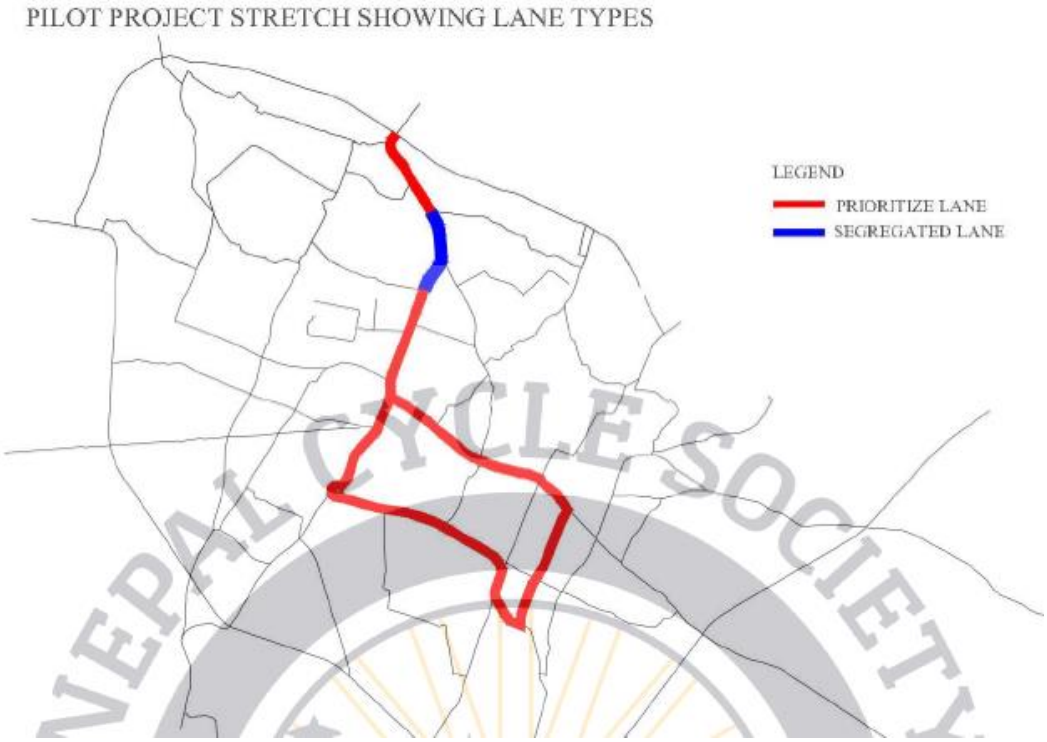
With the main objective to promote cycle culture in Kathmandu valley, Lalitpur Metropolitan City have prepared a report in 2019. Together with "Nepal Cycle Society", they have prepared a document that establishes long term vision of cycle city master plan within LMC. This document has also prepared general implementation plan of the project after prioritizing them. In order to prioritized the systemic investment, they have defined the seven different criterion. These criteria are:

1. Population Density
2. POI (Point of Interest)
3. Ward Preference
4. Road Surface Condition
5. Supported type of Cycle Lane
6. Public Transportation route
7. Movement between Wards

On the basis of these criteria, the document has selected the following route to be integrated with cycling infrastructure:

Ranking	Road Name	Start Point	End Point	Marks
1	Ring Road Section 1	Balkumari Bridge, Koteshwor	Ekantakuna	97
2	Ring Road Section 2	Ekantakuna	Balkhu Bridge	89
3	Jawalakhel-Lagankhel Road	Jawalakhel	Lagankhel	67
4	Pulchowk-Patan Durbar Square	Pulchowk	Patan Durbar Square	67
5	Patan Durbar Square-Gwarko	Patan Durbar Square	Gwarko	59
6	Jawalakhel-Ekatakuna Road	Jawalakhel	Ekantakuna	58
7	Lagankhel-Mangalbazar Road	Lagankhel	Mangal Bazar	57
8	Lagankhel-Satdobato Road	Lagankhel	Satdobato	57
9	Bagmati Corridoor Road	Balkhu Bagmati Corridoor	Sankhamul Bridge	56
10	Patan Hospital-Mahalaxmithan Road	Patan Hospital	Mahalaxmithan Chowk	56
11	Kupandole-Jawalakhel Road	Kupandole	Jawalakhel Road	55
12	Kupandole-Bhanimandal Road	Kupandole	Bhanimandal, Ringroad	52

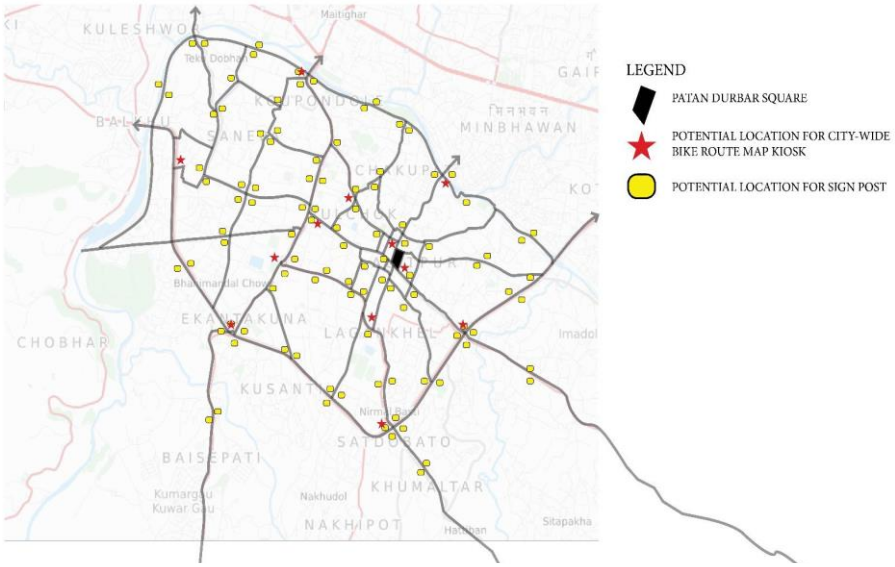
The document also has selected Kupondole-Pulchowk-Lagankhel route and Pulchowk Mangal bazar –lagankhel route to develop as a pilot project of cycle lane.



Details and location for the various cycle infrastructure i.e cycle parking, signage has also been mentioned. The proposed location for the cycle parking are:

- Lalitpur Metropolitan City office (In front of LMC)
- Patan Durbar Square (In front of Bhimsen Mandir parking area)
- Patan Durbar Square (Uma Maheswor temple, on existing parking area)
- Patan Durbar Square (In front of Hakha Buddha, existing parking area)
- Gabahal (Purnachandi road side parking area)
- Bangalamukhi Temple (In front of Bangalamukhi Temple,existing parking area)
- Lagankhel (Behind Lagankhel bus park)
- Patan Dhoka (In front of Patan gate, existing parking area)
- Nugah Lu Hiti, Sundhara Patan (Side of Sundhara)
- Lagankhel (In front of Patan Hospital On existing bike stand area)
- Nakabahil Tole (In front of Lokakirti Mahavihar, Nak Bahi)
- Jawalakhel in front of children park (Existing parking area)

Potential locations for signage has also been identified and shown in the map below.



But, detail of the various road signs and road marking relevant to bicycling has not been included in the study.

2.5.6 Motor Vehicles and Transport Management Rules, 1997

Government of Nepal brought forward this rule in order to exercise the power conferred by section 179 of Motor Vehicles and Transport Management Act, 2049 (1993). This rule has put forward various related to motorized vehicles. This rule also provided the list of traffic sign to be used in the road.

In relation to bicycling, it has only mentioned two signs in informative sign category in Annex 63 of the document.

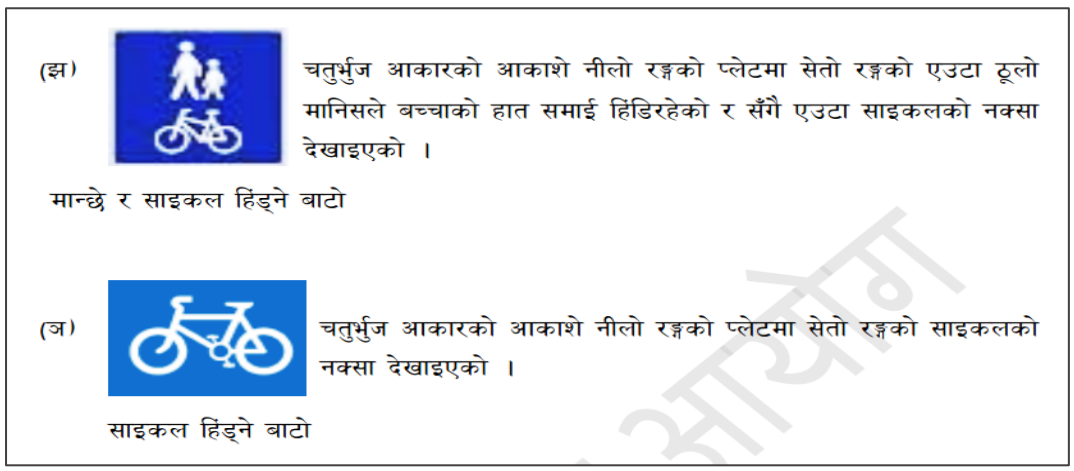


Figure 5: Traffic signs related to bicycle

2.5.7 MTMP's Review:

Budanilkantha Municipality and Kageswori Manahara Municipality's MTMP

Municipality Transport Master Plan (MTMP) is one of the major document of the local level governing the entire transport sector of a local level. It provided the detail review of transport situation of a local level and necessary plan for transportation sector development cost estimations. Regarding bicycle not much information can be viewed in them.

In Budanilkantha Muncipality MTMP only thing mentioned about cycling is that "Golphutar to Budhanilkantha would be proposed". But, no estimation has been proposed by prioritizing it.

Even during assessment of the vehicle data, priority has only been given to motorized transportation and no data has been assessed for bicycle use and cycle data was not collected.

2.6 International documents and practices review

2.6.1 AASHTO Guide

The American Association of State Highway and Transportation Officials' (AASHTO) task force on geometric design created a guide for the development of bicycle facilities in 1999 with the intention of providing information on the development of facilities to promote safe bicycling. The document has undergone periodic updates, and the most recent one is dated 2012. This document clearly outlines the various cycle facilities, such as lanes, parking spaces, road signs, etc., that should be taken into account when planning bicycle facilities. The documents include various cycle lane types as well as a detailed geometrical design of each facility. Along with these, this document includes information on the road signs, their assemblies, and bicycle-related road markings. The guide includes detailed specifications for the necessary grade, cross slope, design speed, drainage, and lighting. Additionally, the guide has information on programs and activities for maintenance and operation, such as sweeping, surface repair, vegetation removal, utility cuts, etc.

2.6.2 International Case Study

City of Amsterdam

With a population of 1.2 million, Amsterdam is the largest city in the Netherlands. In the present world, this city is practically synonymous with cycling where 900,000 people use cycle. The Netherlands, and particularly Amsterdam, are unique in having a very integrated cycling culture. To begin with, it is established in Dutch tradition that children are given bicycles by the time they are four (Elliot, 2022). Everyone uses bicycles, including the elderly, men, women, and children.

Due to its ideal topography and spatial development patterns, it is incredibly easy to ride to numerous locations. The length of trips is minimized in mixed-use neighborhoods. The profusion of tiny bike bridges and bypasses also makes it convenient to pedal through the city center. In contrast, motorized vehicle driving in the city's center presents difficulties. Parking spaces are scarce, there are several cul-de-sacs, and one-way streets limit car traffic. Regional Networks, Round Trips, and National Biking Routes are the major recreational bike alternatives. Additionally, there are 25 cycle superhighways. As cycling grows in popularity, a secure route for longer

distances enables cyclists to keep using their bikes for transportation (Bicycle Policy in the Netherlands, n.d.).

Figure 6: Safe bicycle riding

(Source: www.vox.com)

But, this was not always the condition. The major reason behind the current bicycle culture level in Amsterdam is the investment in cycling infrastructure that began in the early 1970s, followed by unacceptably high death rates for cyclists in the post-war auto reliance boom. Cycling used to be the main transportation mode in the country's pre-World War II days but after the war, the car gradually started replacing them. Cycling's mode share decreased to only 25% of all trips between 1955 and 1970. This decline in cycling was accompanied by increased suburbanization and increased car ownership. Bicycle supporters and environmentalists advocated bicycle use in the city since the late 1960s and early 1970s. Their main worries related to the use of automobiles in the city, which resulted in air and noise pollution, traffic jams, and unsafe traffic conditions. Record number of 3000 people including 450 kids died in car accidents in 1971 alone. This sparked the "Stop de Kindermoord" movement. Amsterdam's traffic issues at the time could be resolved in one of two ways: either by modifying the city's development patterns and physical layout to accommodate automobiles, or by prohibiting cars from entering the city's core and encouraging pedestrian, bicycle, and public transportation use instead. Instead of enlarging highways and constructing parking facilities in the city center, the municipal council chose to advocate for alternate modes of transportation. Also, the Organization of Arab Petroleum Exporting Countries (OAPEC) chose to restrict its crude oil supplies to nations like the Netherlands in 1973 because of its alliance with Israel in the Yom Kippur War against many Arab governments. In order

to address the fuel scarcity, the Dutch government decided to ban Sunday car traffic. Finally, a freshly elected municipal council turned its attention to bicycling as a crucial instrument for resolving the city's transportation issues in 1978. Since then, cycling has become more popular since the early 1970s. Midway through the 1980s, it reached 31% of all automobile journeys, and in 2005, it was at 37% of all automobile trips (Pucher & Buehler, 2007). As per the "Long-term Bicycle Plan 2012 – 2016" of Amsterdam city, bicycle trips increased by more than 40% over 20 years before 2012. There was also a 2.5% modal shift to bicycles. in the period from 2005 to 2018 (Netherlands Institute for Transport Policy Analysis, 2018). As of 2017, bikes made up 68% of commuter travel to and from work or school, and 36% of total traffic movements in Amsterdam. Beyond the early 1970s, Amsterdam's transportation strategy has been focused on non-motorized modes of transportation. Although improving accessibility for all forms of transportation is the city's primary transportation objective, concerns about air quality and quality of life give bicycles a special place in transportation planning. Bicycle theft, a lack of secure bike parking, traffic safety, and relatively long wait times at signalized junctions were the top concerns for cyclists in 2006. The city has begun to try to address these issues through its bicycle policy plan "Choosing for Cyclist: 2007-2010" by expanding bike parking facilities, combating bicycle theft, enhancing and promoting traffic safety, completing and improving the bike network, and encouraging young people to bike more. Approximately €40 million were scheduled to be spent between 2007 and 2010 on bicycle projects. Improvements to bike parking spaces and secured bicycle garages also received significant funding. Similarly, traffic-calmed areas with a 30km/hr speed limit were extended. Additionally, substantial funds were invested in activities like public relations campaigns, bike education, and other initiatives aimed at encouraging young people and other social groups that don't pedal as frequently to do so (Pucher & Buehler, 2007). On-road bike lanes were also changed by the city to separate bike lanes. To integrate public transportation with bicycles, a bicycle garage was built close to the train station The city adopted comprehensive strategies to combat bike thefts, including official bike registration, cooperation with bike shops, and stringent police checks for bike ownership. For instance, the city strongly supported the engrave-a-code program for bicycle frames. Both engraving and police registration of engraved bikes were free. With the use of this special registration code, authorities could identify stolen bikes and

return them to their rightful owners. Even a unique website dedicated to this initiative and other bike theft issues is maintained by the city. Even Amsterdam's bike shops implemented a new rule prohibiting the repair, purchase, or resale of any bicycles that might be stolen. Amsterdam police also increased their examinations of bikes that are riding on the road.

In favor of the cyclist, the city of Amsterdam has limited automobile access to the city center. One way for automobiles traffic, paths dedicated to walkers and bikes are the common characteristics of many streets. The city has decreased the number of parking spaces as well as significantly increased car parking costs since 1970 (Dutch Bicycling Council, 2006). Citizens even voted to keep the number of parking spaces in the city center from growing in 1992. Car excursions to the city were discouraged when parking is expensive and scarce. Additionally, many residential neighborhoods have low-speed traffic control, as is the case in most Dutch cities.

Parking facilities are appropriately provided at different points within the city. An interactive map of the secure bike parking spaces can also be accessed through the official website of the Amsterdam City Council. The lack of parking spaces in the downtown area and the subpar transit service to other parts of the city were the main impetuses for the adoption of the "Park and Bike" scheme in 2006. This makes it possible for drivers to park their cars outside of the city limits and continue their trip to the downtown area on a bicycle. Through this scheme, automobile and bicycle use have been creatively integrated in Amsterdam.

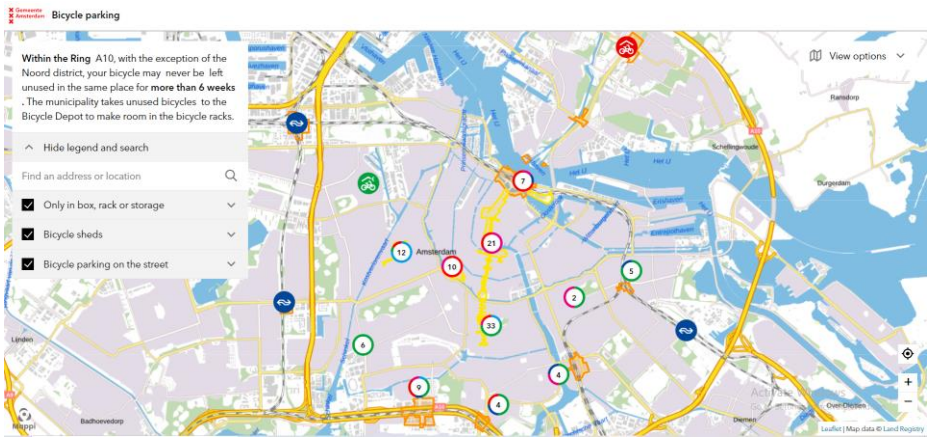


Figure 7: Parking location in Government website

Furthermore, a lot of kids in the Netherlands start riding bicycles at a young age. In the Netherlands, schoolchildren go through bicycle training, just like in other nations in

Europe. The municipal government provides free bicycles to schools so that students who do not own a bicycle can learn at school how to pedal safely in Amsterdam.

Even though Dutch cycling culture is far more established than that of the rest of the globe, there are still certain areas where it may be improved. Congestion is getting worse as the number of bicycles rises. As a result, there is more bike traffic, less space for storage or bicycle locking places, and widespread bike theft because of inadequate protection. Furthermore, tourists sometimes are unfamiliar with or ignorant of the cycling culture, such as their own parking, traffic lights, insurance, etc. are a few notable differences.

Despite being democratic, capitalist, wealthy cultures with practically universal vehicle ownership, they have been effective in boosting overall bicycle travel while reducing the number of fatal and serious cycling accidents. It has demonstrated that the success of cycling does not depend on poverty, autocratic governments, or a lack of other means of transportation to drive people onto bicycles. It does, however, primarily depend on a wide range of government programs to make cycling safe, convenient and socially preferable (Pucher & Buehler, 2007).

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Conceptual Framework and Methodology

Ontology and epistemology, according to (Grix, 2004), are the foundations upon which research is built. The researcher's ontological and epistemological assumptions influence the methods and research methodologies used. The study's ontological position is that the bikeability of the city is defined by how much the user prefers to use the bicycle as a mode of transport. It is concerned with social reality. Asking users how the built environment influences their preference for using bicycles as well as self-experiencing the existing situation is an epistemologically valid source of knowledge.

