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Parisar Pune

Measuring the quality of bicycle routes in Pune, India

A field survey to measure bicycle route quality as part of the sustainable transport initiative in Pune, India

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Preface

Experiencing India for almost five months was wonderful. I really enjoyed my stay and the research project. In addition, I enjoyed the political process around the cycling project and feel connected to the project. The cycling project has the potential to really help Pune. I would like to thank the University of Twente, ITC and the Interface for Cycling Expertise (I-CE) for this opportunity.

I would like to thank dr Mark Zuidgeest and prof Martin van Maarseveen for providing good and efficient help. I also thank mr Sujit Patwardhan and mr Ranjit Gadgil for taking really good care of me, and for the several nice lunches.

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I thank Swapnil Hajare of Binyas IT for providing me with the necessary GIS expertise to do this project. In addition, I thank Julie Bytheway, Kasper Jansen and Ans Sanders for great advice on the language and Alje van den Bosch for keeping my Dutch up to date. Finally, I thank Janwani and the Transport Research and Injury Prevention Program (TRIPP) for providing office space. Both Pune and Delhi are excellent workplaces.

Not only the country, but mostly the people made my stay great.

Summary

Pune, a city of three million people in India is facing traffic problems due to an increasing volume of vehicles. In order to reduce pollution and traffic congestion the municipality created an ambitious policy on improving bicycle infrastructure and cycling. However, after finishing the first bicycle routes in recent times, the usage of these routes remains rather low.

A survey was developed to obtain information about the strengths and the weaknesses of bicycle routes in Pune using a Dutch methodology as a basis. After conducting the survey on two bicycle routes, the information obtained shows the safety, directness and comfort degree of the bicycle routes. Observations show that Pune takes bicycle routes seriously, but aspects as uniform signage and attention for cyclists at intersections still pose challenges. The information obtained is used to suggest improvements for the routes. Furthermore, the survey developed in this research might be useful to measure other bicycle routes in emerging economies.

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1 Introduction

First, begins the study with providing background information about Pune and the organization structure of this research. Next, the problems that this study aims to address are discussed, the objective is defined, and the objective is translated into research questions. The study follows the order of the research questions.

The objective of the study is the collection and interpretation of bicycle route quality data in Pune. Therefore, a pilot survey is developed based on experience in The Netherlands. The survey is carried out at two bicycle routes. The obtained data indicates the quality of these bicycle routes.

Background

This background aims at providing basic knowledge about the area, in which this research is conducted: the basics of the urban transport problems in Pune and a description of the organization structure in which this study is realized.

Pune

Pune is a city about 450 sq kms, has 3 million citizens and is for 88% flat. At the western and the southern side of the city there is a hilly area. The temperature of city ranges between Minimum 12°C to Maximum 37°C; and the average rainfall recorded is 600 to 700 mm.

These details make the city convenient for cycling and Pune is constructing 150 km of bicycle track at the moment (TRIPP - IIT Delhi & CIRT - Pune, 2008). Figure 1[1] shows the modal split, i.e. the mode wise distribution of person trips in Pune city (Pune Municipal Corporation, 2005).

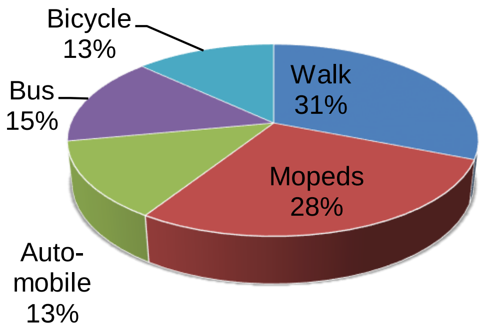

Figure 1: Mode wise distribution of persons trips in Pune

Congestion and air pollution are problems in Pune. The observed ambient air quality trend in Pune is certainly disturbing and approximately 6,800 new vehicles are introduced on the roads per month. Vehicles and industries are considered to be the main causes of air pollution in Pune. The pollution due to vehicles is creating bad impact on the public health. Details are used from the Maharashtra Pollution Control Board (2004).

Organization structure

The initiative of this study comes from the University of Twente and the International Institute for Geo-Information Science and Earth Observation (ITC), who are partners in the Cycling Academic Network (CAN). The CAN is executed by the Dutch NGO, the Interface for Cycling Expertise (I-CE). CAN is carrying out scientific research on themes related to cycling inclusive city

[1] Automobiles are cars and auto's
Mopeds are two-wheelers

planning. In cycling inclusive city planning is the bicycle integrated into the urban transport and development planning.