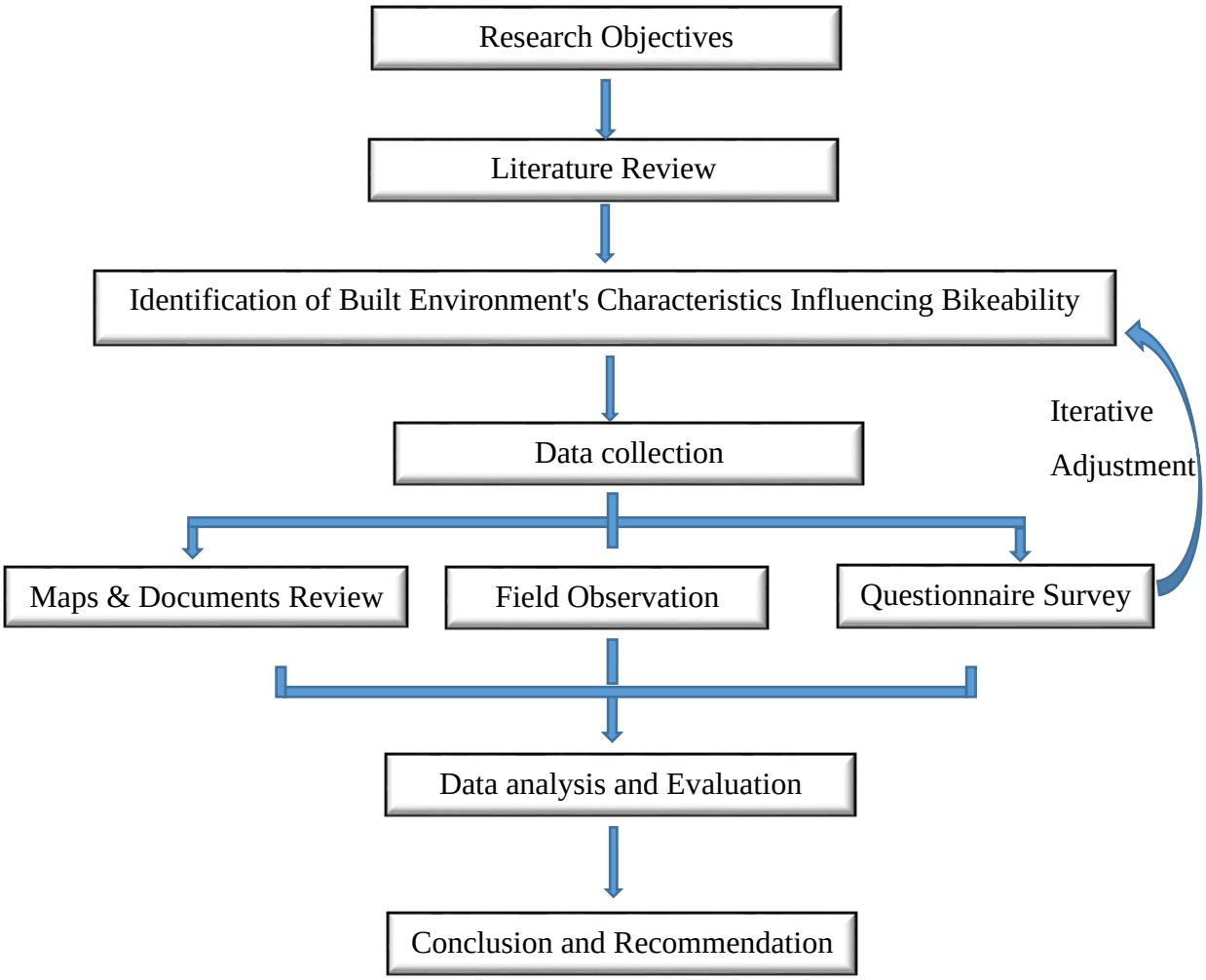
Selection by rejection would be an excellent strategy for selecting the suitable paradigm for a research project by rejecting the incorrect paradigm. In any research, a paradigm can influence how knowledge is interpreted and studied. This will aid a researcher in selecting methods, methodologies, and literature for his or her research project. Some of the most commonly used paradigms for research are positivist, post positivist, interpretivist, and constructivist. Positivists think that a cause-and-effect relationship can be established. They are looking for regularities in order to generate predictions and develop scientific rules, and they believe that based on this component, scientific methods can be used to evaluate the social environment. Post-positivism is intuitive and holistic, inductive and exploratory, and qualitative in its findings. Despite the fact that qualitative methods can be utilized within this paradigm, quantitative methods are more commonly used (Mertens, 2005). The critical realism ontology is held by post positivists, according to which a real world exists, driven by actual natural forces, but it is impossible for humans to fully experience it. Since in this research people's perception of the built environment determines the bikeability, it falls under post positivistic paradigm.

3.2 Methods

To assess the bikeability, a mixed-method will be used. At first, a street stretch within Kathmandu valley is selected as a study area. Next, various built environment's attributes affecting bicycle friendliness will be selected through literature review. Questionnaire survey will be conducted with the road users to incorporate the user

perspective into the study. Field study will provide various data related to the existing infrastructures, topography and surroundings in the selected street stretch. Surveys are generally suitable for explaining the features of a large population and it assures reliability by asking all respondents identical questions and by providing all respondents with standard stimuli (Hossain et al., 2015). For the study random sampling method will be used.

3.3 Research Framework



In the first phase, literatures and policy documents related to cycling and bikeability will be reviewed. From the study, various attributes of the built environments that influences the bikeability of an urban road will be identified. The obtained knowledge will be tested through peer review and analysis. Once, suitable attributes in our context

are identified, questionnaire survey will be undertaken to evaluate the identified attributes significance on bikeability of an urban road.

Random sampling will be conducted to obtain the survey result. This data will provide the level of significance each attributes hold to enhance the bikeability of an urban road. At last, bikeability of Kupondole-Jawalakhel-Lagankhel road will be qualitatively assessed and necessary recommendation will be provided.

3.4 Data analysis

Primary data are collected through field observation and measurement, questionnaire survey, and whereas secondary data were collected from study of maps, different literature studies, journals, case studies, and official department. The quantitative and qualitative data collected are then analyzed statistically as well as descriptively as per the nature of the data.

Descriptive statistics entails several sorts of statistical analysis aimed at describing, summarizing, and explaining a set of data such that the important elements can be easily understood (Christensen, Johnson & Turner, 2015). The data collected will be analyzed using simple descriptive statistics. A descriptive statistical study is a good technique to investigate a social phenomenon and lay the framework for more advanced statistical analysis in the future (Islam et al., 2019). Users' perceptions on various attributes of built environment influencing of bicycle friendliness will be analyzed using frequency distributions, percent, averages, and various charts and graphs.

CHAPTER 4: STUDY AREA

The study area selected is the road stretch Kupondole-Jawalakhel-Lagankhel. The study area is located in Lalitpur Metropolitan City The total length of the selected stretch is 3.15 km. For this study, area along the road as well as proximity to the road will also be investigated. Lalitpur Metropolitan City has selected this stretch to implement its first master plan to obtain cycle city. Hence, this stretch is selected considering the various infrastructure constructed in favor of bicycle use.

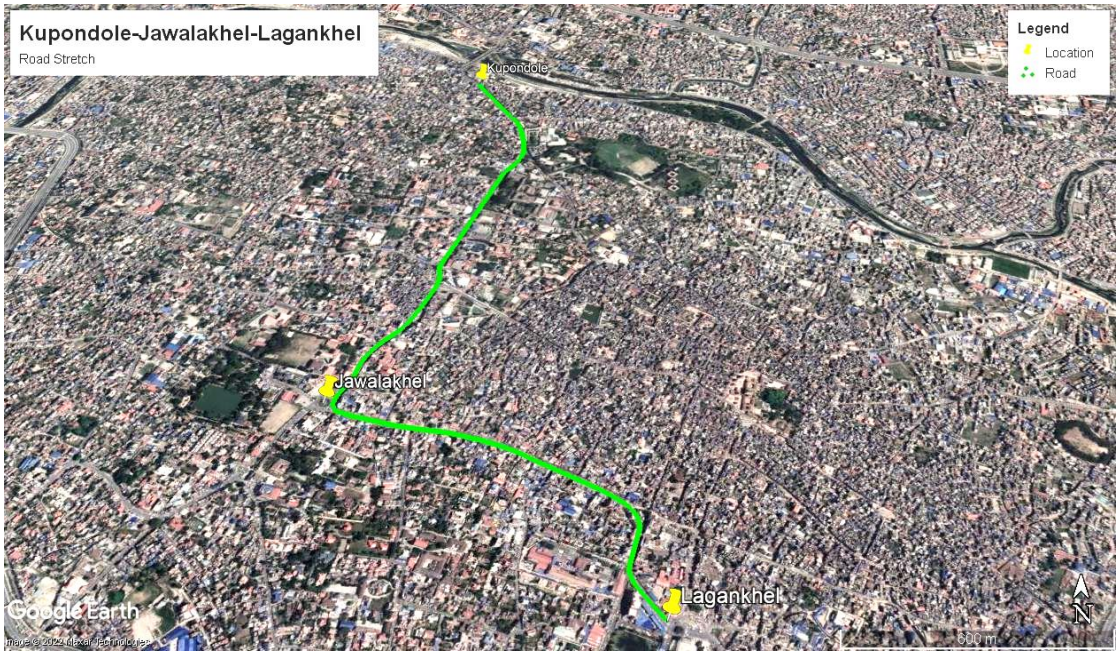
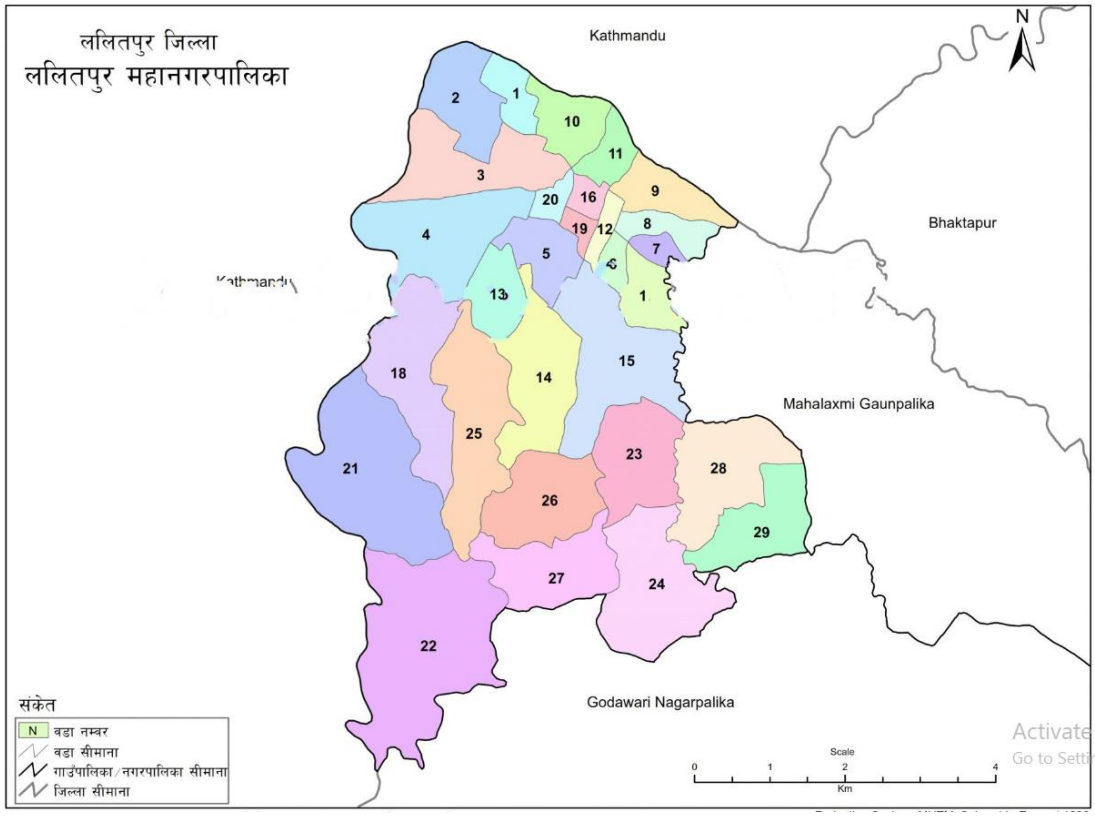


Figure 8: Study Area

(Source: Google Earth)

The selected road stretch for the study passes through ward no. 10, 3, 4 and 5 of Lalitpur Metropolitan City. Along the route there are number of significant location serving as a popular destination for the people. Pulchok campus is the largest engineering campus of TU within Kathmandu Valley. Lalitpur Metropolitan City office also lies along the same route. There are also popular hospital such as Alka and Patan Hospital. Beside this various destination lies in the proximity to the stretch such as Labim mall, central zoo, UN house, Bhatbahteni, number of banks, Gurudwara etc. Further, this road also

serves as a route for world heritage site of Patan Durbar Square as well as cultural and historic residential areas in the vicinity.



Map 1: LMC political map

(Source: https://www.nepalarchives.com)

The selected road stretch is an arterial road. The road width is approx. 25m with sidewalks in both edges of road. Along some section, there is provision of median island with plants. Zebra crossing and overhead bridge area available for crossing streets. The road section is mostly busy with high traffic flow all day.

LMC, on the basis of its "Study on Making Lalitpur Cycle Friendly City" selected this stretch as its pilot project and has installed number of bicycle related road infrastructures such as bicycle lane, bicycle rated traffic signs and road marking and bicycle friendly.

For the purpose of study, the selected route is further divided into 3 stretch:

Stretch 1: Kupondole to Hariharbhawan road with length of 1km. This is denoted by red color path in figure

Stretch 2: Hariharbhawan to Jawalakhel road with length of 1km. This is denoted by blue color path in figure

Stretch 3: Jawalakhel to Lagankhel road with length of 1.35 km. This is denoted by yellow color path in figure

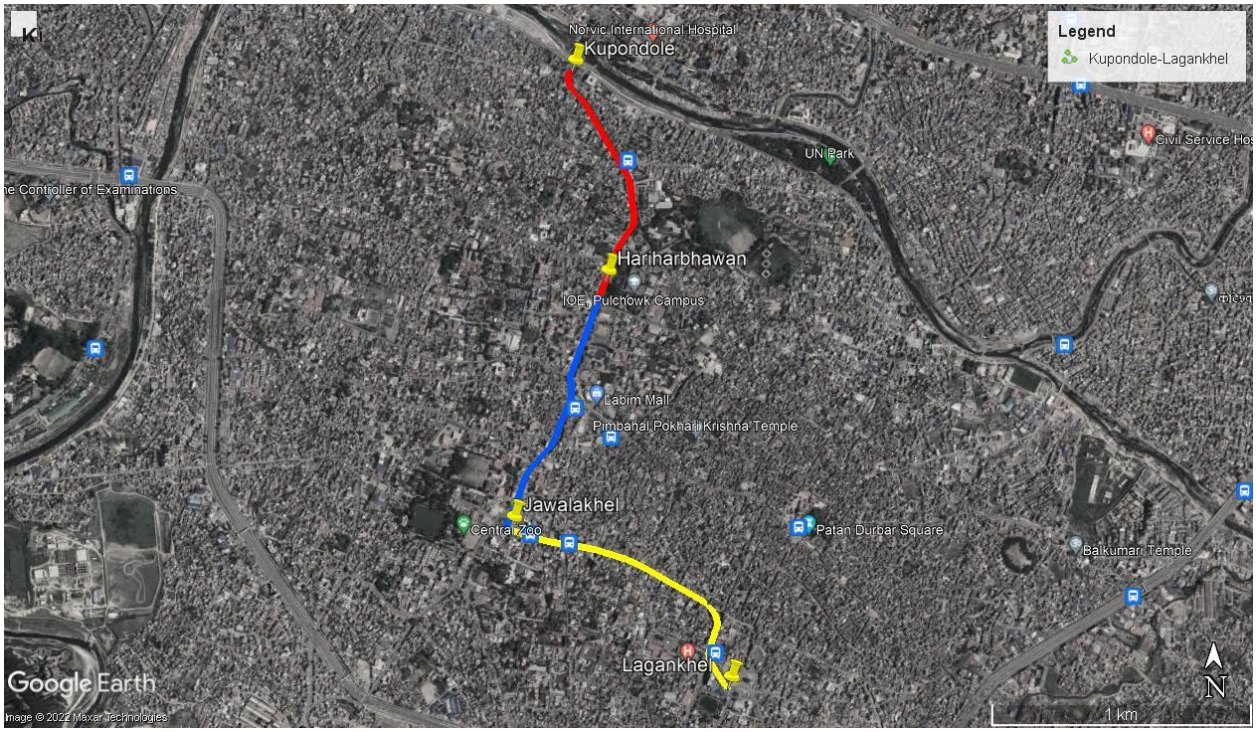


Figure 9: Study area

(Source: Google Earth)

CHAPTER 5: DATA ANALYSIS

In this research, data collection is done in two-step. At first, survey is done to collect data on determining the influence of various built environment attributes on bicycling. Survey questionnaire were broken down into 2 different section. First section focused on the demographic and travel behavior information of the respondents. Second section were asked on various attributes of the built environment considered to be contributing on bikeability. The establishes attributes were categorized into 3 categories:

1. Natural Precondition
2. Road Infrastructure and Traffic
3. Surrounding

These were further sub divided into:

1. Natural Precondition
    - Topography
    - Weather condition
2. Infrastructure and Traffic
    - Presence of bicycle lane
    - Continuous bicycle lane
    - Separation of cycle lane from motorized traffic
    - Speed of motorized vehicle traveling adjacent to the bicycle lane
    - Bicycle related Traffic signs and road markings
    - Bicycle activated intersections
    - Connectivity
    - Availability of bicycle parking facility
    - Availability of bicycle repair workshops
3. Surrounding
    - Mixed land use
    - Pollutions
    - Safety concerns/perception
    - Obstruction in the routes
    - Maintenance
    - Aesthetic and green surrounding

Each attributes mentioned above have been questioned to respondent on its influence on Bikeability of the road.

5.1 Demographic data

In total 202 samples were collected. Data were collected through google form. Random sampling was conducted and 202 responses were received out of 450 people approached in this phase of research.

5.1.1 Age

This data is useful to understand how needs differentiate by age group. Out of all respondents, 136 were from age group 20-30. 52 were from age group 30-40. The targeted diversity of all age groups were not met but opinion of current youth will matter more in forming indicators for future.

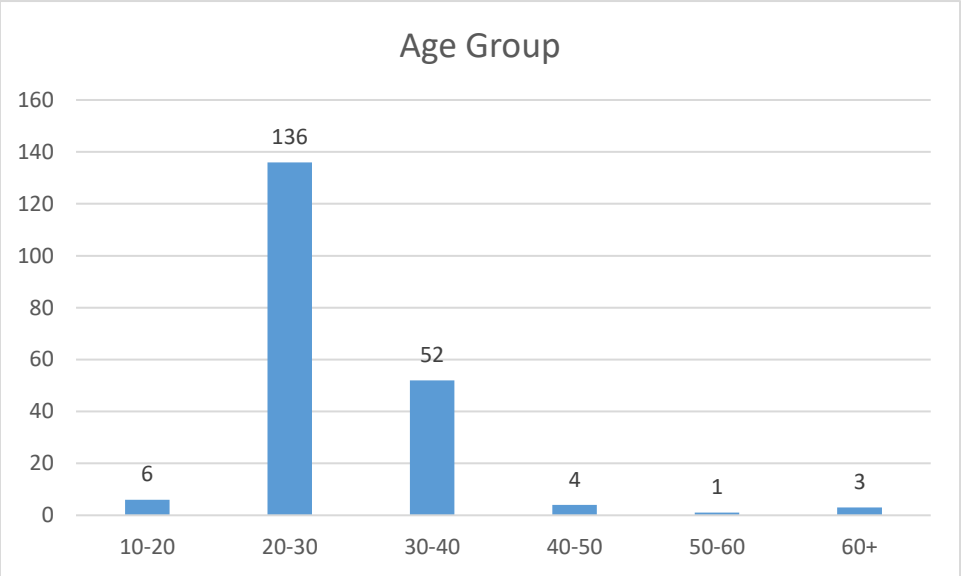


Chart 1: Distribution of Age Group

5.1.2 Gender

Out of 202 respondents, 68% were male and 32% were female. This data will be helpful to know needs by gender .

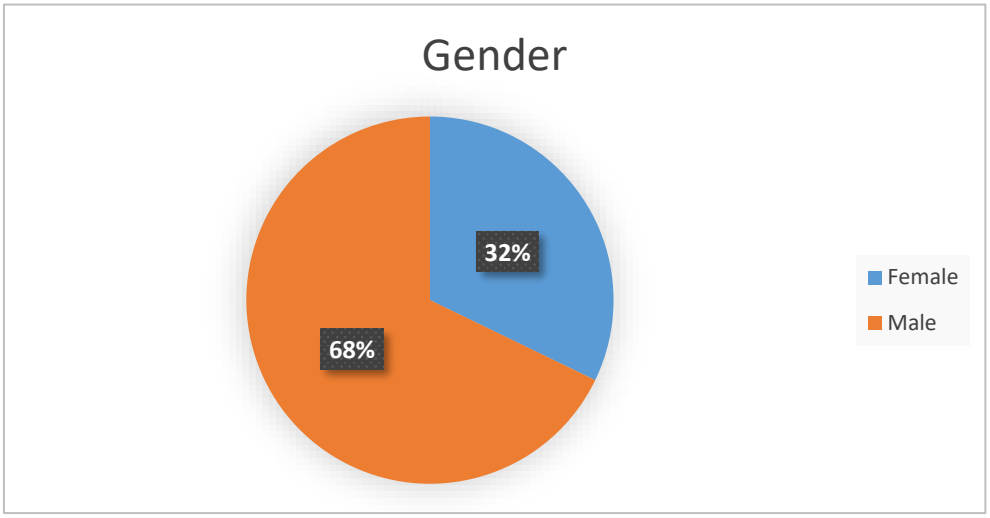


Chart 2: Distribution of Age Group

5.1.3 Education Level

Education level was divided into 4 categories. It is believed that basic level of education will help in better understanding. 59% of respondents have completed their bachelors. 34% respondents responded to have higher education than bachelors. The required level of education was obtained from survey.