The study was conducted partly at the Non Motorised Transport-cell (NMT-cell) in Pune and partly at the Transport Research and Injury Prevention Program (TRIPP), at the Indian Institute of Technology in Delhi, both organisations are partners in the Bicycle Partnership Program (BPP). BPP is a program that supports cities and civil society organizations in Asia in their ambition towards cycling inclusive city planning. TRIPP has knowledge of bicycling in developing countries and is one of the founding members of CAN. The Non Motorised Transport-cell consists of Pune Municipal officials and people from Parisar. The NGO Parisar is implementing cycling policies and promoting bicycling in Pune.

Research problem

In order to solve pollution and congestion problems is Pune developing a bicycle network in corporation with the Transport Research and Injury Prevention Program (TRIPP) (TRIPP - IIT Delhi & CIRT - Pune, 2008). The first bicycle routes are already opened, however, their usage (in terms of bicycle trip volumes) is considered to be rather low.

A key issue for successfully implementing bicycle networks in developing countries is an attitude shift towards cycling: the image of cycling needs to be improved. Hirotaka Koike (2000) concludes in his research about cycling in developing countries, that this can be achieved by improving bicycles, improving bicycle related facilities, awareness raising and sometimes restriction of automobile usage to some extent.

In order to improve bicycle related facilities and in order to understand why the usage of the current bicycle routes is low, detailed knowledge on the quality and (barriers to) usage of the existing infrastructure is required (Bicycle Partnership Program, 2008). Such knowledge of the bicycle infrastructure, which is not widely available in Pune, can be obtained from collecting appropriate bicycle route quality data. Such data inventories are frequently done in The Netherlands.

Objective

As such, the objective of this study is the collection and interpretation of bicycle route quality data in Pune, by developing a survey instrument (based on experience in The Netherlands), conducting a field survey, and interpreting the quality of bicycle tracks based on this survey.

Research questions

Main research question

The main research question below aims to obtain the objective.

- *What is the quality of the bicycle routes in Pune?*

Sub-research questions

In order to obtain the main research question it is divided into three sub-research questions, which are discussed throughout the study. Chapter two describes the ‘quality’ of a bicycle route, in order to understand what the study aims to improve.

1) *How can ‘quality’ of bicycle routes be defined?*
   Chapter three aims to develop a survey to measure the quality of bicycle routes in Pune. To achieve the accompanying sub-research question, it is divided in five questions.
2) *How to measure the quality of bicycle routes?*
   a) *How is the quality of bicycle routes measured in The Netherlands?*
   b) *Which factors are different in the context of Pune, India?*
   c) *Which parameters will be measured in India?*
   d) *How to set up a survey instrument for measuring the quality of bicycle routes in Pune?*
   e) *How to organize and conduct bicycle route quality measurement, using the survey instrument in Pune?*

   Chapter three also describes a method for analysing obtained survey data.
3) *How should the obtained data be analysed?*

Chapter four describes the results of the pilot survey, carried out at two bicycle routes in Pune. The obtained data suggests improvement of the quality of the bicycle routes is possible. The final chapter, Conclusions and recommendations, indicates the utility of the developed survey.

2 Definition of the ‘quality’ of a bicycle route

Good quality bicycle routes have to be safe, direct, attractive, coherent and comfortable for cyclists. These aspects of quality are described below (CROW, 2006: TRIPP - IIT Delhi & CIRT - Pune, 2008).

Safety
The cycling-infrastructure guarantees the road safety of cyclists and other road-users. Minimising conflicts, minimising the outcome of conflicts, allowing interaction between road users and providing safety margins are important. For example, a separated bicycle track next to roads can increase safety.

Directness
The cycling-infrastructure continually offers cyclists routes that are as direct as possible. Minimising detours, minimising delays and maximising traffic circulation is important. For instance, traffic light optimization and a dense network of bicycle routes can increase directness.

Comfort
The cycling-infrastructure enables a quick and comfortable flow of bicycle traffic. Minimising energy consumption and avoiding inconvenient manoeuvring are important. Effective maintenance is an example of increasing comfort.

Coherence
The cycling-infrastructure forms a coherent unit, and links with all departure points and destinations of cyclists. The speed that the bicycle route is designed for, connectivity (the degree to which the bicycle routes are a fine meshed bicycle network), recognisability and continuity are important. A bicycle route should be recognizable and easy to understand. For example, an intersection with a low number of pavement changes is easy recognizable for cyclists, which positively influences coherence.

Attractiveness
The cycling-infrastructure is designed and fitted into the surroundings, in a way that cycling is attractive. Pleasant surroundings and minimum stress are important. For instance, a high social security increases attractiveness.

3.1 Survey: Defining parameters

Chapter two described the ‘quality’ of bicycle routes, chapter three aims to develop a survey to measure this quality. In paragraph 3.1 are the parameters for this survey defined. Most parameters are based on the Dutch Bicycle Route Inspection Method, other parameters are developed in India.