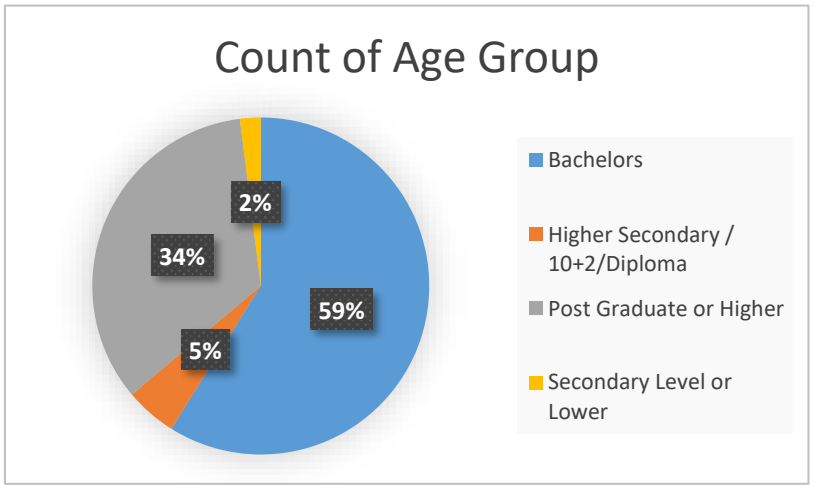


Chart 3: Distribution of Education Level

5.1.4 Disabilities

Out of 202 respondents, 1 male and 1 female responded to have some form of disability.

5.1.5 Own Bicycle

Out of the 202 respondents of the survey, 23% of the total own bicycle. Remaining 156 do not have their own bicycle.

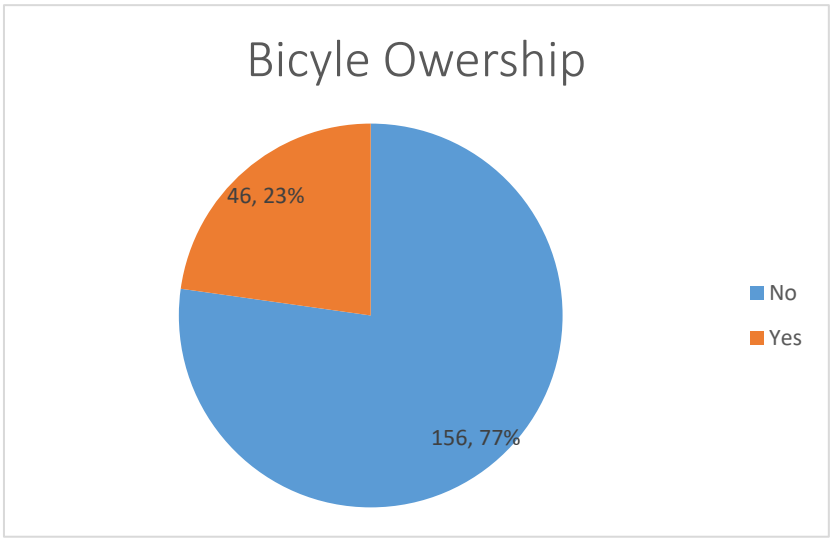


Chart 4: Distribution of Bicycle ownership

5.2 Travel Behavior

5.2.1 Frequency

Out of those 46 respondents who own bicycle, only 7 use the bicycle on daily basis. 4 people never use it despite of owning. Remaining use it in different frequency in a week.

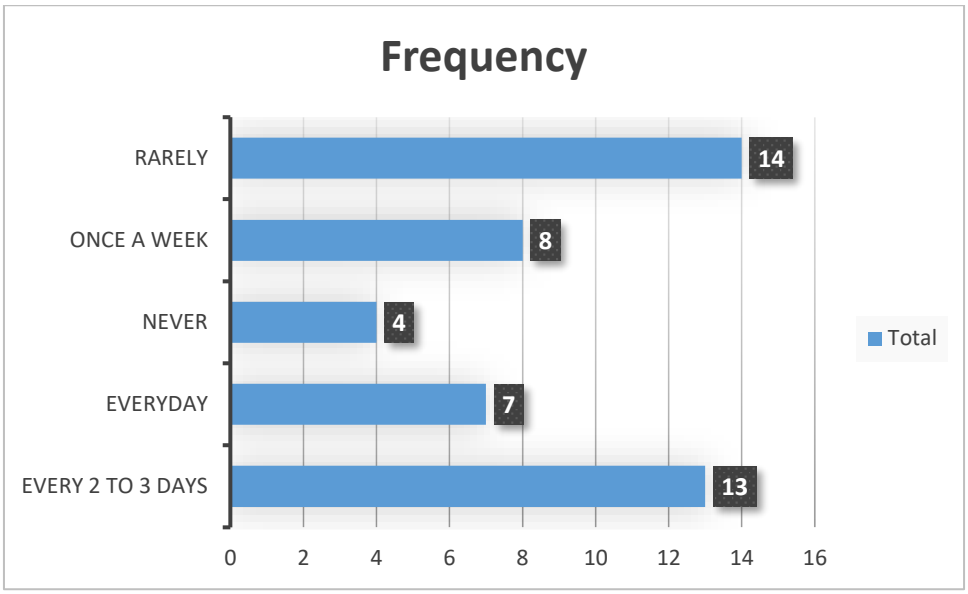


Chart 5: Bicycle use Frequency

5.2.2 Major purpose of bicycle use

It was found that the major purpose of bicycle use was for exercise and recreation purpose. Only 2 people use it to access public transport. 26% of total bicycle owner us it for traveling to work.

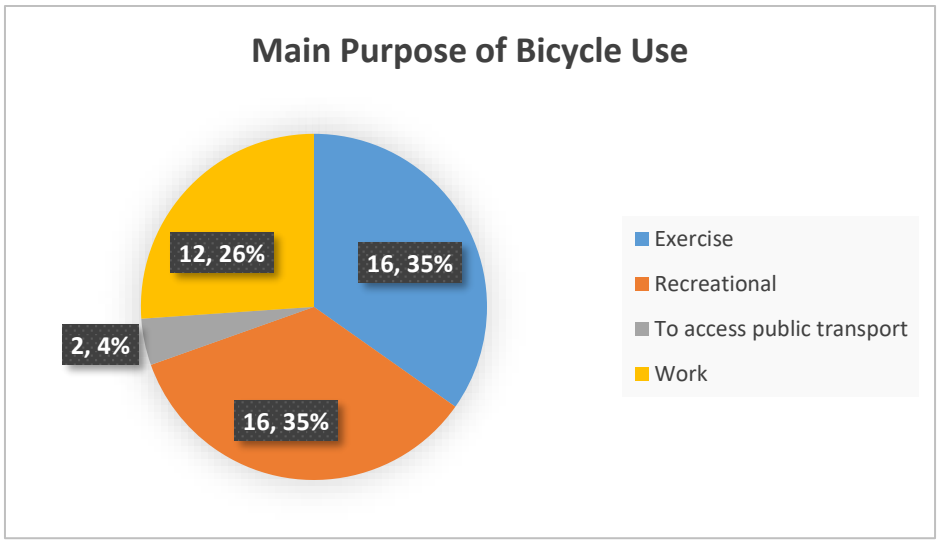


Chart 6: Bicycle use main purpose

5.2.3 Reasons for not using bicycle

In total 170 people who did not use bicycle responded to this question. Majority of people felt the physical factors made them not to use bicycle. These factors as

mentioned by them were terrain, poor condition or lack of bicycle related infrastructures and unsafe roads condition. 21% of the respondent put forward social reasons such as cycle being considered as inferior mode of transport than motorized vehicle, feeling of being judged while using bicycle, less cool option for transport etc. Similarly, 8% did not use cycle because of personal reasons such as lack of bicycle riding skill, physical disability and age factor. Remaining found it to be tedious and time consuming for travelling in long distance.

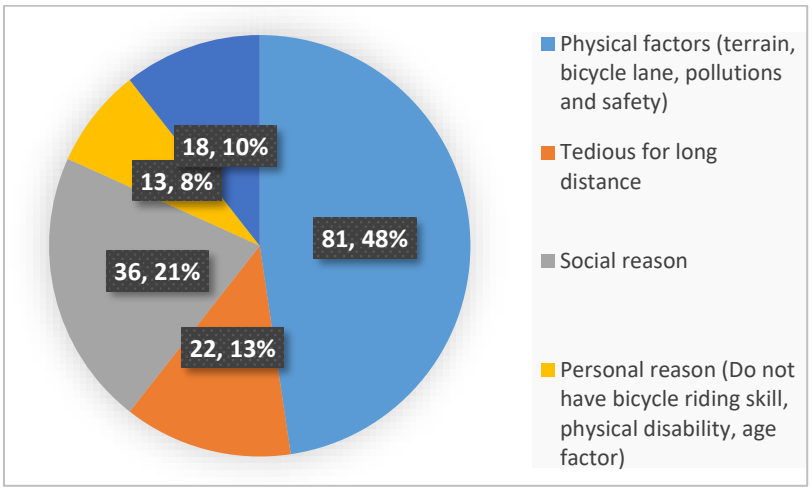


Chart 7: Reason for not using bicycle

5.2.4 Willingness to change in behavior

68.3 % people responded that they are willing to cycle more or will start using bicycle

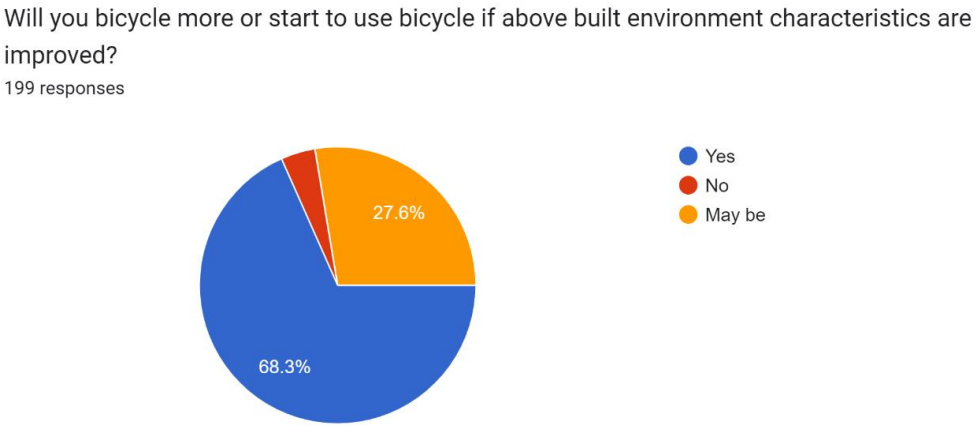


Chart 8: Willingness to use bicycle

Built

Environment characteristics are improved and 27.6 % responded they might. Only 4.1% respondents said they are not going to change their behavior. This shows our city has great potential to enhance cycling culture if improvements are made.

5.3 Response on built environment attributes

Questionnaire were forwarded to the road users for rating the influence of various attributes of built environment on bikeability of an urban road. Each attributes were rated in 5 point Likert scale. The response ranged from 1 to 5 with 1."No Influence", 2."Limited Influence", 3."Moderate Influence", 4."High Influence" and 5 "Very High Influence".

5.3.1 Natural Preconditions

5.3.1.1 Topography

Out of total 202 responses, 34.2% responded the influence of topography of cycling is only high. 18.8% responded it to be have very high influence. 5% though it has no influence on cycling

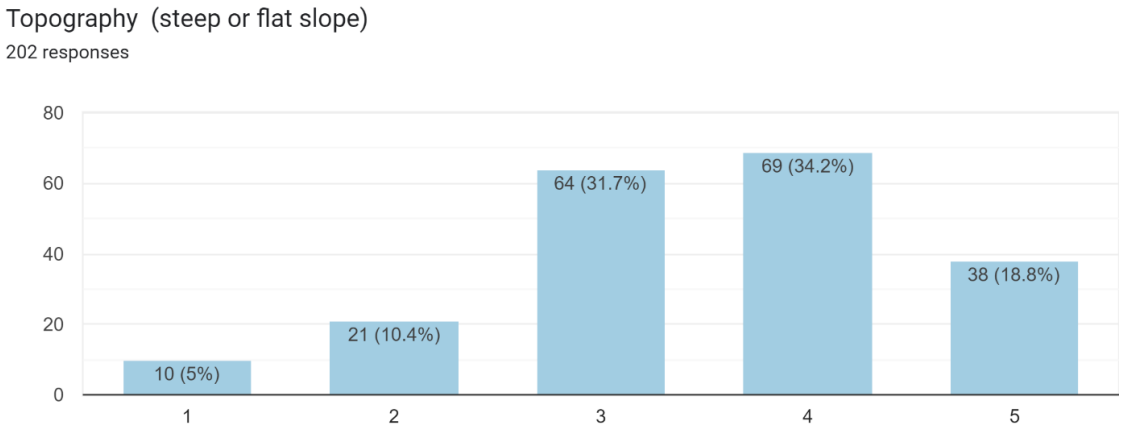


Chart 9: Influence of Topography

5.3.1.2 Weather

For weather and its stability 32.7 % responded it to have moderate influence followed by 31.7% for very high influence.

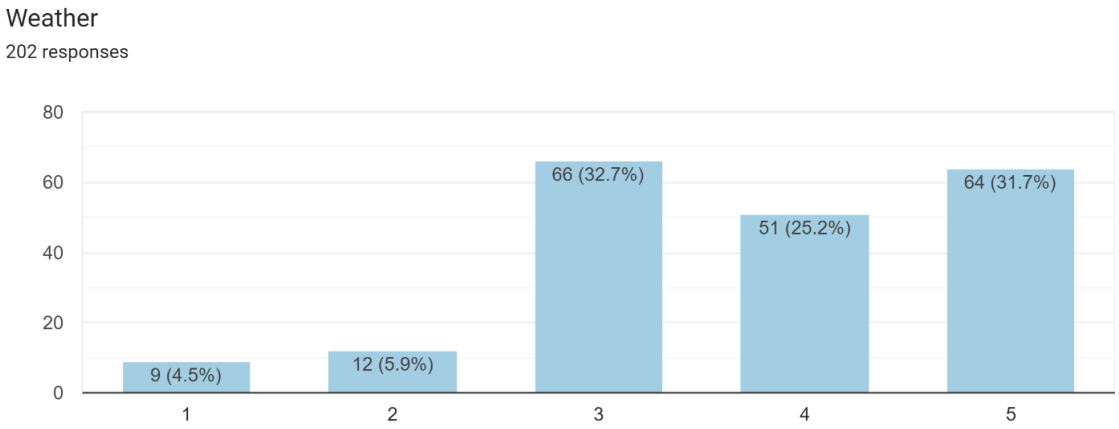


Chart 10: Influence of weather

5.3.2 Infrastructures and Traffic

5.3.2.1 Presence of bicycle lane

Significantly percentage of sample responded the presence of bicycle lane to have very high influence. Only 4.95% though it to have no influence.

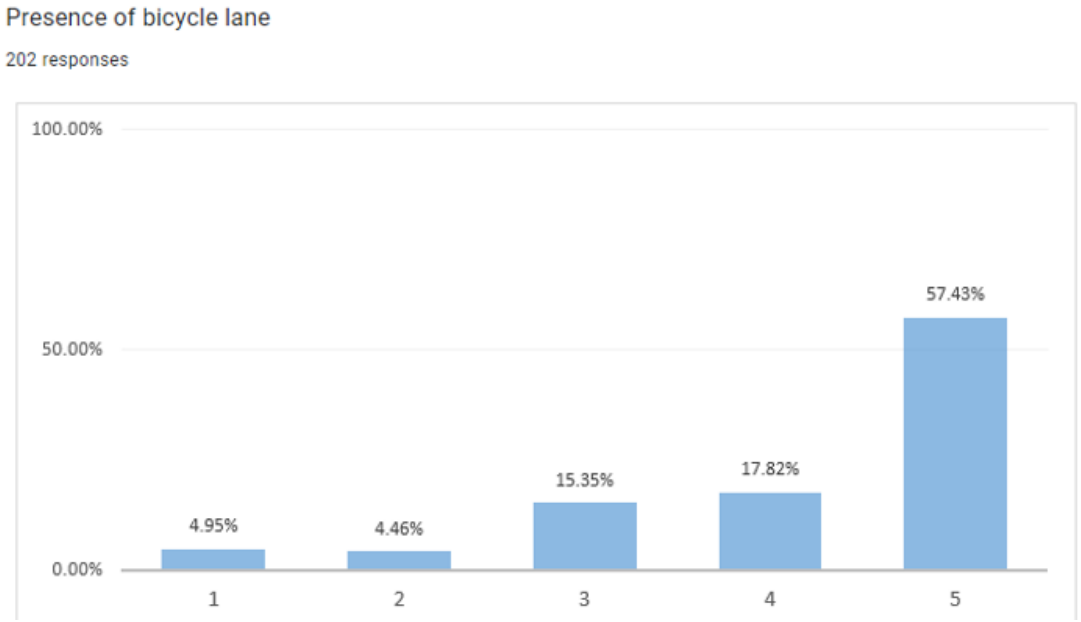


Chart 11: Influence of presence of bicycle lane

5.3.2.2 Width of bicycle lane

55.45 % of total responded believed that the width of bicycle lane has very high influence in choice to cycle or not. Whereas, only 5.45% thought it not to have any influence.

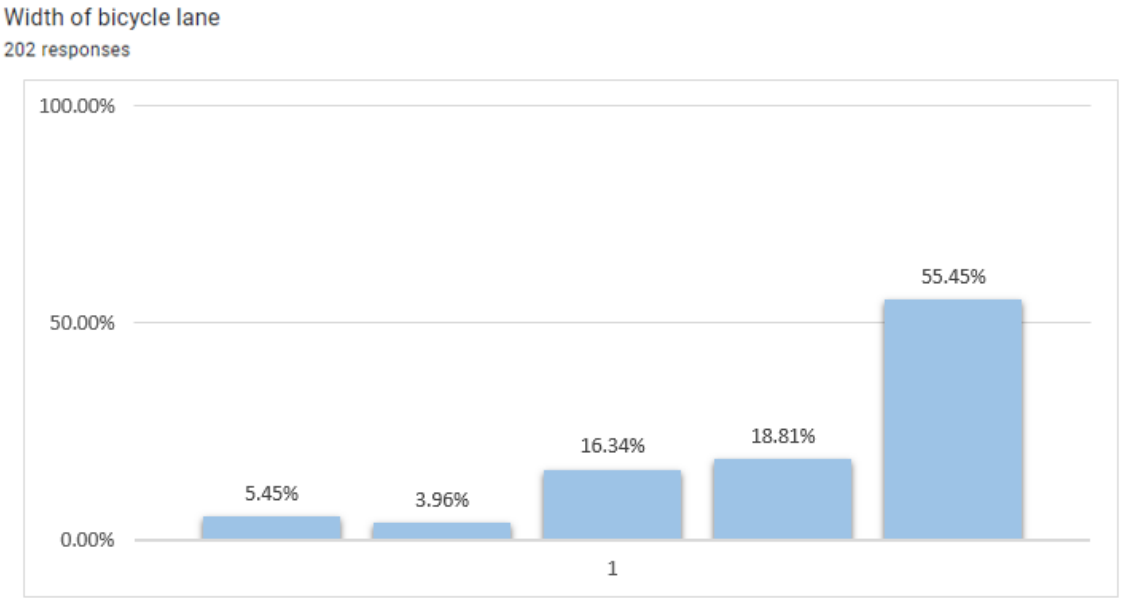


Chart 12: Influence of width of bicycle lane

5.3.2.3 Continuous bicycle lane

108 people out of 202 believed that continuity of the bicycle lane along the entire route has “very high influence” which is 53.5% of the total response obtained.

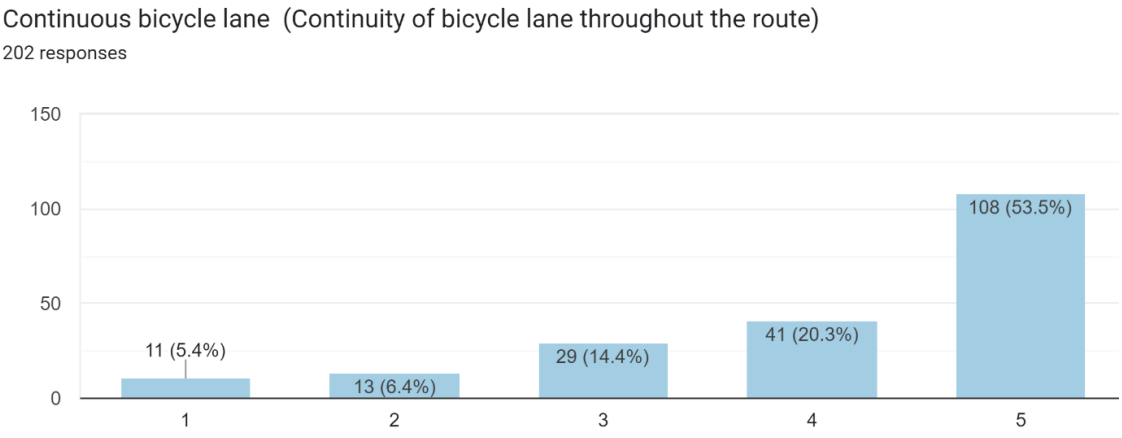


Chart 13: Influence of continuous bicycle lane

5.3.2.4 Separation of cycle lane from motorized traffic

58.4 percentage of total respondent thought that the separation of bicycle lane from the motorized traffic has very high influence on bikeability of the road. Whereas, only 3.5% believed it to have no influence on choice of cycling.

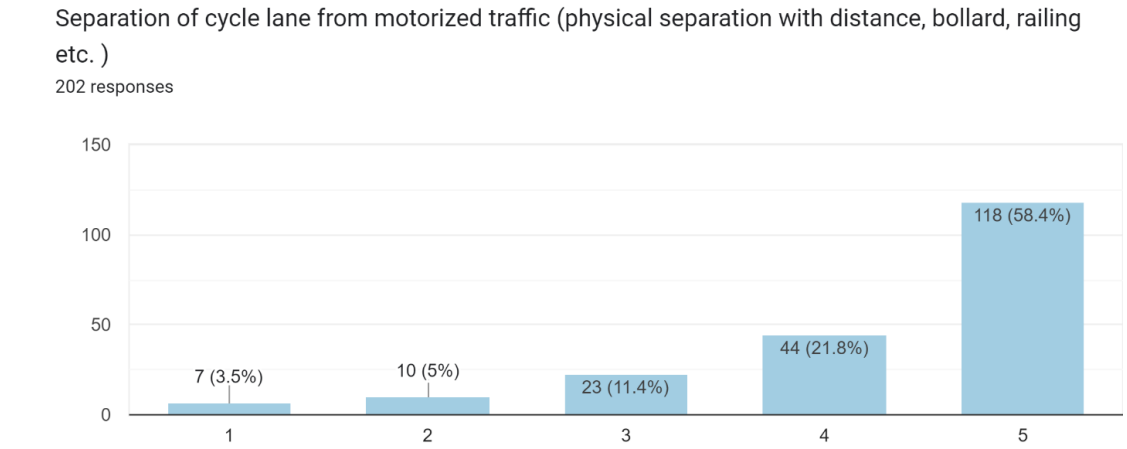


Chart 14: Influence of continuous bicycle lane

5.3.2.5 Speed of motorized vehicle traveling adjacent to the bicycle lane

Speed of motorized vehicle which is directly related to the safety of the cyclist is believed to have very high influence by 42.1% of total respondent follower by 23.8% be it to be have high influence in Likert scale response.

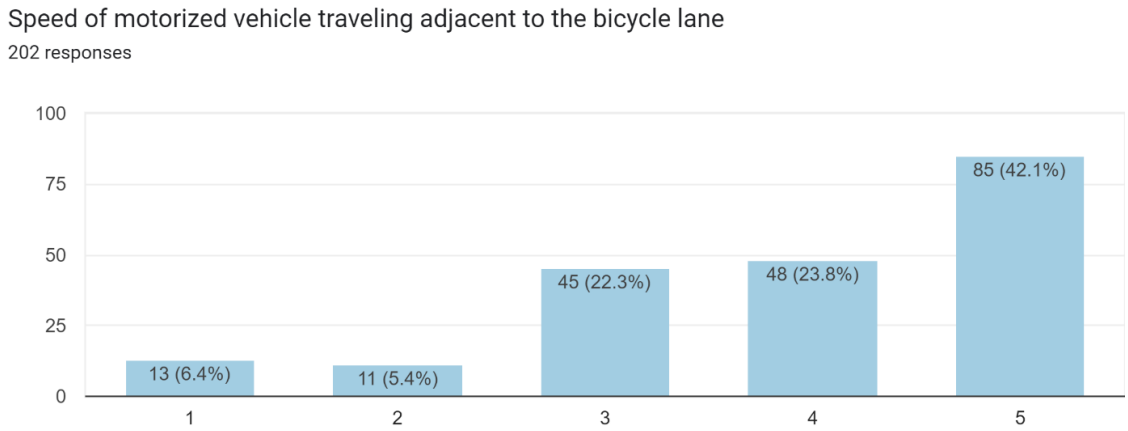


Chart 15: Influence of Speed of Motorized Vehicle

5.3.2.6 Bicycle related traffic signs and road markings

88 people thought that availability of proper signs and markings related to bicycle have very high influence on bikeability. Only 4% believed it not to have any influence.

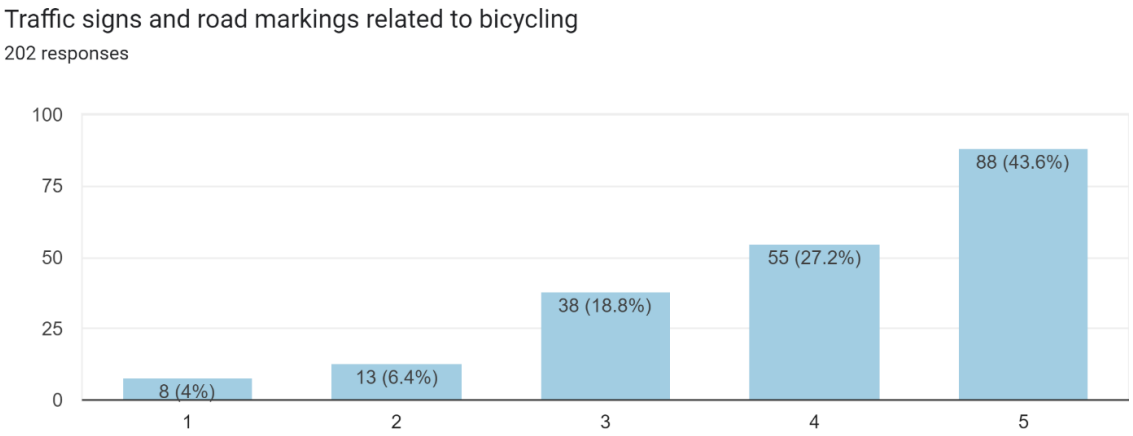


Chart 16: Influence of Traffic Signs and Markings

5.3.2.7 Bicycle activated intersections

Significant number of response were in favor of influential effect of bicycle activation in intersection with 44.1% voting it as having very high influence is obtained. Only 3.5 % people thought it was not necessary.

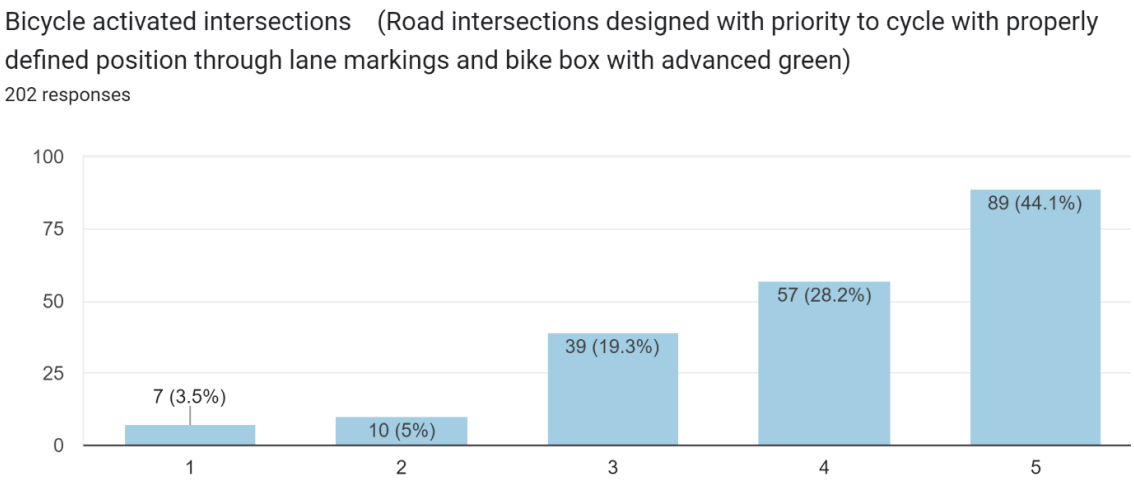


Chart 17 Influence of Bicycle Activated Lane

5.3.2.8 Connectivity

82 % respondent viewed the connectivity of existing route with other bicycle network to have very high influence on bikeability of the route whereas, 4% people considered it not important at all.

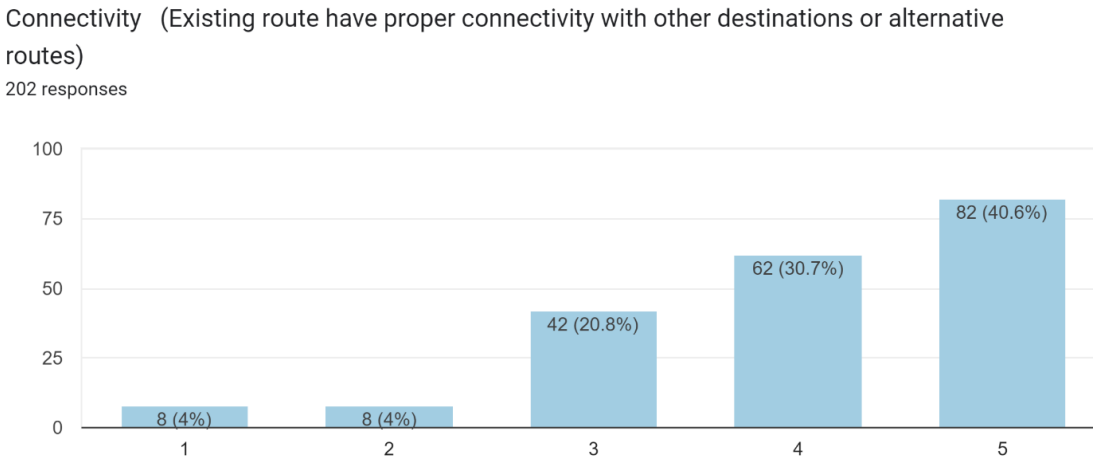


Chart 18: Influence of Connectivity

5.3.2.9 Availability of Bicycle Parking

Bicycle parking facilities which supports cyclist to park their bicycle safely is considered to have "very high influence" and "no influence" on bikeability by 82 and 14 people respectively out of 202 people.

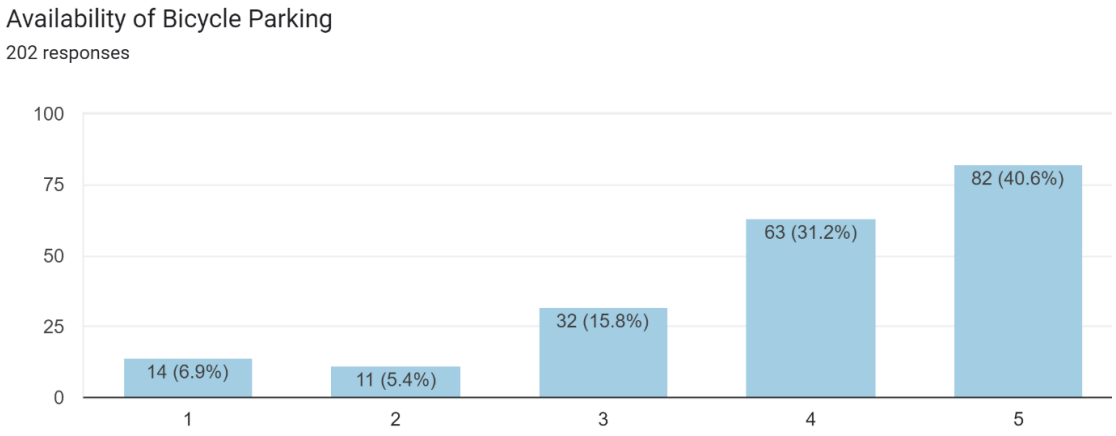


Chart 19: Influence of Bicycle Parking Facilities

5.3.2.10 Availability of Bicycle Repair workshops

37.1% of people believe that bicycle repair workshop along the route is must for ensuring high bikeability of road and voted for "very high influence" in the Likert scale. This was followed by 27.2% people who though it to be "influential" only.

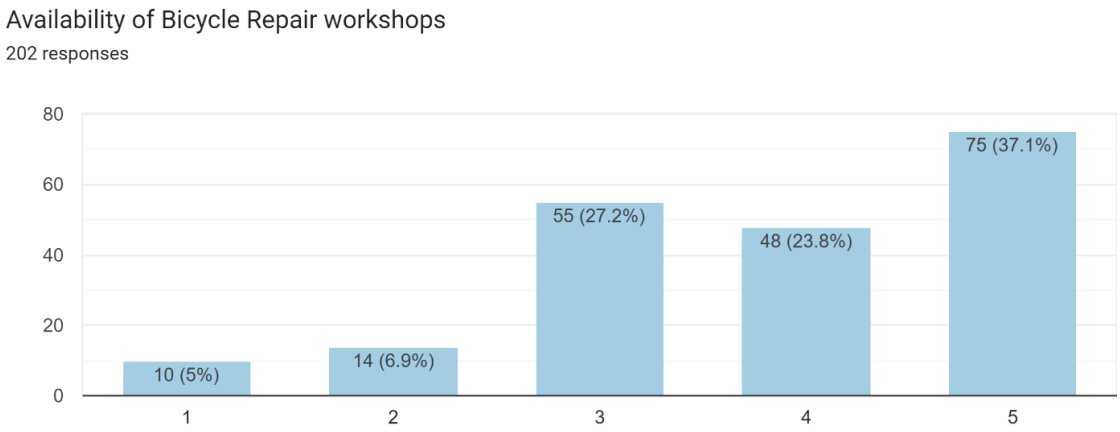


Chart 20: Influence of Bicycle Repair workshop

5.3.3 Surrounding

5.3.3.1 Mixed land use

36.6% people believed that land use has only "influential" role in bikeability. Just 17.8% people scored it to have "very high influence".

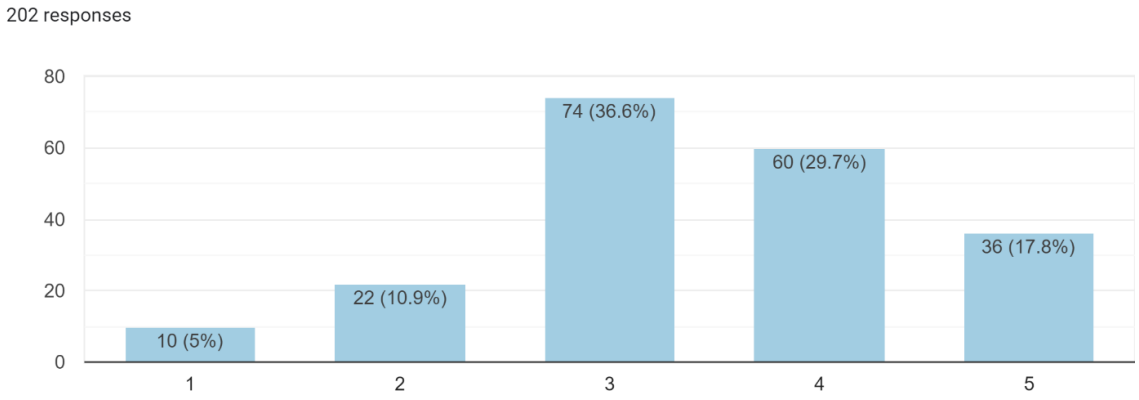


Chart 21: Influence of Land Use

5.3.3.2 Pollutions

Substantial amount of people believed pollution as important factor for bikeability. 31.7 % and 33.2% people scored it to have "very high influence" and "high influence" for making them choose cycling for commuting.

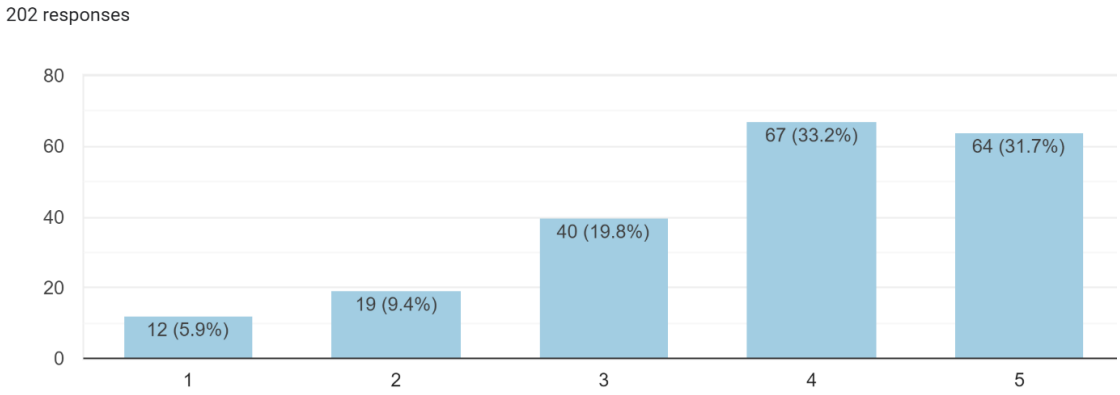


Chart 22: Influence of Pollution

5.3.3.3 Safety concerns/perception

Safety concern was considered an important factor and 52% people voted it to have "very high influence" in deciding the bikeability of a road. Only 4% voted it as having "no influence".

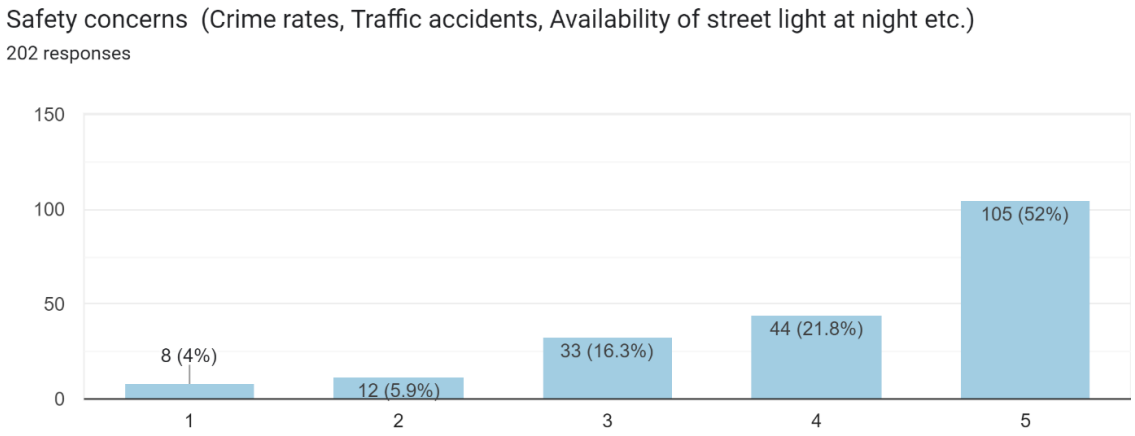


Chart 23: Influence of continuous bicycle lane

5.3.3.4 Obstruction in the routes

Various obstructions in the route was scored having "no influence" by only 4% of people. 29.2% score it as "very high influence" factor and 76 people voted it to have "high influence".

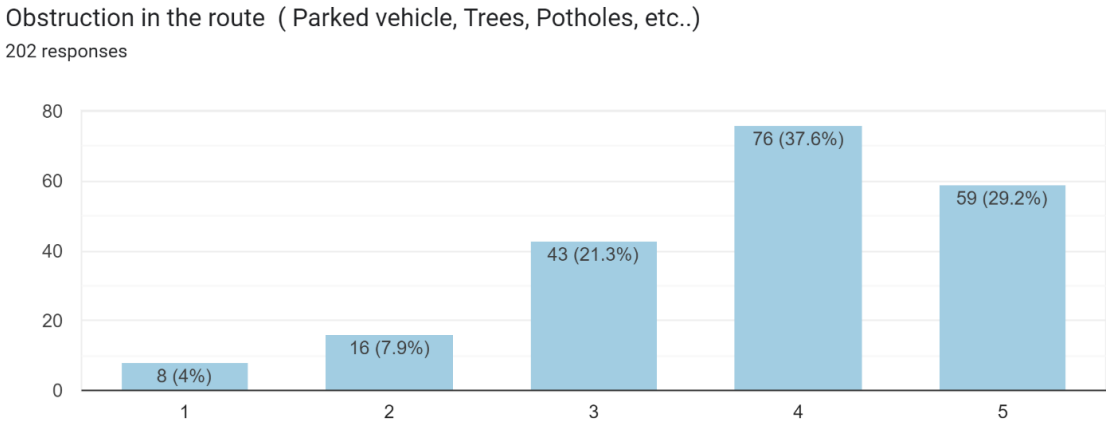


Chart 24: Influence of Obstruction

5.3.3.5 Maintenance

"High Influence" obtained the highest score with 37.1% response and "very high influence" received 33.7% response for the various obstructions present in the road.