Paragraph 3.2 discusses the survey method, the conducting and the analysing of the survey. For a better understanding of the study, it could be helpful to glance at appendix A for the Frequently used words list.

Dutch research method

The Dutch Cyclists union, developed in 2005, a pilot research method called the Routekeuring (Bicycle Route Inspection Method*)*, that measures the quality of a bicycle route in an objective way (Fietsersbond, 2005). The Dutch Cyclists union claims that the research method is world leading, among other factors, due to the highest density of bicycles in the world. In the Netherlands, there is one bicycle for each inhabitant (Ministerie van Verkeer en Waterstaat, 1993).

The Bicycle Route Inspection Method illuminates the five main aspects of quality: safety, directness, comfort, coherence and attractiveness. The parts of the Dutch Bicycle Route Inspection Method that seemed highly relevant in the Indian context, have been adopted and where needed adapted, in this study.

Unfortunately, a halt is called to the Dutch Bicycle Route Inspection Method, mainly since the research method is too time consuming. The Dutch Cyclists union focuses now, on the quality of bicycle networks instead of bicycle routes.

From Dutch parameters to Indian parameters

The Dutch Bicycle Route Inspection method contains a large parameter list, which are measured in the field and analysed. For example, parameters like the width of the bicycle track, the quality of the pavement and the speed of intersecting traffic.

Some Dutch parameters are used in this survey and some Dutch parameters are also adapted to Indian circumstances. Adaption is based on observations of Indian traffic, road conditions, user behaviour and discussions with residents of Pune.

A risk of using Dutch parameters in India is the different environment. Therefore, each parameter is selected according to four criteria.

Criteria for selecting parameters to measure the quality of bicycle routes in Pune:

1. Excellence of the indication of an aspect of quality in Pune (like safety)
2. objectiveness
3. efficiency of measuring & analysing
4. Variation in answers

Variation in answers indicates whether a parameter has different answers at different locations. If there are no traffic islands in Pune at all, the availability of traffic islands will not be a parameter.

All the attractiveness and coherence parameters are removed in the selection process, mainly since they are time consuming for this survey.

Creating Indian Parameters

Next to parameters based on the Dutch research method are new parameters created, Indian parameters. Indian parameters are survey questions and measurements developed in India, which indicate the quality of a bicycle route and which are not used in the Dutch Bicycle Route Inspection Method.

Indian parameters are created with Indian traffic observations, road conditions observations, user behaviour observations and discussions with residents of Pune. Analogue to the previous paragraph are Indian parameters selected on the basis from four criteria: indication of an aspect of quality (like safety), objectiveness, efficiency of measuring & analysing and variation in answers.

Parameter list

The table below shows the parameters, which are used to conduct the pilot survey in Pune. Appendix A, Measurement handbook, further describes the parameters. Appendix B, Not used parameters, shows the parameters, which are not used in the survey in Pune, with a description of the parameters and how they scored to the criteria mentioned above. Obviously, these parameters may still be used in a follow-up activity.

Safety parameters	Directness parameters	Comfort parameters
Lighting	Delay & safety due to barriers	Roadside flatness
Mixed road space or separated bicycle track	How much delay gives a barrier	Number of posts or bollards
Width of the bicycle track	Pedestrians on the bicycle track	Number of useful posts or bollards
Number of lanes to cross	Quality of the pedestrian path	Bicycle route surface quality
Sight at intersection while approaching	Average green time of traffic lights	Quality observation bicycle infrastructure
Maximum speed of intersecting cars	Average red time of traffic lights	
Maximum speed parallel cars	Delay at intersections without traffic lights	
Quality observation bicycle infrastructure	Quality observation bicycle infrastructure	

Table 1: Defined parameters for measuring the quality of bicycle routes in Pune

3.2 Survey: conducting and analysing

With the parameters ready, the conducting and the analysing of the survey can begin. This consists of three parts:

1. Questionnaire
   The questionnaire consists of the defined parameters and obtains data of existing bicycle routes. The fieldworker measures the parameters under fixed conditions. The freeware software Cybertracker is used to conduct the questionnaire with a PDA and a GPS.
2. Analysis
   The obtained survey data is analysed with the software Microsoft Excel to find an indication of safety, directness and comfort for each bicycle track.
3. Presentation
   The open source software QuantumGIS and the software ArcGIS makes the results of the analysis clear in a map.

Questionnaire

The questionnaire is formulated in appendix A, the Measurement handbook. However, before conducting the questionnaire there are some definitions set about the survey instrument. There are decisions made about the road surface classification and different types of measurement, which are used. In addition, the used software and technology is discussed. The output is a spreadsheet with survey data, which will be analyzed in the next sub-paragraph.

Choosing bicycle routes and segments

Before conducting the questionnaire, bicycle routes have been chosen and divided into segments.

Definitions:
Bicycle tracks are roads, paths or marked lanes designated for use by cyclists from which motorised traffic is excluded.
Bicycle routes are signposted, described or otherwise facilitated routes for recreational or commuter purposes.
Segments are parts of bicycle routes. A segment is about 2 km and the start and end point are chosen with respect to details of the infrastructure.
The aim is to choose the start and end, points in a way, which results in as much coherence as possible during one segment.

The results of the measurements will be presented by segment. So, the aim is to have as little difference between the results of the measurements of one segment. Working with segments enables indicating differences in quality at different parts of bicycle routes.
Bicycle routes and segments will be respectively, around 5 km and 2 km long. In order to choose a bicycle route it is possible to look after major attractions and destination points. However, in the scope of this research only bicycle tracks are measured, which were available. The municipality can be consulted for choosing the preferred bicycle routes for measurement. Each segment will be measured in one direction.

Types of Measuring

There are four types of measuring used in the survey: measuring at points, measuring at intersections, measuring of events and measuring at segments, which are explained below. For each measurement, a GPS reading is taken to obtain the location and photographs are made to show the situation in the field. During the analysing different types of measurements will be combined for each segment.

1. *Measuring at points*
   Measuring at points captures parameters successive at a segment of a bicycle route.

   Measurement points:
   - At a measurement point, 25 meters length of the bicycle route is measured, in the direction, which the bicycle route is heading, unless the question indicates otherwise.
   - Measuring at points is every 250 meters.
   - There is at least one measuring point between two intersections.
   - After measuring a intersection, the fieldworker starts again with a measuring point after 250 meters.

2. *Measuring at intersections*

*Mea*suring at intersections captures parameters at every observation intersection. Intersections gain extra attention since they cause the most safety problems for cyclists (TRIPP - IIT Delhi & CIRT - Pune, 2008).

   Observation intersection:
   1. Observation intersections are intersections, where cyclists have no priority, and intersections, where it is of greater importance, that the intersections are well regulated.
   2. In general all intersections are measured, however if a side-road of a priority road has low traffic during peak hour, it is not an observation intersection. Low traffic is less than one vehicle every 10 seconds.
   3. If the route does not cross an intersection because of a turn to the left, it is no observation intersection.

3. *Measuring of events*

Since not all information about bicycle routes is gathered by parameters, a fieldworker can make an event at an exceptional situation. This is especially meant for barriers at or around the bicycle route, which disproportional influence the quality of the bicycle route, and for administrative purposes.

4. *Measuring at a segment*

Fieldworkers have many observations during the measurements, which are not captured by the parameters. They give and explain marks for the quality of the bicycle infrastructure, considering these observations and the events noted down.

Conducting the questionnaire with Cybertracker

The questionnaire is conducted with Cybertracker. Therefore, the Measurement handbook is inserted in a Cybertracker database. Figure 2 shows a question on the PDA using the questionnaire in Cybertracker. After conducting the field measurements shows Cybertracker the obtained survey data in an Excel spreadsheet.

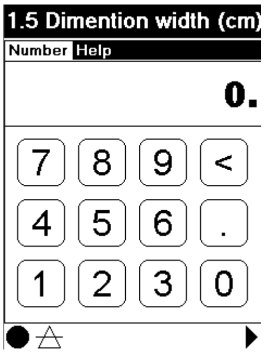

Figure 2: Screenshot of PDA while conducting the questionnaire

Analysis

The analysis aims to find the existing bicycle routes quality, using the obtained survey data. The Indian and Dutch conventions are used as reference, when available. The result of the analysis is a table with the quality of the bicycle routes for each segment, specified to aspects of quality (safety, directness and comfort). The calculations used for the analysis are explained below.

Calculation of an aspect of quality for one segment:

1. A score is connected to each answer of a parameter of the questionnaire
2. The average score for one parameter (P) is calculated
3. P is connected to a weight
4. The average of the weighted parameters is calculated

The score is connected to the answer of the questionnaire in order to grade the answer. One meter of low quality bicycle route, is not completely compensated with one meter of high quality bicycle route, due to the grading.

The weight of a parameter depends on the objectivity and on the excellence of the indication of quality. In addition, the more measurements are conducted for a parameter, the better a parameter is measured, the higher the weight.

The explanation of the calculations and the weights of each parameter are written in Appendix C and Appendix D respectively.

Presentation

The quality and location of each segment are mapped in a GIS map, a digital map (figure 3). The input of the presentation is the obtained survey data and the table with the quality of the bicycle routes for each segment, specified to safety, directness and comfort. The GIS map is able to show for each segment: the general quality, the safety, directness and comfort degree.