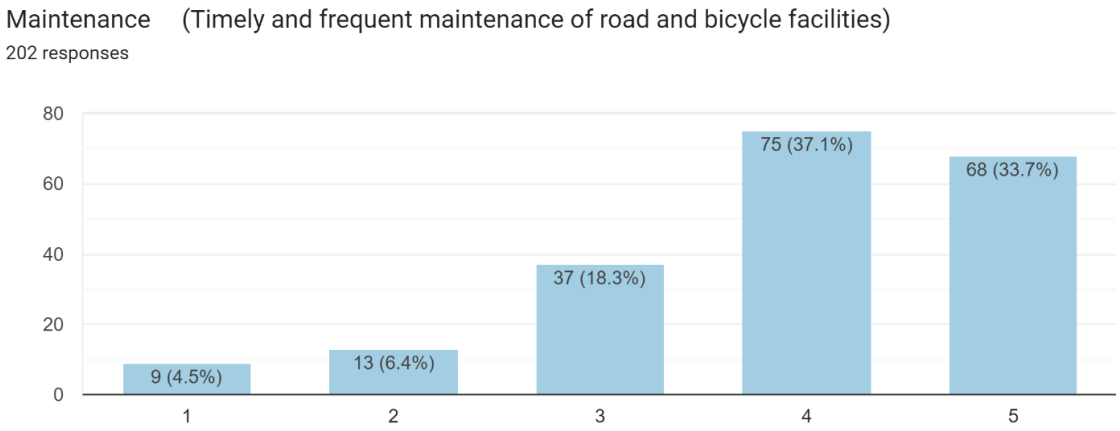


Chart 25: Influence of Maintenance

5.3.3.6 Aesthetic and green surrounding

Aesthetic and green surrounding received 32.7% response as "very high influence" but only 2.5% response in "no influence". Second highest response of 30.2% was for "moderate influence".

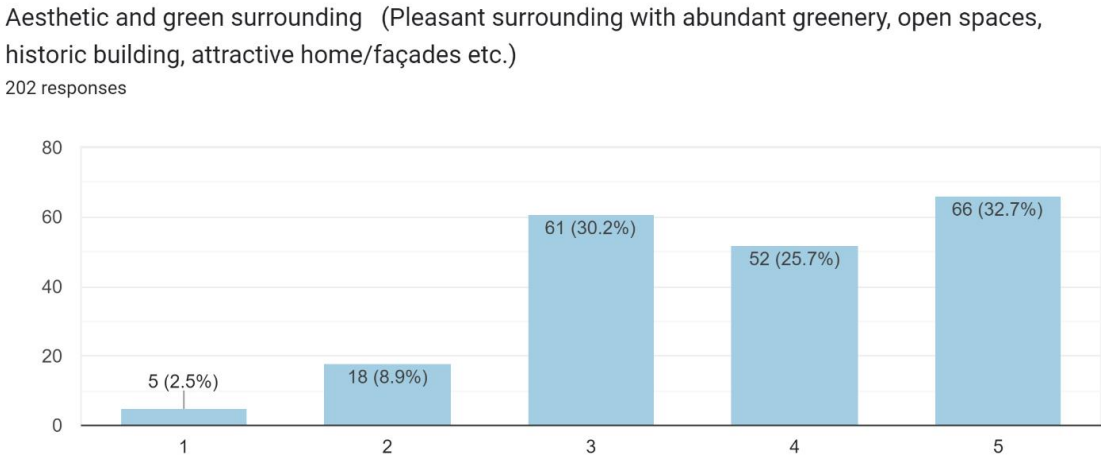


Chart 26: Influence of Aesthetic and Greenery

5.4 Indicator Analysis

Among the selected indicators all of the indicators were perceived by users as influential in some way. 90% of surveyed people responded the indicators influential at different level.

In natural precondition category, more people thought weather has high influence than the steepness of the slope.

Separation from the motorized vehicle and presence of bicycle lane was perceived as having very high influence in infrastructure and traffic category, whereas the presence of bicycle repair workshop was viewed to be less little lower influence.

In the surrounding category safety concern with low crime rate, accidents, streetlights were defined by users to have very high influence on the bikeability of the road.

Table 1: Built Environment Attribute's Influence (5 Points Likert Scale)

Attributes	Total response	No Influence	Limited Influence	Moderate Influence	High Influence	Very High Influence
NATURAL PRECONDITIONS						
Topography	202	4.95%	10.40%	31.68%	34.16%	18.81%
Weather	202	4.46%	5.94%	32.67%	25.25%	31.68%
INFRASTRUCTURES AND TRAFFIC						
Presence of bicycle lane	202	4.95%	4.46%	15.35%	17.82%	57.43%
Width of bicycle lane	202	5.45%	3.96%	16.34%	18.81%	55.45%
Continuity of bike lane	202	5.45%	6.44%	14.36%	20.30%	53.47%
Separation of cycle lane from motorized traffic	202	3.47%	4.95%	11.39%	21.78%	58.42%
Speed of motorized vehicle	202	6.44%	5.45%	22.28%	23.76%	42.08%
Bicycle related traffic sign and road markings	202	3.96%	6.44%	18.81%	27.23%	43.56%
Bicycle activated intersections	202	3.47%	4.95%	19.31%	28.22%	44.06%

Connectivity with other destination and alternative routes	202	3.96%	3.96%	20.79%	30.69%	40.59%
Presence of bicycle parking facility	202	6.93%	5.45%	15.84%	31.19%	40.59%
Presence of bicycle repair workshops	202	4.95%	6.93%	27.23%	23.76%	37.13%
SURROUNDINGS						
Mixed land use	202	4.95%	10.89%	36.63%	29.70%	17.82%
Pollution	202	5.94%	9.41%	19.80%	33.17%	31.68%
Safety concern	202	3.96%	5.94%	16.34%	21.78%	51.98%
Obstructions in the route	202	3.96%	7.92%	21.29%	37.62%	29.21%
Maintenance	202	4.46%	6.44%	18.32%	37.13%	33.66%
Aesthetic and green surrounding	202	2.48%	8.91%	30.20%	25.74%	32.67%

In order to rank the importance of above attributes, the response of the people is analyzed and influencing value will be calculated for each attribute. For this purpose, "no influence" will be given weight of 0% and "very high influence" will be given 100% weight. For responses in between, step value is calculated and assigned accordingly.

Following table shows the calculated influence value of each attributes:

Table 2: Overall Influence Value of Built Environment Attributes

Attributes	Overall influence value (0-1) scale
NATURAL PRECONDITIONS	
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 cycle lane from motorized traffic	0.82
Speed of motorized vehicle	0.72
Bicycle related traffic sign and road markings	0.75
Bicycle activated intersections	0.76
Connectivity with other destination and alternative routes	0.75
Presence of bicycle parking facility	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

From the above table we can see that, the infrastructures such as separation of cycle lane from the motorized vehicle scored the highest and signifies that this has very high influence on bikeability of the urban road. This is followed by presence of bicycle lane, with of bicycle lane and continuity of the lane. Mixed land use and topography scored the least and hence are the attributes that least affects the bikeability of the street among the attributes mentioned above.

5.5 Criteria for Bikeability Analysis

The bikeability of street stretch is analyzed on the basis of the above identified attributes. Criteria for the analysis of each attribute has been identified through literature review and is summarized in the table below:

Table 3: Bikeability Assessment Criteria

Attributes	**High Bikeability Conditions**	**Low Bikeability Condition**	**Primary Source of Assessment**	**References**
Natural conditions				
Topography	relatively flat landscape with slope <3%	presence of steep slope > 5%	**Map study, Field study**	AASHTO Guideline
Weather	Average temperature around 25 degrees Celsius , Humidity: *(52.3%–62.7%), Relatively* stable/predicatable weather condition with low precipitation	Very high or low temperature, High humidity and unpredictable weather conditions	**Document studies, Department of Hydrology and Meteorology**	(Meng et al., 2016), (Richardson (2000), (Ahmed et al., 2010) (Phung & Rose, 2007)
Infrastructure and traffic				
Presence of bicycle lane	Presence of bicycle lane	Bicycle lane not available	**Field study**	(Ghekiere et al., 2015), (Mertens et al., 2014)
Bicycle lane width	≥ 2m for one way lane	<1.4m for one way lane	**Field study**	(Arellana et al., 2020) (NURS 2076)

Continuity of bicycle lane	Bicycle lane continuity along the entire route	Disconnected bicycle lane along the route		(Hagen & Rynning, 2021)
Separation of cycle lane from motorized traffic	Proper separation of cycle lane from motorized traffic through use of bollards, island etc for improved cyclist safety	No/ separation of bicycle lane from	**Field study**	(Winters et al., 2013), (Ghekiere et al., 2015), (Mertens et al., 2014)
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	**Field study**	(Schmid-Querg et al., 2021, Hagen & Rynning, 2021), (Pucher & Buehler, 2017)
Bicycle related traffic signage and road marking	Proper road sign and road marking for cyclist	Lack of road signs and road marking for cyclist for safe travel and convenient way findings	**Field study**	(Hagen & Rynning, 2021)
Bicycle activated intersections	Intersection designed with priority to cycle with properly defined position through lane	Intersections with high priority to motorized vehicles	**Field study**	(Casello et al., 2017) (Hagen &

	markings and bike box with advanced green			Rynning, 2021)
Connectivity	well connected cycling network with alternative routes	No connection with other street with bicycle facilities for alternative routes	**Map study, Field Study**	(Merten et al., 2016) (Hagen & Rynning, 2021)
Bicycle facilities	Sufficient availability of bicycle parking and repair centers	Functional bicycle facilities not available	**Field Study**	(Hagen & Rynning, 2021)
Surrounding				
Land use along the street	mixed land use providing variety of options for multiple of activities and destination choices for the cyclist	Land use without variety of options for multiple of activities and destination choices for the cyclist	**Map study and Field study**	(Hagen & Rynning, 2021), (Chen et al., 2017)(Christiansen et al., 2016)
Pollution	No/Limited amount of pollution in the street	Highly polluted environment and litters in the street	**Field work**	(Merten et al., 2016), *(Winters et al., 2013)*
Perceived safety	Low crime rate, traffic and non-traffic accident, Availability of street	High crime rate, traffic and non-traffic accident. street light not	**Document study, Field visit**	(Hagen & Rynning, 2021), (Ma et al., 2017)

	light at evening and night	available from evening and night		
Maintenance	High focus on maintenance of the cycle related infrastructures	Extremely low focus on maintenance of the cycle related infrastructures	**Field Study**	(Ma et al., 2017)**,** (Hagen & Rynning, 2021)
Aesthetic and green surrounding	Pleasant surrounding with abundant greenery, open spaces, historic building	motorized vehicle oriented environment with no open spaces, greenery and pleasant surrounding	**Field study**	*(Chen et al., 2017),* (Merten et al., 2016), (Christiansen et al., 2016)

5.6 Analysis of Kupondole-Jawalakhel-Lagankhel Road Stretch

For the purpose of analysis, the street is divided into 3 section:

1. Kupondole to Pulchok
2. Pulchok to Jawalakhel
3. Jawalakhel to Lagankhel

Based on defined attributes of the built environment, each street stretch is classified into "Highly Bikeable", "Bikeable" and, "Less Bikeable "

5.6.1 Section 1: Kupondole – Hariharbhawan

5.6.1.1 Natural Precondition

Topography:

Topography wise the section of the road from Kupondole to Pulchok constitutes of steep slopes in at certain portion. The maximum slope goes more than 12%, which is much higher than the 5% slope and is physically challenging to bicycle user. For adventure, purpose this level of slope would not be of big deal, but for daily commuting this slope makes it harder for the cyclist to pedal. Hence, from the topography this stretch "*Bikeable*".

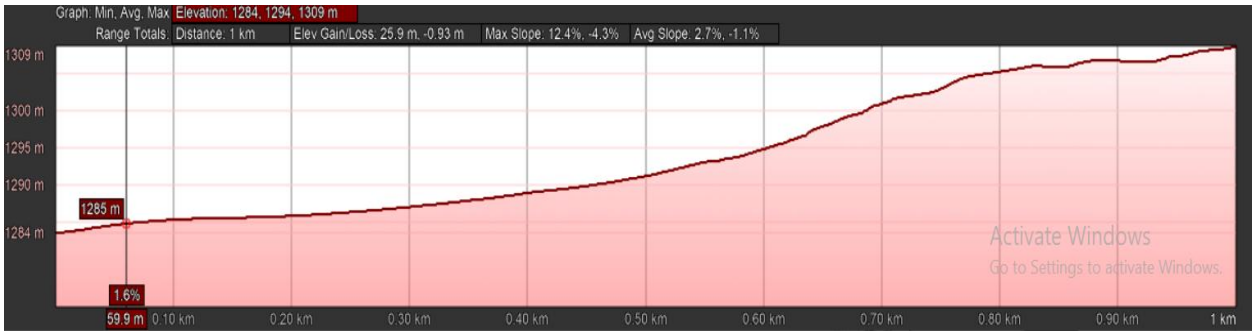


Figure 10: Section 1 road elevation profile

Weather:

According to the 7 years' weather history data from Department of Hydrology and Meteorology, we can see that the pattern of precipitation in the valley is relatively consistent. Precipitation is relatively higher is the month from June to October. In the remaining months, the precipitation is relatively low.

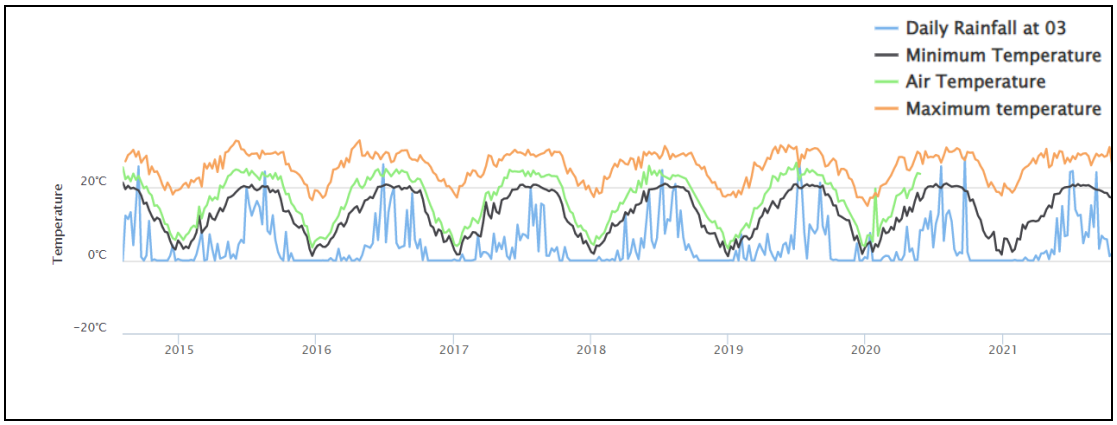


Figure 11: 7 year weather history of Kathmandu

source: http://www.mfd.gov.np/city?id=31.

Temperature of Kathmandu valley is also relatively stable with the maximum average temperature ranging between approx. 30 degrees Celsius to 15 degrees Celsius. As per literature review average temperature of 25 is an ideal temperature for cycling.

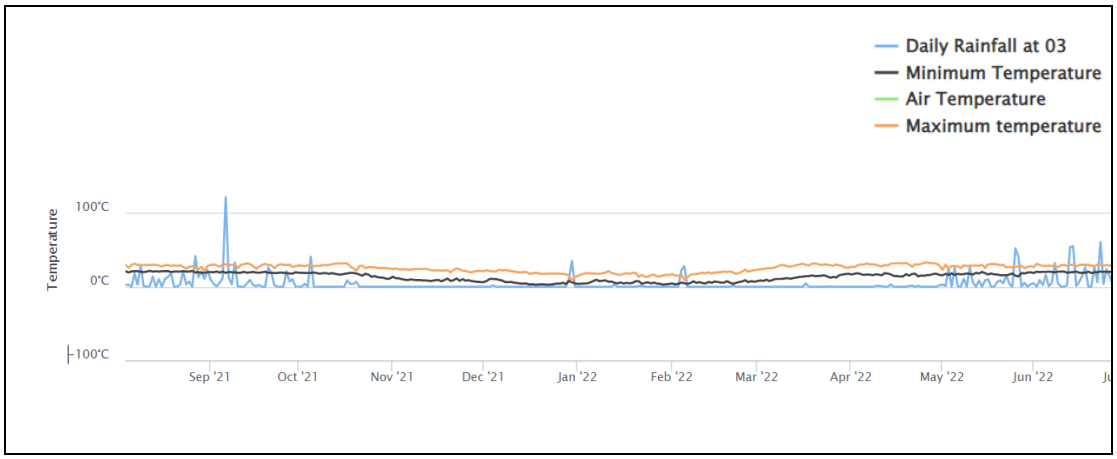


Figure 12: Annual weather report of Kathmandu

source: http://www.mfd.gov.np/city?id=31

Average relative humidity relative humidity of Kathmandu valley is relatively higher than what is favorable for cycling. Below illustration shows that the maximum humidity 85% with average relative humidity more than 70% in all nine months of the year

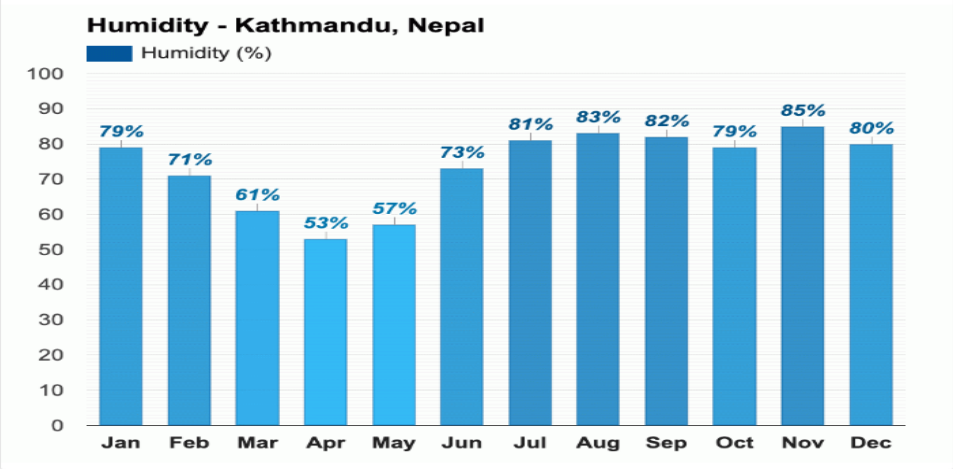


Figure 13: Kathmandu annual humidity record 2022

Source: weather-atlas.com

So, weather of Kathmandu is relatively predictable and stable with temperature suitable in most of the months of the year. Hence, it is "*Bikeable*"

5.6.1.2 Infrastructure and traffic

Presence of bicycle lane:

Bicycle lane is available in both side of the road. This has been done by painting green and providing the road marking of bicycle lane along the two edge of the black topped. This makes the route "*Highly Bikeable*"

Figure 14: Shared bicycle lane

Continuous bicycle lane

Along the entire route the three is continuous bicycle lane. But beyond the Kupondole in the northern side, the main road does not have cycle lane. The existing cycle starts out of nowhere in the middle section of street. Hence, the road on this respect is only "*Bikeable*"

Separation of cycle lane from motorized traffic

Since the entire lane along the route only has shared cycle lane, there is no specific provision of separation from motorized vehicle. Traffic island or just bollards could have separated the lane from the motorized vehicles. Lack of any of these means the route is only "*Less Bikeable* "

Speed of motorized vehicle traveling adjacent to the bicycle lane

No specific speed limit has been assigned in the route. Field study conducted by driving own motorized vehicle shows that the average driving speed exceeds 30 km/hr when the road is less busy and below 30km/hr when the road is busy. This make the road "*Less Bikeable* "

Bicycle related Traffic signs and road markings

Traffic sign of bicycle lane is provided in the regular interval along the stretch. But, the only sign related to bicycle available is the informative traffic sign of cycle lane and cycle lane road markings. Hence on this basis the section is "*Bikeable*".

Figure 15: Traffic sign of bicycle lane

Bicycle activated intersections

Intersection along the route does not seem highly bicycle friendly. In total 6 intersection lies along the stretch. But it is characterized by only the availability of green painted bicycle lane road marking. There is also no provision of bike box and advance green for the cyclists. This makes the road section "*Bikeable*".

Connectivity

The main route have access to multiple of minor roads and has got intersection. However, none of them have bicycle-activated infrastructure. Hence from this point of view the road is just "*Less Bikeable* "

Figure 16: No connectivity with the alternative route

Availability of bicycle parking facility

No bicycle parking facilities are available in the entire section or in the proximity of section. So the route is "*Less Bikeable* ".

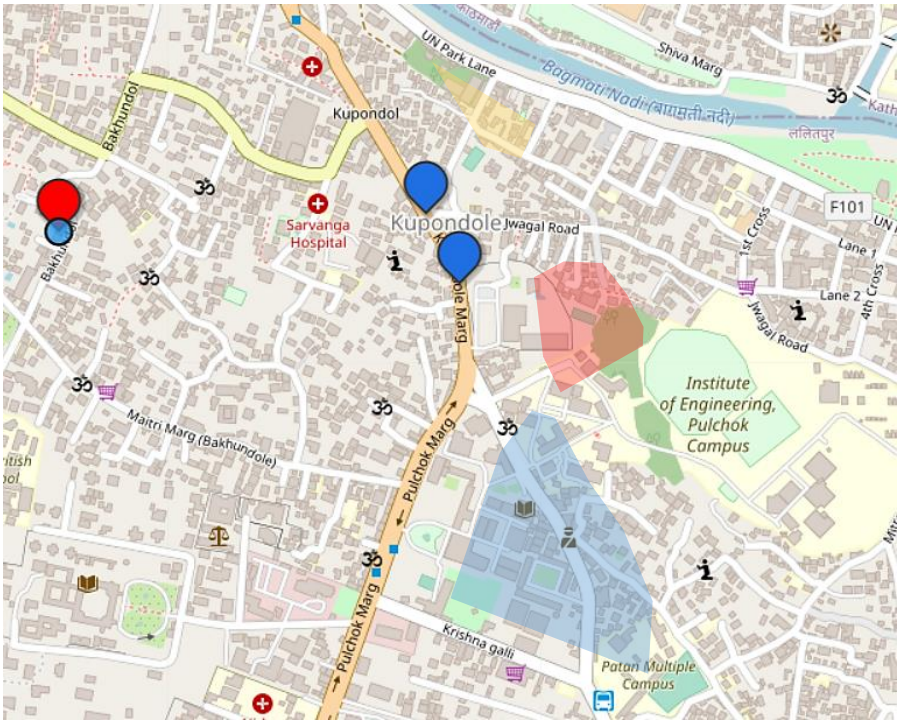
Availability of bicycle repair workshops

No bicycle parking facilities are available in the entire section or in the proximity of section. Therefore, the route is "*Less Bikeable* ".

5.6.1.3 Surrounding

Land use

The surrounding entire section has mixed land use. This varies from markets, hotels, banks to educational institutes. The residential areas are also in accessible distance for the road. Hence, on this basis, the section is "*Highly Bikeable*"



Map 2: Kupondole-Hariharbhawan Road Land Use

Pollutions

High amount of litters is not found in the street. But the motorized traffic volume created the considerable noise pollution. Hence, it is "*Bikeable*"

Safety concerns/perception

Data obtained from District Police Office, Jawalkhel, and shows that there is no incidence of any kind of crimes along or in the proximity of the route. As for the traffic accidents, Traffic Police Office, Jawalakhel informed that there were 43 traffic accident cases in Harihar Bhawana area, 16 in Inarchok and 50 in Kupondole area. But none of

the cases where reported as fatal or severely injured. Streets lights area available along the entire route making the evening time cycling safe.

Hence, the road is "*Bikeable*" from safety perspective

Figure 17: Lamp post with CC camera installed

Obstruction in the routes

No obstruction along the route due to the permanent structures such as trees, trees roots, electric poles etc. But the culture of parking motorized vehicle in the cycle lane, picking and dropping passenger in places other than bus stop creates substantial obstruction while cycling in the lane along the section. This makes the section "*Less Bikeable*".

Maintenance

As observed from the field, painted cycle lane has not been maintained properly. The green paint, which is the only way to identify the cycle lane has already faded and peeled away. This shows the maintenance of the schedule to be very poor. Hence, the road is "*Less Bikeable*" from this perspective.

Figure 18: Poor maintenance of bicyle lane marking

Aesthetic and green surrounding

Presence of limited open spaces along the road makes the stretch less appealing. The buildings along the road are all modern buildings, so they do not carry any historic significance or beauty. Plants have been planted along the road, but these are not in enough number to make it visual. Although Pulchok campus area along the road provides the greenery and aesthetic environment at some level but the coverage of campus parallel to the road is minimum. Hence, the road stretch is only "*Bikeable*".

Figure 19: Greenery along the route

5.6.2 Section 2: Hariharbhawan – Jawalakhel

5.6.2.1 Natural Precondition

Topography:

In the total length of 1 km, this road stretch constitutes of steep slopes with maximum slope more than 8%. However, it also constitutes of relatively flat terrain in 3/10th portion of the stretch. Hence, from the topography this stretch "*Bikeable*".

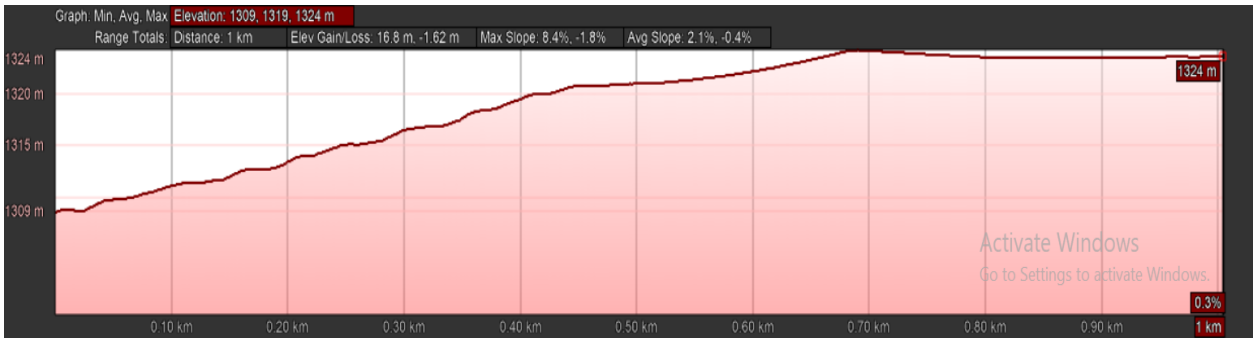


Figure 20: Section 2 road elevation profile

Weather:

Weather condition analyzed in the street section 1 is overall weather condition of Kathmandu valley so, this stretch of is also "*Bikeable*" as the previous.

5.6.2.2 Infrastructure and traffic

Presence of bicycle lane

Bicycle lane is available in both side of the road. This has been done by painting green and providing the road marking of bicycle lane along the two edge of the black topped. This makes the route "*Very Bikeable*"

Continuous bicycle lane

Along the entire route there is continuous bicycle lane in the both side of the road. Hence this road section is "*Highly Bikeable*"

Separation of cycle lane from motorized traffic

Since the entire lane along the route only has shared cycle lane, there is no specific provision of separation from motorized vehicle. Traffic island or just bollards could have separated the lane from the motorized vehicles. Lack of any of these means the route is only "*Less Bikeable* "

Speed of motorized vehicle traveling adjacent to the bicycle lane

No specific speed limit has been assigned in this section the road. Field study conducted by driving own motorized vehicle shows that the average driving speed exceeds 30 km/hr. This make the road "*Less Bikeable* "

Bicycle related Traffic signs and road markings

Traffic sign of bicycle lane is provided in the regular interval along the stretch. But, the only sign related to bicycle available is the informative traffic sign of cycle lane and cycle lane road markings. On this basis the section is "*Bikeable*".

Bicycle activated intersections

Intersection along the route is better than other stretches. Two major junction has even provision of bike box, painted with green paint. Nevertheless, due to the lack of information with traffic police and road users it is not being properly used. This makes the road section "*Bikeable*".

Figure 21: Intersection with Bike Box

Connectivity

This route has connection with other routes of bicycle network from 2 major junctions along the route. Hence, this road stretch is "*Bikeable*"

Availability of bicycle parking facility

Only one place in whole route is allocated as bicycle parking station. Permanent bicycle parking has been constructed in front of LMC office. Available open space along the road, which is currently being used as parking space is overwhelmed by motor bikes and also lacks the infrastructure to park bicycle. So, the route is "*Less Bikeable* " in this perspective.

Figure 22: Permanent bicycle parking facility

Availability of bicycle repair workshops

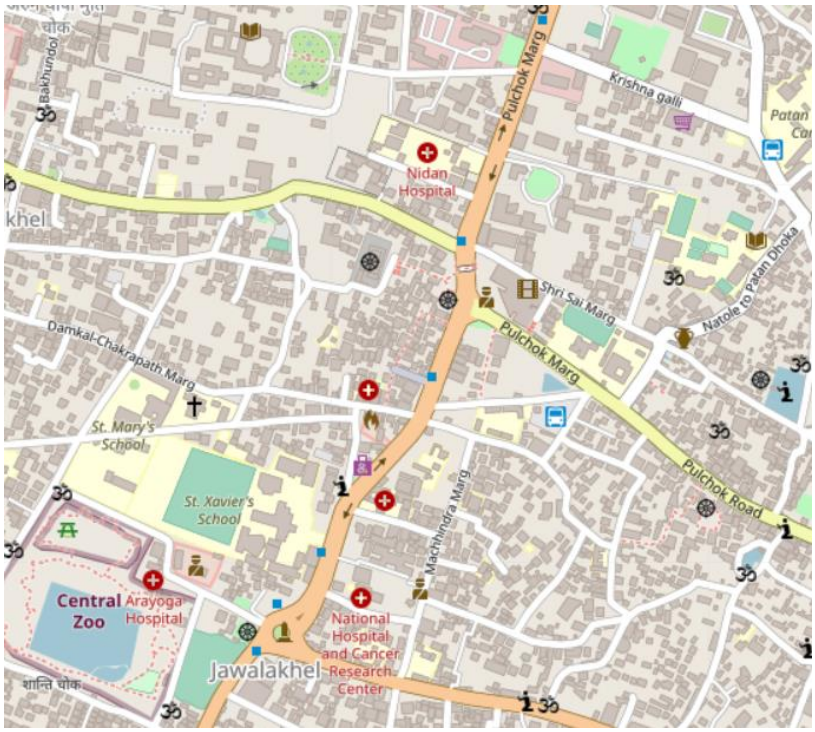
Two bicycle repair workshop, one available in the route and another in the proximity of the route area available. Since the stretch is only one-kilometer-long, these workshops caters some level of the needs of the cyclist. So, the route is "*Highly Bikeable*".

Figure 23: Bicycle repair workshops along the route

5.6.2.3 Surrounding

Land use

The surrounding entire section has mixed land use. This varies from markets, hotels, banks and government institutions as well as recreational area i.e. zoo. There are also open spaces along the route to take rest and spend time. The residential areas are also in accessible distance for the road. Hence, on this basis, the section is "*Highly Bikeable*".



Map 3: Hariharbhawan – Jawalakhel Land use

Pollutions

Large amount of litters is not found in the street. But, the motorized traffic volume created the considerable noise pollution. So categorized as *"Bikeable"*

Safety concerns/perception

Data obtained from District Police Office, Jawalkhel, and shows that there is no incidence of any kind of crimes along or in the proximity of the route. As for the traffic accidents, Traffic Police Office, Jawalakhel informed that there were 47 traffic accident cases in Pulchok area and 85 in Jawalakhel area. But none of the cases where reported as fatal or severely injured. Streets lights as well as CC camera are installed along the entire route making the evening time cycling safe. Hence, the road is " *Bikeable*" from safety perspective.

Obstruction in the routes

No obstruction along the route due to the permanent structures such as trees, trees roots, electric poles etc. However, the culture of parking motorized vehicle in the cycle lane, picking and dropping passenger in places other than bus stop creates substantial obstruction while cycling in the lane along the section. This makes the section "*Less Bikeable* ".

Figure 24: Motorized vehicles creating obstruction in cycle lane

Maintenance

In this section, too painted cycle lane has not been maintained properly. The green paint, which is the only way to identify the cycle lane has already faded and peeled away. This shows the maintenance of the schedule to be very poor and have not been prioritized. Hence, the road is "*Less Bikeable*" from this perspective.

Figure 25: Damaged cycle lane road marking

Aesthetic and green surrounding

There are couple of open spaces with arrangements for sitting along the route. One is in front of LMC office premise and another in Jawalakhel road. Small plants are present along the road. But, the façade of the building along the route are not highly appealing for strolling around. Hence, the road stretch is only "*Bikeable*"

Figure 26: Open Space and Park in Jawalakhel and Pulchok

5.6.3 Section 3: Jawalakhel -Lagankhel

5.6.3.1 Natural Precondition

Topography:

Jawalakhel-Lagankhel stretch has a flat terrain with maximum slope not exceeding more than 3 %. Hence from the topographical point of view this stretch "*Highly Bikeable*".

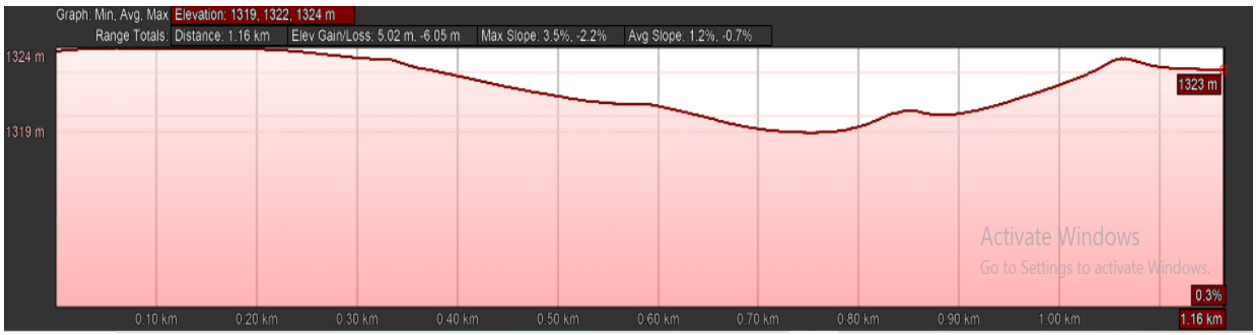


Figure 27: Section 3 road elevation profile

Weather:

Weather condition analyzed in the street section 1 is overall weather condition of Kathmandu valley so, this stretch of is also "*Bikeable*" as the previous.

5.6.3.2 Infrastructure and traffic

Presence of bicycle lane

Bicycle lane is available in only one side of the road. Another side of road is used for parking. This makes the route "*Bikeable*" only.

Figure 28: Bicyle lane in one side only

Along the entire route, there is continuous bicycle lane except after Patan hospital. After crossing Patan hospital junction there is no bicycle lane upto the Lagankhel that again continues after Lagankhel chok. Hence, this road section is "*Bikeable*" only.

Separation of cycle lane from motorized traffic

Since the entire lane along the route only has shared cycle lane, there is no specific provision of separation from motorized vehicle. Traffic island or just bollards could have separated the lane from the motorized vehicles. Lack of any of these means the route is only "*Less Bikeable* "

Speed of motorized vehicle traveling adjacent to the bicycle lane

No specific speed limit has been assigned in this section the road. Field study conducted by driving own motorized vehicle shows that the average driving speed exceeds 30 km/hr when the traffic volume is low. This make the road "*Less Bikeable* "

Bicycle related Traffic signs and road markings

Traffic sign of bicycle lane is provided in the regular interval along the stretch. But, the only sign related to bicycle available is the informative traffic sign of cycle lane and cycle lane road markings. Further, the traffic signs for bus stops overlaps with the cycle lane which creates conflict between cycle and other vehicles. Hence, on this basis the section is "*Bikeable*".

Bicycle activated intersections

Intersection along the route does not seem highly bicycle friendly. No special provision has or priority has been provided to the cycle user such as provision of bike box and advance green for the cyclists. This makes the road section “Less Bikeable ".

Figure 29: Intersection at Kumaripati chok

Connectivity

There are roads connected with the route to provide alternative path but none of these roads are provided with bicycle lane or bicycle prioritized traffic signs. So, there is no connectivity with bicycle network and the road is only "*Less Bikeable* "

Availability of bicycle parking facility

No bicycle parking facilities are available in the entire section or in the proximity of section. Location allocated by LMC as bicycle parking with traffic sign does not have suitable space available for bicycle parking So, the route is "*Less Bikeable* " in this perspective.

Figure 30: Designated Bicycle parking point

Availability of bicycle repair workshops

No bicycle repair workshop is available in the entire section. So the route is “Less Bikeable ".

5.6.3.3 Surrounding

Land use

The surrounding along the route provide some level of diversity for the destination to the people. Patan Hospital, one of the reputed hospital lies in the route. It also consists of Lagankhel Bus Park, which is important to catch public vehicle to travel to other location Kathmandu valley. It also has various institutional buildings such as Nepal telecom in the proximity of the route. It is also connected with route that reaches to Patan Durbar Square, a world heritage site and its historic residential area. There is no provision of open space along the route. Most of the area is "*Bikeable*"

Pollutions

Substantial amount of trashes is not found in the street. However, the motorized traffic volume created the considerable noise pollution. Therefore, the route is "*Bikeable*"

Safety concerns/perception

Data obtained from District Police Office, Jawalakhel, and shows that there are some incidence of crimes along or in the proximity of the route as the road is consist on bust park area. Streets lights are installed along the entire route making the evening time cycling safe and easy. Hence, the road is " *Bikeable*" from safety perspective.

Obstruction in the routes

No obstruction along the route due to the permanent structures such as trees, trees roots, electric poles etc. But the culture of parking motorized vehicle in the cycle lane, picking and dropping passenger in places other than bus stop creates substantial obstruction while cycling in the lane along the section. This makes the section "*Less Bikeable* ".

Figure 31: Motorized vehicle parked in the bicycle lane

Maintenance

Painted cycle lane has not been maintained properly. The green paint, which is the only way to identify the cycle lane has already faded and peeled away. This shows the maintenance of the schedule to be very poor. Hence, the road is "*Less Bikeable* " from this perspective.

Aesthetic and green surrounding

No open spaces are present along the road. Plants have been planted along the road, but these are not in enough number and height to make it highly visual. The buildings along the road are all modern buildings, so they do not carry any historic significance or beauty. The architecture and façade of the building are monotonous. Hence, the road stretch is highly unappealing from aesthetic point of view and is categorized as "*Less Bikeable* ".

CHAPTER 6: DISCUSSION

The discussion of the research is done according to the objective set forth for the study:

6.1 Existing policies and practices review

After reviewing multiple national-level documents, most of the documents support the promotion of cycling in some way. However, not a single document that is completely dedicated to bicycles could be found. As early as 2007, the Periodic Plan, one of the major national planning documents, recognized the need to promote bicycle culture. The current 15th periodic plan has up-scaled the approach and has mentioned multi-sector coordination for bicycle lane establishment. The Nepal Urban Road Standard is the only dedicated guiding document for establishing the bicycle-related infrastructure that currently exists. Even though the NURS has defined some principles such as no obstacles in the lane, continuity while driving, need for shade and light, etc., it fails to provide detailed technical specifications of the bicycle related infrastructure. Related to geometric design, only the width of the lane has been defined in the documents. A municipal-level document prepared by Lalitpur Metropolitan City in 2019 attempted to establish the standard for bicycle infrastructure but was only able to provide the design of parking facilities and a shared lane network plan. Despite its study and plan for establishing the complete bicycle network within the municipality, LMC has not been able to do that accordingly yet. When compared to the geometric design guiding document in the international context, i.e., "AASHTO Guide for the Development of Bicycle Facilities", there seems to be a need for significant improvement and addition of the contents, such as road markings, intersection design consideration, traffic signage, clear definition of different kinds of cycle lanes, speed limits, required grade maintenance and operation, etc., in our national documents. Aside from these, bicycle promotion through training programs and awareness campaigns has been completely ignored in the context of Nepal, despite being some of the most prioritized activities in cities such as Amsterdam.

6.2 Identify the built environment's attributes contributing to bikeability and undertake assessment

Built environment attributes related to infrastructure and traffic were found to have the highest influence level on the bikeability of an urban road. Separation from motorized transport and the presence of a bicycle lane itself were the most influential attributes. Besides these, safety concerns were also found to have a high level of influence. Even though the mixed land use of the city was considered to be an important factor in rendering cities like Amsterdam highly bikeable, its influence was found to be the lowest among the analyzed attributes in Kathmandu. This might be because the cycling culture in Kathmandu is still in a nascent stage and lacks even the minimum infrastructure such as cycle lanes, road markings, and bicycle-activated intersections. Therefore, society might not have reached the stage of appreciating factors related to the environment and aesthetics.

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. Even though the natural conditions were not highly favorable, they were not too discouraging either. Concerns about safety, which were also perceived to have a high influence on bikeability, were found to be satisfactory. This was because of the lower incidence of severe accidents, low crime rates, and the presence of streetlights 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 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 workshops 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. However, when asked for the reason for not using bicycles, 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. In addition, 13% responded that it was time-consuming. Personal reasons, such cycling is considered a hectic mode and lack of riding skills prevails among the people, as 8% confessed not having any riding skills. Furthermore, people may have been unable or difficult to use bicycles due to factors such as age or other physical disabilities and limitations. 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.

6.3 Recommend the strategies to promote urban cycling in context of Kathmandu

On the basis of information acquired from the study, a number of recommendations are proposed. First, immediate recommendations related to the existing infrastructure and facilities are proposed, which will enhance the bikeability of the existing road. General recommendations are provided, which are followed by policy recommendations that will support and promote the bicycling culture in the long term.