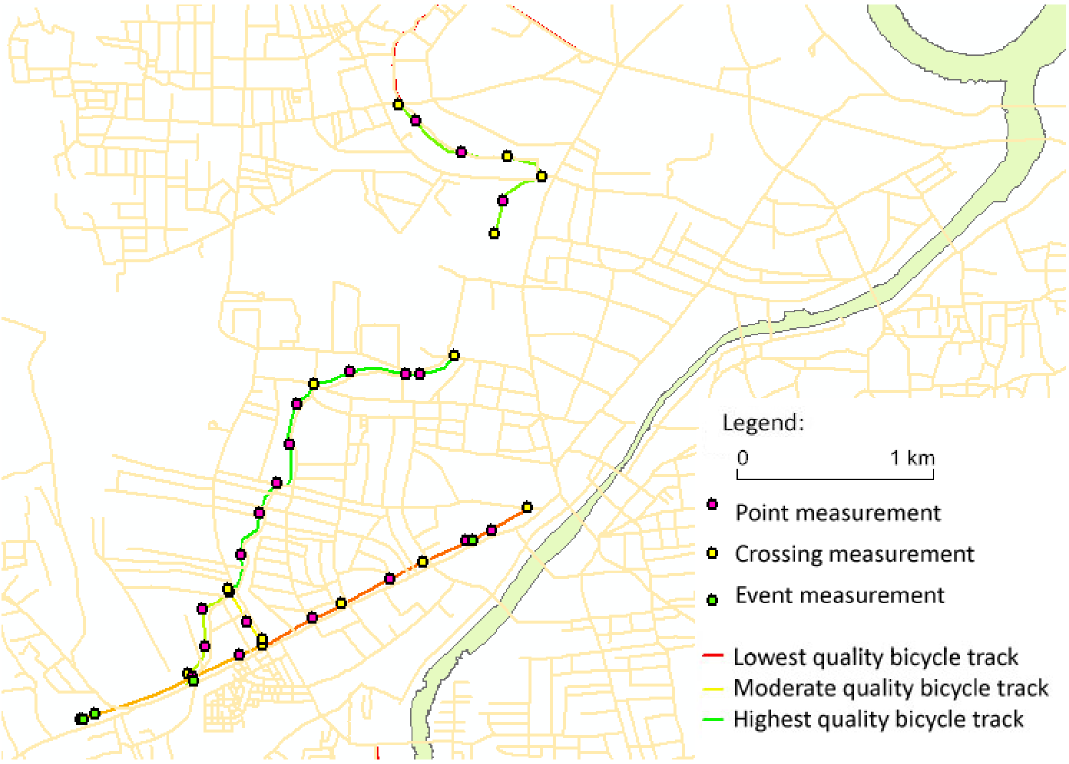

Figure 3: Places and types of point measurements and the quality of bicycle routes in Pune

The GIS map above shows at which points the survey data is measured of the pilot measurements in Pune. It also indicates the type of measurement and the general quality of each segment.

4.1 Results of measuring the quality of two bicycle routes in Pune

Now a pilot survey is developed, which consists partly out of the developed parameters, described in paragraph 3.1 and partly out of the survey method, described in paragraph 3.2.

This pilot survey is conducted at two bicycle tracks in Pune and this chapter presents the results. Paragraph 4.1 first discusses the overview of the bicycle tracks in Pune and shows the summarized results in a map. The more extensive results of the pilot measurements are explicated in paragraph 4.2. This paragraph consists of a table indicating the quality of each segment and explains the specific situation of each segment. For extra details there is a photo appendix and a GIS map, in addition to chapter four, which are not included in this report.

The study ends with chapter five, conclusions & recommendations, discussing the experiences with the pilot survey.

In order to understand which bicycle routes are measured shows paragraph 4.1 an overview of the bicycle tracks in Pune. Then the summarized results of the conducted survey are shown in a map.

The survey is conducted at two bicycle routes in Pune: The Karve Road bicycle route, alongside a sub-arterial road and the Fergusson College bicycle route, which is alongside a smaller road and partly isolated (without a road alongside the bicycle route). As such, these two routes represent different types of routes.

Overview of bicycle tracks in Pune

There are nine bicycle tracks in Pune as showed on the map in figure 4. Numbers 1 & 2 cover the Karve Road bicycle track, numbers 3 until 7 cover the Fergusson College bicycle track, and number 8 until 14 are the other bicycle tracks in Pune. Bicycle routes numbers 8, 12, 13 and 14 are under construction.