6.3.1 Immediate Recommendations:

The study has concluded a list of built environment attributes that dictate the bikeability of urban roads and their influence levels. The most influential attributes of the built environment for enhancing bikeability are mostly related to the infrastructure and traffic, followed by surrounding conditions and natural preconditions. From the assessment of the study area, we also found out that the condition of these attributes is not satisfactory. Hence, improvements to these attributes must be taken into consideration according to their influence level and existing situation. Even though there is availability of the cycle lane, due to poor maintenance, it is almost not visible 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. The cycle lane width provided was only 1.2 meters. 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 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 very limited 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. Alternative routes also help bicycle users avoid particular routes with traffic jams, temporary obstacles or hard terrain. The intersection should be designed such that it would be more favorable and safe for bicycle users. Advanced green and a bike box should be provided in the road intersection along the bicycle route. Furthermore, aesthetics and greenery should be promoted along the route as is done along the road. Municipal authorities should implement strong regulations to discourage actions such as parking by motorized vehicles and passengers picking and dropping off public vehicles in the cycle lane. These actions will enhance the bikeability of the urban roads and, hence, make it more appealing to use a bicycle.

6.3.2 General Recommendations

- Promotion of bicycles as a sustainable option from a personal health, environmental and economic perspective should be done. Awareness campaigns should be organized to disseminate the benefits of cycling among the people. Use of influential personnel such as celebrities and political leaders could upscale the influence of an awareness campaign. This can also help to remove people's underlying false perception of the bicycle as a socially inferior mode of transportation.
- The study found the fact of the limited availability of bicycle workshops. Government action on this matter can bring positive change and ensure enough workshops are in operation. Provision of incentives and other facilitation, i.e.,

training courses for producing repair mechanics, could be initiated by the government.

- School-based training should be provided. This will equip the future generation with bicycle riding skills and increase the use of bicycles in the future.
- E-bikes should be promoted so that people of old age or physical disabilities can also use them regardless of their limitations. This could be done through partial or complete custom duty exemption and by promoting e-bike manufacturing industries.
- While preparing plans related to bicycle promotion and the design of roads, inclusive participation should be ensured. Inclusive participation helps to bring forward the issues faced by different groups in society, i.e. gender, ethnicity, age group, etc. This will ultimately support incorporating different physical, cultural, and social challenges that different groups are facing while using bicycles in a city.
- Frequent qualitative assessments of bikeability, as well as regular data collection on bicycle infrastructures, bicycle numbers, users, and so on, can provide valuable insight into the current situation, current trend, and achievements. This also helps to update plans and strategies as per the changing context.

6.3.3 Policy Recommendation

- Existing documents such as NUDS provide some level of information and direction on bicycle related infrastructure construction. However, more detail specification, providing information on of lane and its classification, separation of lane form motorized vehicles, permissible grade, maintenance requirement, intersection design and speed limit.
- Existing MVTMA and MVTMR should be updated with more bicycle related traffic signs & its assemblies and road markings.

CHAPTER 7: CONCLUSION

Bicycles have numerous advantages; they enhance health, reduce traffic, save money, take up less space, and offer effective transportation with no fuel usage and no carbon emissions. So, the concentration of a city's population on two wheels can significantly affect the city's general well-being. Despite this, cycling is still not a popular mode of transport in the cities of Nepal. For this reason, this study attempted to identify the various built-environment characteristics that dictate the bikeability of an urban road and suggest possible measures to promote bicycling. In total, 18 different built environment attributes were identified and were broadly classified into 3 categories, namely, natural conditions, infrastructure and traffic, and surroundings. Through a questionnaire survey, the influence level of each of the built environment attributes on bikeability was determined. An evaluation criteria was also defined to assess the attributes of the study area. Based on the set out objectives, following are the major findings of the study:

- Though some level of initiation have been done, current national policy documents are still insufficient to encourage bicycle.
- 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 to motorized vehicles.
- Personal characteristics such as bicycle riding skills, age, and physical disabilities were also found to limit people from cycling despite their interest in cycling.

For the immediate improvement of the situation, the existing condition of the infrastructure and surroundings needs to be improved on the basis of the identified influence level of the built environment attributes. Sufficient availability of bicycle facilities, such as parking and repair shops, motivates people to choose bicycles. Timely

and frequent maintenance of existing infrastructures should be prioritized. On the soft component side, government authorities should facilitate people who are willing to bicycle but lack the necessary riding skills.

A review of the national document and an international case study of Amsterdam showed that, even though multiple policy documents seem to favor cycling, there is still a long way to go. Nepal still lacks proper guiding documents dedicated solely to bicycle promotion. In addition, existing planning documents rarely consider bicycles as a mode of transport and ignore bicycle-related data while preparing the city's plan. Therefore, for the long-term and sustainable promotion of cycling culture, city plans should incorporate cycling as an important mode of transport. Policy should not only be directed toward infrastructure development but also focus on the behavioral change of the population. People's negative perceptions of bicycles can only be overcome through an awareness campaign about their benefits and international practices. Integrating bicycle riding training and its benefits into school-level education could produce future generations with a more positive attitude and enthusiasm toward using bicycles.

These measures will definitely pave our way forward in achieving a bicycle-friendly and highly bikeable city.

Recommendation for future study

This study was conducted focused on Kathmandu valley. Hence, further study could be conducted in cities with different social and environmental setting using similar methodology. Since, significantly few number of female were found to own bicycle in this study, bicycling from the gender perspective could be studied in detail in order to determine the constraints, challenges and opportunities for promoting bicycle from gender point of view. Similarly, unlike in larger cities and hilly areas, there are still places in Nepal, especially in terai region, where bicycle use are still popular. So, study could be conducted to identify these areas and figure out the existing factors supporting the use of bicycle.

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ANNEX I

Survey Questionnaire

Public Perspective on Bikeability of an Urban Road

This survey is being conducted for a thesis study of Masters in Urban Planning.
The data collected will be used to establish urban road bikeability indicator. All information will be kept confidential unless needed to show in front of jury.

* Required

1. Name of Respondent

_____

2. Age Group *

Mark only one oval.

- ◯ 10-20
- ◯ 20-30
- ◯ 30-40
- ◯ 40-50
- ◯ 50-60
- ◯ 60+

3. Gender *

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Other
- ◯ Prefer not to say

4. Education Level *

Mark only one oval.

- Secondary Level or Lower
- Higher Secondary / 10+2/Diploma
- Bachelors
- Post Graduate or Higher

5. Any form of Disabilities

Mark only one oval.

- Yes
- No
- Prefer not to say

Travel Behavior

6. What is your most preferred mode of urban transport? *

Mark only one oval.

- Public transport
- Private motorized transport (Car, Motorbike, etc.)
- Bicycling
- Walking

7. Do you own bicycle? *

Mark only one oval.

- Yes *Skip to question 8*
- No *Skip to question 10*

Travel Behavior

8. What is the major purpose of your cycling? *

Mark only one oval.

- ◯ Work
- ◯ Exercise
- ◯ Recreational
- ◯ To access public transport

9. How often do you use bicycle? *

Mark only one oval.

- ◯ Everyday *Skip to question 11*
- ◯ Every 2 to 3 days *Skip to question 11*
- ◯ Once a week *Skip to question 10*
- ◯ Rarely *Skip to question 10*
- ◯ Never *Skip to question 10*

Skip to question 11

Travel Behavior

10. What is the main reason for you not to bicycle?

Natural Preconditions of an Urban Road

How influential are following factors to make you cycle?

(1=No influence, 2=Limited Influence, 3=Moderate Influence, 4= High Influence and 5=Very High Influence)

11. Topography (steep or flat slope) *

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

12. Weather *

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

Infrastructure and Traffic of an Urban Road

How influential are following factors to make you cycle?

(1=No Influence, 2=Limited Influence, 3=Moderate Influence, 4=High Influence and 5=Very High Influence)

13. Presence of bicycle lane *

Mark only one oval.

	1	2	3	4	5	
No Influence						Very High Influence

14. Width of bicycle lane *

Mark only one oval.

	1	2	3	4	5	
No Influence						Very High Influence

15. Continuous bicycle lane (Continuity of bicycle lane throughout the route) *

Mark only one oval.

	1	2	3	4	5	
No Influence						Very High Influence

16. Separation of cycle lane from motorized traffic (physical separation with distance, bollard, railing etc.) *

Mark only one oval.

	1	2	3	4	5	
No Influence						Very High Influence

17. Speed of motorized vehicle traveling adjacent to the bicycle lane *

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

18. Traffic signs and road markings related to bicycling *

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

19. Bicycle activated intersections *

(Road intersections designed with priority to cycle with properly defined position through lane markings and bike box with advanced green)

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

20. Connectivity *

(Existing route have proper connectivity with other destinations or alternative routes)

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

21. Availability of Bicycle Parking *

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

22. Availability of Bicycle Repair workshops *

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

Surroundings of an Urban Road

Surrounding environment and conditions of the street
How influential are following factors to make you cycle?

(1=No Influence, 2=Limited Influence, 3=Moderate Influence, 4=High Influence and 5=Very High Influence)

23. Mixed land use (commercial, schools, open spaces/parks etc.) *

(mixed land use for providing multiple options for destination, functions and activities)

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

24. Pollutions *

(Air pollution and litters/rubbish in the street)

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

25. Safety concerns *

(Crime rates, Traffic accidents, Availability of street light at night etc.)

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

26. Maintenance *

(Timely and frequent maintenance of road and bicycle facilities)

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

27. Obstruction in the route *

(Parked vehicle, Trees, Potholes, etc..)

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

28. Aesthetic and green surrounding *

(Pleasant surrounding with abundant greenery, open spaces, historic building, attractive home/façades etc.)

Mark only one oval.

	1	2	3	4	5	
No Influence	◯	◯	◯	◯	◯	Very High Influence

29. Will you bicycle more or start to use bicycle if above built environment characteristics are improved? *

Mark only one oval.

- Yes
- No
- May be

30. Do you think there are any other built environment attributes determining the bikeability of a road beside mentioned above? *

Mark only one oval.

- Yes
- No

31. If yes, please mention the attribute

_____

32. How influential do you think this attribute is to make you cycle?

Mark only one oval.

	1	2	3	4	5	
No Influence						Very High Influence

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Date: September 14, 2022

To Whom It May Concern

This is to confirm that the paper titled "*Assessing Bikeability of an Urban Road: A Case of Kupodole-Jawalakhel-Lagankhel Road Stretch*" submitted by **Gaurav Paudel** with Conference ID **12145** has been accepted for presentation at the 12th IOE Graduate Conference being held in October 19 – 22, 2022 at Thapathali Campus, Kathmandu.

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Convener,
12th IOE Graduate Conference

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[Placeholder for Publication Information]

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.

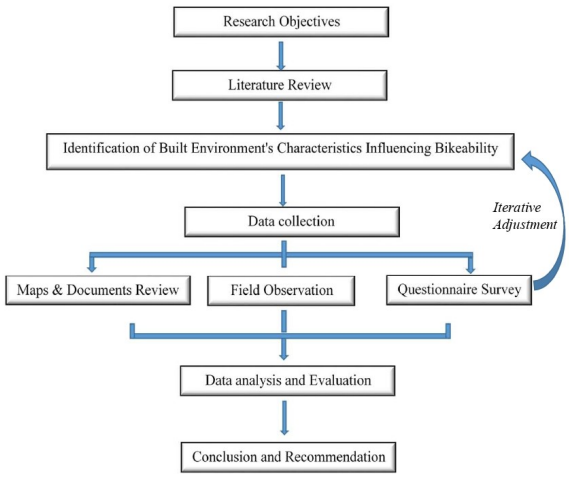

Figure 1: Research framework

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.

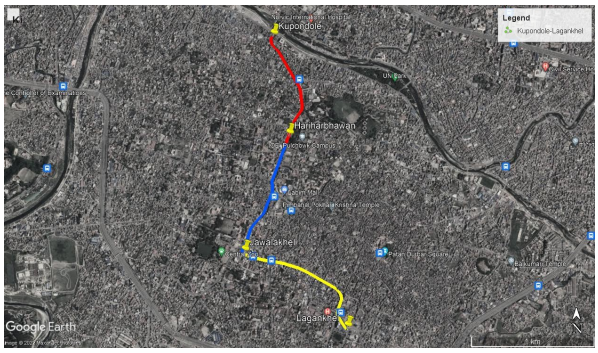

Figure 2: Study Area

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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THESIS PRESENTATION ON:

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

Msc. In Urban Planning
Pulchowk Campus

Presented By:
Gaurav Paudel
076MsUrp005

Date:
22nd Sep, 2022

OUTLINE OF PRESENTATION

1. Introduction
2. Problem statements
3. Research objective
4. Limitation of Research
5. Study Area
6. Literature Review
7. Data analysis
8. Conclusion and Recommendation
9. References

Addressed Comments

Comments from Mid-term Presentation	Remarks
Limits SDGs to only those which are highly relevant	SDGs :- **Goal 11 and Goal 3**
To consider social issue	Addressed through survey and recommendation
Omit obsolete documents	**"The Kathmandu Valley Air Quality Management Action Plan, 2017"** is removed
Try to consider the latest traffic survey data	Last official data related to cycle available is only from JICA 2012 survey report.
Add case study in the report	Amsterdam city case study

Introduction

Bicycling

- Bicycle is a human powered mechanical device → NMT Mode
- First introduced by German baron **Karl von Drais in 1817 AD**
- Introduced in Nepal in the early 20th century

Source: msmugs.com

Evolution of Cycle

Introduction

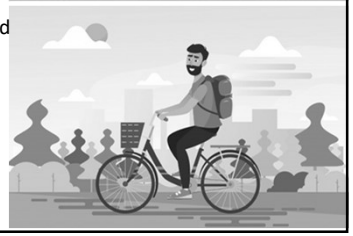
Pros and Cons of Bicycling

Pros

- Health benefits
- Environmental benefits
- Economic benefits
- *Social benefits*
- Equity

Cons

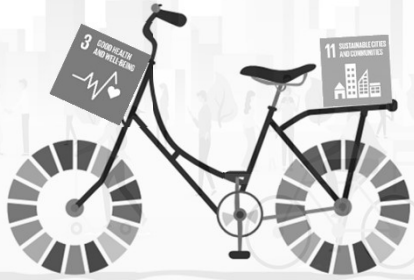
- Limited travel distance
- Low speed and physically exhausting
- Exposure to the environmental elements
- Relatively less safe in motorized traffic prioritized area



Introduction

Bicycling and SDG's

- Goal 3: "**Good health and well-being**"
- Goal 11: "**Sustainable cities and communities**"



Introduction

Bikeability

- Bikeability is simply **the ability of travel safely and efficiently using bicycle.**
- Bikeability measures **how well an area supports using a bicycle as a means of transportation** and the conditions under which cycling occurs (Nielsen & Skov-Petersen,

Source: https://www.theguardian.com/

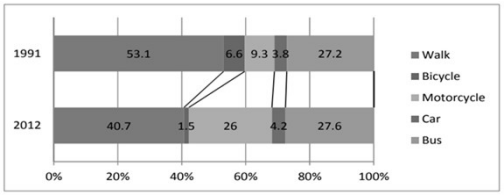
Problem Statement

Keith Cunningham, Peace Corps
Photo Collection/Doug Hall, 1969

Source: Myrepublica, 2022

Problem Statement

- In Nepal, promotion of cycling to obtain sustainable transport system is accorded well between policymakers, politicians, and academicians
- Despite of plethora of benefits → cycle not a popular choice of transport
- This shows that the **policy interventions as well as practices has been inadequate to promote the use of bicycle** as a desirable mode of urban transport



(Source: JICA, 2012)

Research Objective

The main objective of the study is **to assess the bikeability of an urban road and identify the ways to promote cycling** in context of Kathmandu.

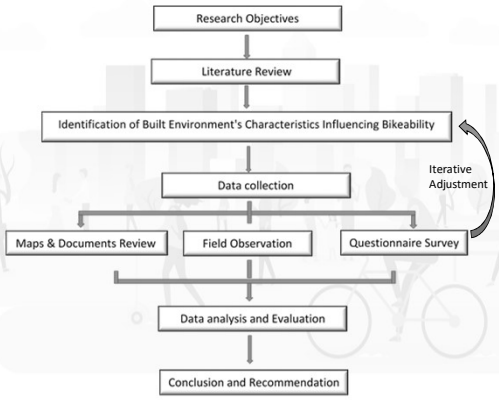
The specific objectives of the study are:

- **To review existing policies and practices related to bicycling**
- **To identify the built environment's attributes contributing to bikeability and undertake assessment**
- **To recommend the strategies to promote urban cycling in context of Nepal**

Limitation of the study

- The study depends on the **primary data (people's perception) to rank the built environment attribute's** influence on Bikeability
- Bicycling considered for assessing bikeability is for manual bicycle only (e-bike/scooters will not be considered)
- Findings and conclusion of the study are based on the selected study area (Kathmandu Valley), hence, might not be 100% relevant to other urban area

Research Framework

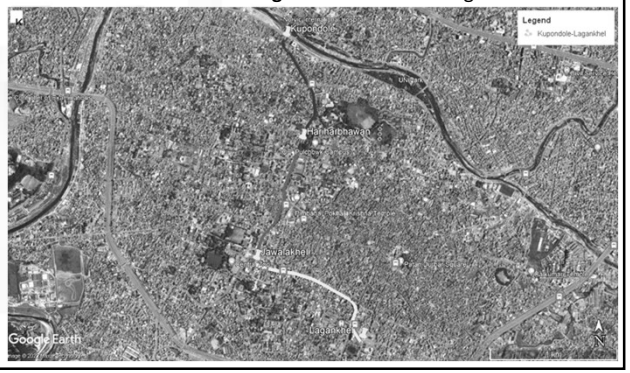


Study Area

Kupondole-Jawalakhel-Lagankhel – Road Stretch

- Total Length: **3.15km**
- Passes through ward no. **10, 3, 4 and 5** of Lalitpur Metropolitan City, Bagmati Province
- Reason for selection : LMC developed the stretch as 1st pilot project as per its master plan

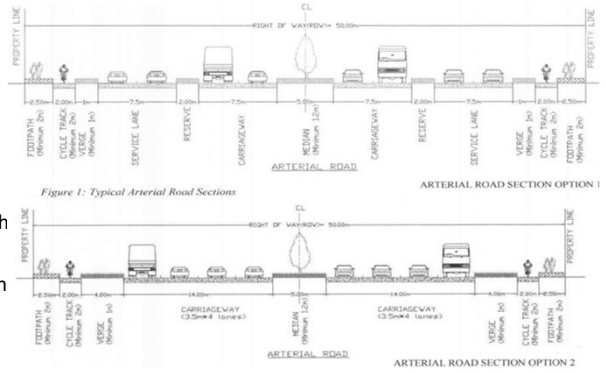
Stretch 1: **Kupondole to Hariharbhawan** road with length of 1km.
Stretch 2: **Hariharbhawan to Jawalakhel** road with length of 1km.
Stretch 3: **Jawalakhel to Lagankhel** road with length of 1.35 km.