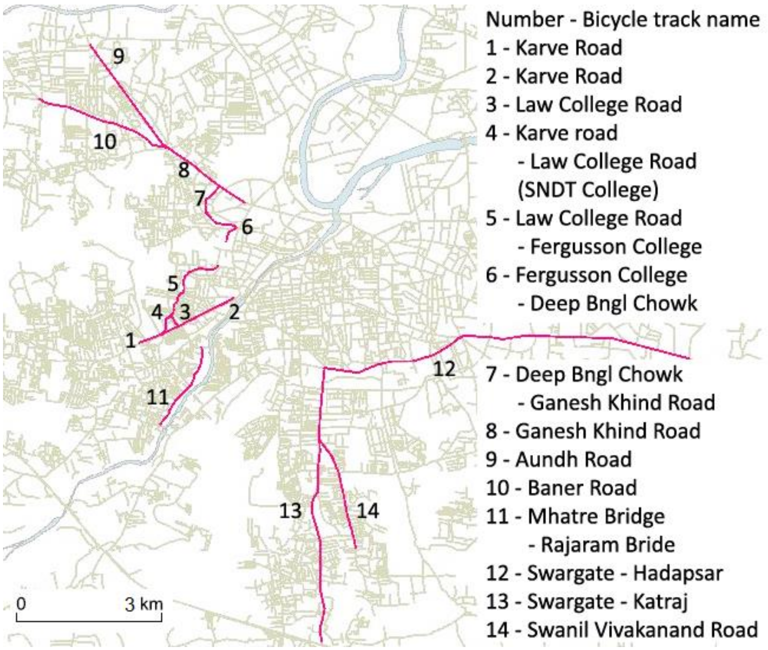

Figure 4: Bicycle tracks in Pune

Summary of results

The map below shows the average quality of each segment of a bicycle track. In addition, the map shows the safety, directness and comfort degree for each segment (figure 5).

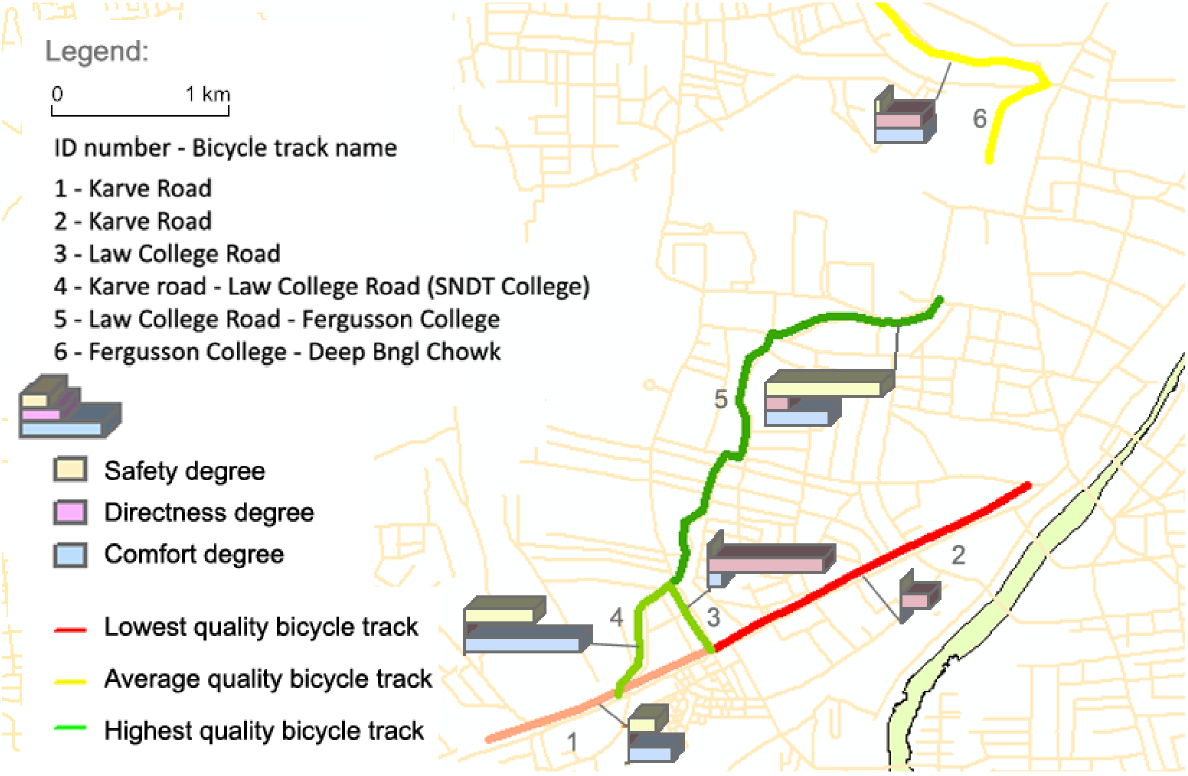

Figure 5: Quality of six segments of bicycle routes in Pune

Explanation

A directness degree of 5 indicates, the segment is the most comfortable for cyclists of all segments, which are measured in this survey and shown in figure 5. See chapter two for descriptions of safety, directness and comfort.

Segment 2 of the Karve Road bicycle route is of the poorest quality, primary due to the pedestrians on the bicycle track and the poor surface quality. Segment 5 of Fergusson College bicycle route is the best quality, primarily due to the high width and the fact there is no road alongside the track.

Remarks

1. One meter of poor quality bicycle route, is not completely compensated with one meter of good quality bicycle route.
2. This survey measures the differences in quality between segments of bicycle routes. Since parameters with a low variety in answers are not measured, the survey gives no grade for the actual (absolute) quality. The survey measures the relative quality of segments of bicycle routes.

   For instance, if traffic islands are important for the quality of bicycle routes, but never present at bicycle routes in Pune, traffic islands are not measured in this survey. However, the actual (absolute) quality of a bicycle route in Pune is influenced by the presence of traffic islands.
3. The parameters used to gain the results are described in Appendix A, Measurement handbook.

4.2 Explicated results of measuring the quality of bicycle routes in Pune

Table 2 shows the same results as figure 5 on the previous page: the results of the pilot survey for the Fergusson College and Karve Road bicycle track in Pune. Next to discussing this table, discusses this paragraph the specific situation of each segment of a bicycle track and general observations of the survey.

Quality of bicycle routes in Pune, India				
Segment of a bicycle route	*Safety*	*Directness*	*Comfort*	*Total score*
1. Karve road	1.2	0.0	1.9	*0.9*
2. Karve road	0.0	1.2	0.0	*0.5*
3. Law College Road	0.1	5.0	0.6	*2.2*
4. Karve road - Law college road (SNDT College)	3.0	0.1	5.0	*2.2*
5. Law college road - Fergusson College	5.0	1.0	2.7	*2.9*
6. Fergusson College - Deep Bngl Chowk	0.2	2.0	2.1	*1.3*
Legend	*Range*			*0 - 5*
	Highest value in colomn			(green)
	Lowest value in colomn			(red)

Table 2: Quality of segments of bicycle routes in Pune

Explanation

A safety degree of 5 indicates, the segment is the safest of all segments, which are measured in this survey and shown in Table 2. Segments are parts of bicycle routes, see paragraph 3.2 for a full description.

Remarks

1. The segments can be localised on the map shown on the previous page (figure 5).
2. In order to obtain the average value of the safety, directness and comfort degree, the weights 2, 2 and 1 apply respectively. Comfort has a lower value since there are less comfort parameters compared to the number of safety and directness parameters. Weights are further explained in Appendix D.

Results specific for the individual segments of the bicycle routes

This sub-paragraph discusses the quality of each specific segment by: showing details of each segment, repeating sections of table 2, indicating the quality and discussing future possibilities of every segment.

For each segment is the parameter 'Quality observation' compared with the results of table 2, in order to know if different measurements are in line with each other. For 'Quality observations' have the fieldworkers, their own observations of the segment, which results in substantiate marks with explanation of the bicycle infrastructure.

1 & 2 Karve Road, Segment 1 & 2

Segment of a bicycle route	*Safety*	*Directness*	*Comfort*	*Total score*
1. Karve Road	1.2	0.0	1.9	*0.9*
2. Karve Road	0.0	1.2	0.0	*0.5*
Legend	*Range*			*0 – 5*

The weak results of Karve Road bicycle track are primary due to the fact there is no physical segregation of cyclists and pedestrian (Table 2). Pedestrians and shopkeepers instead of cyclists use the bicycle track. The positive effect is that this creates separation between pedestrians and other traffic at Karve Road.

Details

Karve Road is measured in the direction from segment one to segment two. The effective width[2] of this 1.2 km long bicycle track is about 90 cm, which should be between 1.8 m to 3 m (Pune Municipal Corporation, 2005). Sometimes, the effective width reaches 50 cm or less. The narrower a bicycle track is, the more unsafe it is.

At an average of 50 meters of the bicycle track, there are two pedestrians and there is one parked vehicle, lamppost or signposts, which causes delay for cyclists[3]. In addition, the quality of the road surface is low and cyclists have to bicycle up and down from the road level to the level of the bicycle track.

The cyclists prefer the busy road, since they cycle on the road instead of using the bicycle track. The quality observation of the fieldworker confirms the lowest measured quality, of the measured bicycle routes in Pune.

Future

The bicycle track is levelled with the pedestrian path, which attracts pedestrians. It might be a solution to construct a bicycle track with a physical barrier, on the road space next to the current bicycle track and the pedestrian path, in order to obtain enough space for pedestrians and different heights between the pedestrian path and the roadway.

3. Law College Road, Segment 3

Segment of a bicycle route	*Safety*	*Directness*	*Comfort*	*Total score*
3. Law College Road	0.1	5.0	0.6	*2.2*
Legend	*Range*			*0 – 5*

Segment three shows a high value for directness and a low value for safety and comfort. The directness degree is mainly due to the small number of barriers at the bicycle track. The low safety and comfort degree is mainly due to respectively the low width of the track and many bollards.