Literature Review

Existing National Policy and Documents review

- **Nepal Urban Road Standard (2076)**
  - Minimum width of bicycle lane = 2m (+1m for each additional lane)
  - Continuity, without obstructions, smooth surface, tree shade, street lights and 0.6m buffer between cycle track and carriageway & parking

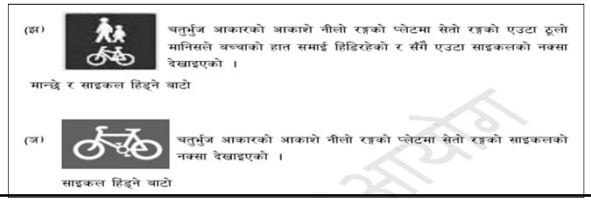


Literature Review

Existing National Policy and Documents review

- **Periodic plans:**
  - 10th plan: In the area of heavy traffic road widening with cycle lane will provide
  - 12th plan: Footpath and bicycle lane will provide where possible
  - 15th plan: through multisector coordination, construction and establishment of cycle lanes
- **Motor Vehicles and Transport Management Rules, 1997**

  In relation to bicycling it has mentioned two signs in informative sign category in Annex 63 of the document:


(झ) चतुर्भुज आकारको आकाशे नीलो रङ्को प्लेटमा सेतो रङ्को एउटा ठूलो मानिसले बच्चाको हात समाई हिँडिरहेको र सँगै एउटा साइकलको नक्सा देखाइएको ।

मान्छे र साइकल हिड्ने बाटो

(ञ) चतुर्भुज आकारको आकाशे नीलो रङ्को प्लेटमा सेतो रङ्को साइकलको नक्सा देखाइएको ।

साइकल हिड्ने बाटो

Literature Review

Existing National Policy and Documents review

- **National Sustainable Transport Strategy (NSTS) (2015-2040)**

  Has identified poor infrastructure and lack of bicycle lane as key issue in urban transport sector

  ❑Its targets are:
  - **Has set target of minimizing motor vehicle ownership**
  - **Minimize per capita CO2 emission from transport sector**
  - **Increase share of NMT in total trips**

  ❑Strategic actions are:
  - **Invest for pedestrian and Non Motorized Transport (NMT) infrastructure in Kathmandu, NMT lanes in urban areas**
  - **Making provision for bicycle stands**
  - **Dedicated bicycle lane in national highways**

Literature Review

Existing National Policy and Documents review

Lalitpur Metropolitan City's Making Lalitpur Cycle Friendly City, 2019

- Prepared cycle city master plan.
- Prioritized various road stretch within LMC and selected Kupondole-Pulchowk-Lagankhel route and Pulchowk Mangal bazar –Lagankhel route to develop as a pilot project of cycle lane.
- Provide possible locations and detail design of of bicycle parking facilities

Fig: Bicycle Network Plan of LMC

Literature Review

International Guidelines Review

- **AASHTO Guide for the Development of Bicycle Facilities (2012)**
  Provides detail specifications on all infrastructure related to cycling in high way:
  1. Road Signs and their assemblies
  2. Road Markings
  3. Lane and its classifications
  4. Speed limit
  5. Grade
  6. Intersection design considerations
  7. Bicycle parking facilities
  8. Lighting
  9. Maintenance and operations

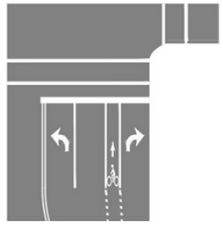


Fig: Road markings

Fig: Road Signs

Literature Review

International Case Study

City of Amsterdam

- City is practically synonymous with cycling
- Out of 1.2 million population 900,000 cycle
- One way for automobiles traffic, paths dedicated bikes are the common characteristics of many streets
- Pre World War II : cycle was popular

  After WW II: Cars started replaced them

(Source: www.vox.com)

Literature Review

International Case Study

City of Amsterdam

Major events ➔

1971 : Stop de Kindermoord" movement

1973 : Organization of Arab Petroleum Exporting Countries (OAPEC) oil supply restriction

1978: New Municipal council's priority for cycling

(Source: www.vox.com)

International Case Study

Literature Review

City of Amsterdam

- Approximately €40 million were scheduled to be spent between 2007 and 2010 on bicycle projects
- 30km/hr speed limit
- On-road bike lanes were also changed by the city to separate bike lanes
- Strategies to combat bike thefts,
- Dedicated website for cycle,
- Free bicycle for traveling to school and its training for children

Also has problems due to overwhelming cycle number

Bikeability and Built Environment Attributes

Literature Review

❑ **Ito & Biljecki (2021), has considered the various characteristics of surrounding in order to access the bikeability**

- **Connectivity:** measured through number of intersections with lights, intersections without lights, and cul-de-sacs
- **Environment:** slope, the number of POIs, land use mix, AQI, and pixel ratios of greenery, buildings, and water
- **Infrastructure:** type of road and pavement, the width of the road, number of transit facilities, and presence of potholes, street lights, bike lanes, street amenities, utility poles, bike parking spaces, sidewalks, crosswalks, and curb cuts
- **Vehicle cyclist interaction**: the number of vehicles and speed control devices and the presence of on-street parking and traffic lights/stop signs
- **Perception**: attractiveness for cycling, spaciousness, cleanliness, building design attractiveness, safety as cyclists, beauty

Bikeability and Built Environment Attributes

Literature Review

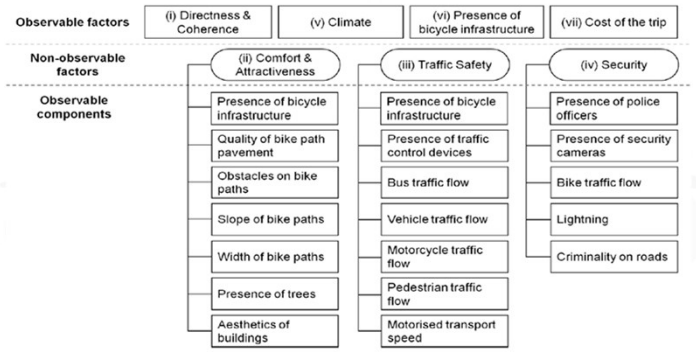
❑**Hagen & Rynning, (2021) has summarized built environment characteristics influencing bikeability into 4 categories namely :**

- **Natural and place-specific conditions**: location and role of the area in its region and city, topography and weather condition
- **Infrastructure and traffic:** cycling infrastructure, cycling facilities at destinations, traffic volumes, speed level, traffic safety, intersections, and accessibility by public transport and car
- **Surrounding and activities** : the density, proximity, urban structure and permeability
- **Urbanity**: density, proximity, urban structure and permeability

Bikeability and Built Environment Attributes

Literature Review

❑ **Arellana et al., (2020), after reviewing 50 articles related to bikeability index, considered the following factors to identify the bikeability:**



Literature Review

Bikeability and Built Environment Attributes

❑From the Literature reviews, following attributes relevant to our context are identified :

Natural Precondition
- Topography
- Weather

Surroundings
- Mixed land use
- Pollution
- Safety condition
- Obstructions in the route
- Maintenance
- Aesthetic and green surrounding

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 and alternative routes
- Presence of bicycle parking facility
- Presence of bicycle repair workshops

Survey

For the data collection,

❑Judgement sampling was done

❑Via google form for the convenience of respondent

❑Analysis was done by using excel

- Out of total 450 form circulated 202 response were received
- For the total population of Kathmandu valley

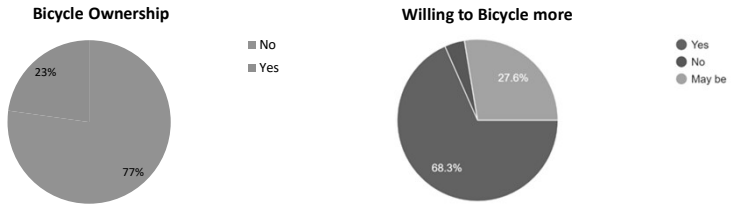
  Margin of error: 6.9%

  Confidence level: 95%

  Response distribution of 50%

Survey

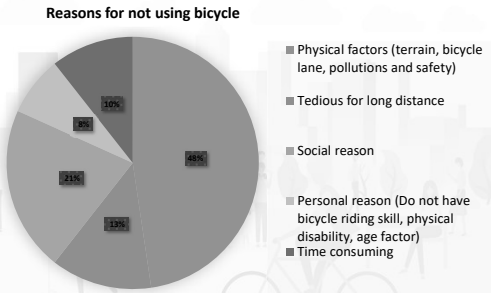
Survey findings



- Significant percentage of people has willingness to cycle if the built environment attributes are made better

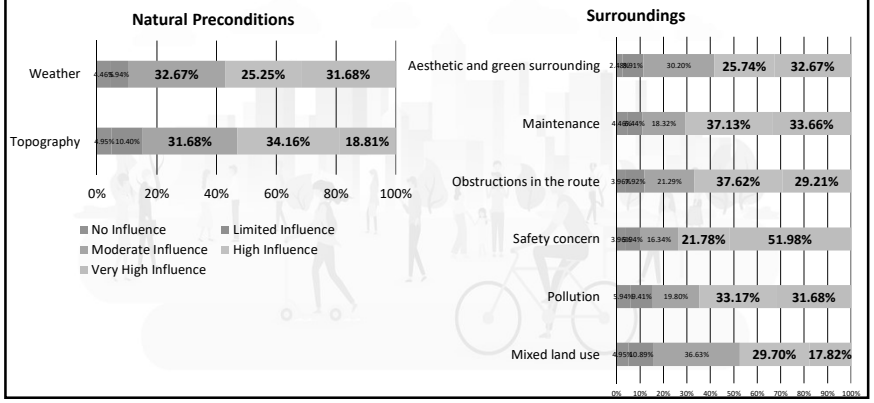
Survey

Survey findings

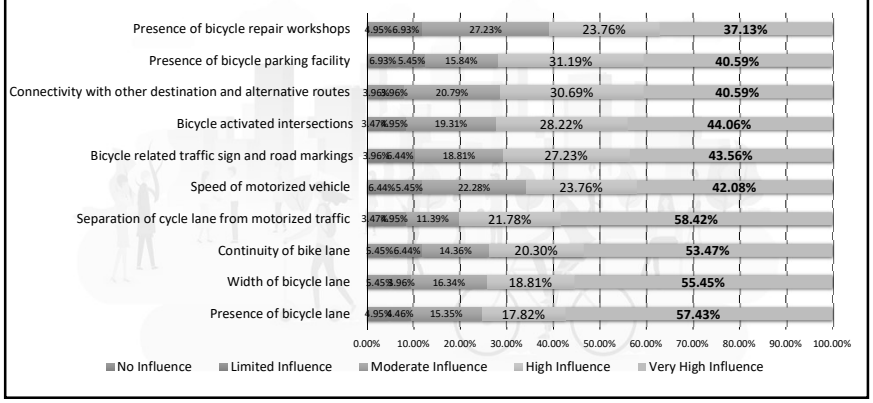


- For most of the respondent who didn't own bicycle, main reasons for not to bicycle were the built environment factors followed by social factors

Users Perspective Attribute's Influence on Bikeability



Users Perspective Attribute's Influence on Bikeability



Indicator Analysis

For quantification of the response received in 5 point Likert scale

$$Step\ value = \frac{1}{(number\ of\ categories - 1)} = 0.25$$

Value of each response :

- 1= 0 (No influence)
- 2= 0.25 (Limited Influence)
- 3= 0.50 (Moderate Influence)
- 4= 0.75 (High Influence)
- 5= 1.00 (Very High Influence)

Indicator Analysis

Attributes	Overall influence value (0-1) scale
NATURAL PRECONDITIONS	
Topography	**0.63**
Weather	**0.68**
SURROUNDINGS	
Mixed land use	**0.61**
Pollution	**0.69**
Safety condition	**0.78**
Obstructions in the route	**0.70**
Maintenance	**0.72**
Aesthetic and green surrounding	**0.69**

Attributes	Overall influence value (0-1) scale
INFRASTRUCTURES AND TRAFFIC	
Presence of bicycle lane	**0.80**
Width of bicycle lane	**0.78**
Continuity of bicycle lane	**0.77**
Separation of cycle lane from motorized traffic	**0.82**
Speed of motorized vehicle	**0.72**
Bicycle related traffic sign and road markings	**0.75**
Bicycle activated intersections	**0.76**
Connectivity with other destination and alternative routes	**0.75**
Presence of bicycle parking facility	**0.73**
Presence of bicycle repair workshops	**0.70**

Bikeability Assessment Criteria

Attributes	High Bikeability Conditions	Low Bikeability Condition	Primary Source of Assessment	Ref
Natural conditions				
Topography	**<3%** (relatively flat landscape)	**> 5%** (presence of steep slope)	Map study, Field study	*AASHTO Bicycle Guideline*
Weather	Temperature: **Avg. temp around 25 degrees** Celsius **Humidity:(52.3%–62.7%)** Relatively stable/predicatable weather condition with **low precipitation**	Very high or low temperature, High humidity and unpredictable weather conditions	Document studies, DoHM website	*(Mang et al., 2016), (Richardson (2000), (Ahmed et al., 2010) (Phung & Rose, 2007)*
Surrounding				
Land use along the street	Mixed land use providing variety of options for multiple of activities and destination choices for the cyclist	land use without variety of options for multiple of activities and destination choices for the cyclist	Map study and Field study	(Hagen & Rynning, 2021), (Chen et al., 2017)(Christiansen et al., 2016)
Pollution	No/Limited amount of pollution in the street	Highly polluted environment and litters in the street	Field work	(Merten et al., 2016), *(Winters et al., 2013)*
Perceived safety	Low crime rate, traffic and non-traffic accident, Availability of street light at evening and night	High crime rate, traffic and non-traffic accident. street light not available from evening and night	Document study, Field visit	(Hagen & Rynning, 2021), (Ma et al., 2017)
Maintenance	High focus on maintenance of the cycle related infrastructures	Extremely low focus on maintenance of the cycle related infrastructures	Field Study	(Ma et al., 2017), (Hagen & Rynning, 2021)
Aesthetic and green surrounding	Pleasant surrounding with abundant **greenery, open spaces, historic building**	**motorized vehicle oriented** environment with no open spaces, greenery and pleasant surrounding	Field study	*(Chen et al., 2017),* (Merten et al., 2016), (Christiansen et al., 2016)

Bikeability Assessment Criteria

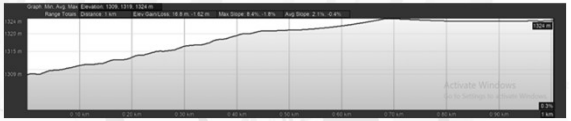
Attributes	High Bikeability Conditions	Low Bikeability Condition	Primary Source	Ref
Infrastructure and traffic				
Presence of bicycle lane	Presence of bicycle lane	Bicycle lane not available	Field study	(Ghekiere et al., 2015), (Mertens et al., 2014)
Bicycle lane width	**≥ 2m** for one way lane	**<1.4m** for one way lane	Field study	(Arellana et al., 2020) (NLRS 2076)
Continuity of bicycle lane	Bicycle lane continuity along the entire route	Disconnected bicycle lane along the route	Field study	(Hagen & Rynning, 2021)
Separation of cycle lane from motorized traffic	Proper separation of cycle lane from motorized traffic through use of bollards, island etc. for improved cyclist safety	No separation of bicycle lane from	Field study	(Winters et al., 2013), (Ghekiere et al., 2015), (Mertens et al., 2014)
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	Field study	(Schmid-Querg et al., 2021, Hagen & Rynning, 2021), (Pucher & Buehler, 2017)
Bicycle related traffic signage and road marking	Proper road signs and road marking for cyclist for safe travel and convenient way findings	Lack of road signs and road marking for cyclist for safe travel and convenient way findings	Field study	(Hagen & Rynning, 2021)
Bicycle activated intersections	Intersection designed with priority to cycle (through lane markings, bike box with advanced green etc)	Intersections with high priority to motorized vehicles with proper markings, and signage for cycle	Field study	(Casello et al., 2017) (Hagen & Rynning, 2021)
Connectivity	well connected cycling network with alternative routes	No connection with other street with bicycle facilities for alternative routes	Map study, Field Study	(Merten et al., 2016) (Hagen & Rynning, 2021)
Bicycle facilities	Sufficient availability of bicycle parking and repair centers	Functional bicycle facilities not available	Field Study	(Hagen & Rynning, 2021)

Bikeability Assessment

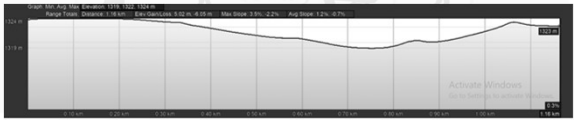
Topography

Stretch 1:

Stretch 2:

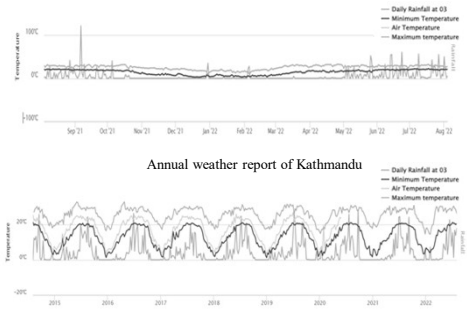


Stretch 3:



Bikeability Assessment

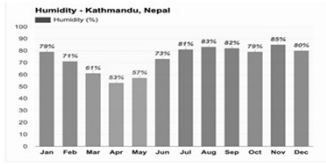
Weather



Annual weather report of Kathmandu

7 year weather history of Kathmandu

source: http://www.mfd.gov.np/city?id=31

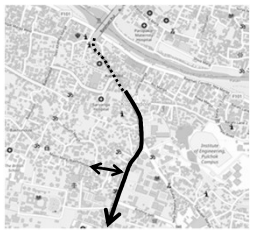


Annual Humidity of Kathmandu

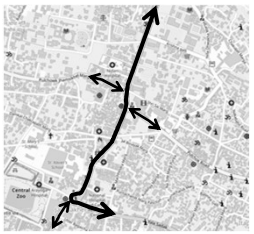
Source: weather-atlas.com

Bikeability Assessment

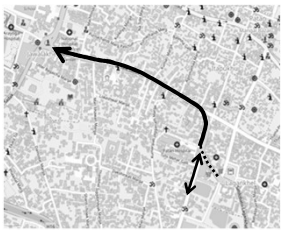
Continuity of Bicycle Lane and Connectivity with other road network



Stretch 1



Stretch 2



Stretch 3

Bikeability Assessment

Separation of Lane from Motorized Traffic

Bikeability Assessment Criteria

Bicycle related traffic signage and road marking

Bikeability Assessment

Bicycle activated intersections

Intersection with bike-box

No provision for bicycle

Bikeability Assessment

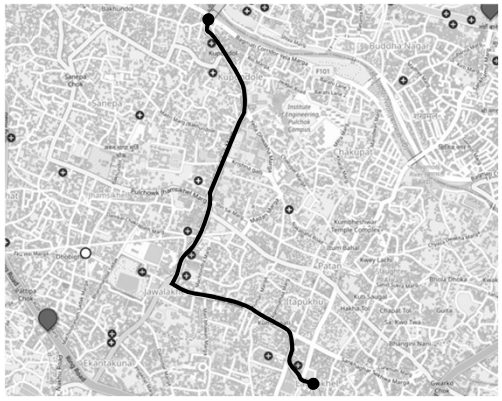
Repair workshops and Parking facilities

Bikeability Assessment

Maintenance

Bikeability Assessment

Land Use



Bikeability Assessment

Safety Conditions

- No incidence of any kind of crimes along or in the proximity of the route
- Traffic accidents number:
  - Harihar Bhawana area →43
  - Inarchok →16
  - Kupondole area → 50
  - Pulchok area → 47
  - Jawalakhel area → 85
  - Lagankhel → 15

But, none were severely injuring or fatal

Street lights and CC camera installed

(Source: Nepal Police and Traffic Police Office, Jawalakhel)

Bikeability Assessment

Pollution

- Air Pollution

WHO recommended level

Pollutant	Interim target				AQG (2021)	AQG (2005)
	1	2	3	4		
$PM_{2.5}$	35	25	15	*10*	**5**	10
PM_{10}	70	50	30	*20*	**15**	20
NO_2	*40*	30	20		**10**	40

Kathmandu Valley (Ratnapark Station)

PM 10	**57.2** µg/m³
PM 2.5	38.09 µg/m³

(Source: https://pollution.gov.np)

- No significant amount of litters were found along the cycle route

Bikeability Assessment

Obstructions



Bikeability Assessment

Aesthetic and green surrounding




Bikeability Assessment

Attributes	Kupondole to Hariharbhawan	Hariharbhawan to Jawalakhel	Jawalakhel to Lagankhel
Natural conditions			
Topography	Bikeable	Bikeable	Highly Bikeable
Weather	Bikeable	Bikeable	Bikeable
Surrounding			
Land use along the street	Highly Bikeable	Highly Bikeable	Bikeable
Pollution	Bikeable	Bikeable	Bikeable
Safety Condition	Bikeable	Bikeable	Bikeable
Obstructions in the route	Less Bikeable	Less Bikeable	Less Bikeable
Maintenance	Less Bikeable	Less Bikeable	Less Bikeable
Aesthetic and green surrounding	Bikeable	Bikeable	Less Bikeable

Bikeability Assessment

Attributes	Kupondole to Hariharbhawan	Hariharbhawan to Jawalakhel	Jawalakhel to Lagankhel
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 signage 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

Conclusion

- Though some level of initiation have been done, current national policy documents are insufficient to promote bicycle
- 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 study area's current built environment is not very bicycle-friendly.
- People are willing to cycle more if the built environment is made more safe, appealing, and cycle-friendly.
- Beside built environment, factors influencing bicycling:
  - False perceptions of cycling as a socially inferior mode of transportation to motorized vehicles.
  - Personal characteristics: riding skills, age, and physical disabilities/inabilities →limits people despite their cycling interest.

Recommendations

Immediate Recommendation

Improvement of current built environment's attributes (Priority on the basis of established influence level in this study)

- Installing bollards or metal rails,
- Regular maintenance
- Strong regulation for road side parking, passengers pickup and drop
- Proper Provision of bicycle parking
- Increase connectivity

Recommendations

General Recommendation

- Awareness campaigns (use of influential personnel's) → help to remove people's underlying false perception of cycling as inferior means of transport
- Provision of incentives and other facilitation, i.e., training courses for producing repair mechanics, could be initiated by the government
- School-based cycle riding training → equips the future generation with bicycle riding skills and motivation
- E-bike promotions → Partial or complete custom duty exemption, promoting e-bike manufacturing industries → will support people with physical inabilities/disabilities
- Inclusive participation while planning city and designing road.
- Frequent assessments of bikeability, regular data collection on bicycle infrastructures, bicycl numbers, users, etc. → helps to understand current trends and update strategies and policies accordingly

Recommendations

Policy Recommendation

- More specific document dedicated to cycle needs be drafted such as AASTHO bicycle guidelines, for cities.
- Existing MVTMA and MVTMR should be updated with more bicycle related traffic signs & its assemblies and road markings

Recommendation for future research

- A similar study in a city with a different setting might be carried out over a wider area.
- Since, significantly few number of female were found to own bicycle in our study, bicycling from the gender perspective could be studied in detail.

Thank You

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