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[2] Effective width is width of the bicycle track minus 25 cm penalty, if it is not possible to cycle over the roadside of the bicycle track (Appendix I).
[3] Data from point measurements is used.

Details

Segment three is measured in the direction of Nal Stop. The effective width of this 400 m long bicycle track is 80 cm, which should be between 1.8m to 3m (Pune Municipal Corporation, 2005). Due to the low width, the low quality of the road surface and since the roadside is not flat, have cyclists little possibilities to make a swerve or to cycle around barriers. Cyclists pass bollards at an average 50 meters of the bicycle track.

The quality observation of the fieldworker indicates that the quality of this track is comparable with segment four and six. The number of unpleasant constructions and the busy road make cycling worse, however the location of a bicycle track at a busy road is good. Examples of unpleasant constructions are low width and constructing a bicycle track at one side of the road only.

Future

Improving this track could attract cyclists, since the location of the track is at a busy road. The pedestrian path should be able to let two people walk next to each other. Further, the entries of the bicycle track are difficult to find and reach, primary due to large intersections with little guidance for cyclists. A bicycle track at both sides of the road could make the guidance more logical. In addition, it will reduce the detour cyclists have to make. In general do cyclists not easily cross the road to cycle a short bicycle track.

Finally, it could be safer to place bollards a few meters away from the intersection, in order to increase safety for cyclists. In addition, to the inconvenience of bollards for cyclists, they can be unsafe, since they ask attention from cyclists. Therefore, cyclists have less attention for the traffic, when entering an intersection.

4. *Karve Road - Law College Road (SNDT College), segment 4*

Segment of a bicycle route	*Safety*	*Directness*	*Comfort*	*Total score*
4. Karve Road - Law college road (SNDT College)	3.0	0.1	5.0	*2.2*
Legend	*Range*			*0 – 5*

The high comfort degree is mainly due to the good quality of the pavement. The main problems here are the pedestrians and other barriers at the bicycle track, which lower the directness degree.

Details

This segment is measured in the direction of segment five. The effective width of this 500 meters long bicycle track is 100 cm, which should be between 1.8m to 3m (Pune Municipal Corporation, 2005). In addition,

cyclists pass posts at an average intersection[4], and cyclists pass a pedestrian and a structural barrier like a tree on the bicycle track, at an average 50 meters . Finally, the road surface is of high quality and the quality observation conducted by the fieldworker, indicates the quality of the bicycle infrastructure is comparable with segment three and six.

Future

Bicyclists and pedestrians use the track, which is at the same height as the pedestrian path and the road. The pedestrian path should at least be 1.50 m width and two meters is preferred for two people who can walk next to each other (ASVV, 2004). The bicycle track should be at a different height as the pedestrian path. If barriers as trees on the track are removed and if the entries and the intersections of the tracks are good, cyclists will be able to travel faster.

5. Law College Road - Fergusson College, segment 5

Segment of a bicycle route	*Safety*	*Directness*	*Comfort*	*Total score*
5. Law college road - Fergusson College	5.0	1.0	2.7	*2.9*
Legend	*Range*			*0 – 5*

This segment consists of two parts . The first 500 meter near Law College Road is of comparable quality as segment four. The second part, a one kilometre isolated bicycle track near Fergusson College, is of the best quality measured. The high safety degree is mainly due to the width and the fact there is no parallel road with other traffic alongside the bicycle track.

Details

This segment is measured in the direction of segment 6. The second one km of this 1.5 km segment has an effective width of 2 meter. Cyclists pass two pedestrians at an average 50 meters of this part. In addition, cyclists pass bollards or a fence where, cyclist have to lift over their bicycles, at an average intersection, which is inconvenient. The quality observation conducted by the fieldworker, indicates this is clearly the best segment measured. Primary since there is no road alongside the bicycle track and the high width. A pity is how is taken care of cyclists at intersections, which is a problem at each segment.

Future

Next to the good maintenance are active reparations of the surface important. Potholes and bollards keep cyclists away and a good pedestrian path might keep pedestrians off the bicycle track, however due to the high width can cyclists cycle around pedestrians. Since there is no road alongside the bicycle route the social security could easily drain. Measures like houses with large windows towards the bicycle track could help.

This segment seems to be of good quality, it will be used more, if the other segments of the Fergusson College bicycle route are of comparable quality and when the segment of the bicycle route through Fergusson College itself is open.

[4] Data from junction measurements is used

6. Fergusson College - Deep Bngl Chowk, segment 6

Segment of a bicycle route	*Safety*	*Directness*	*Comfort*	*Total score*
6. Fergusson College - Deep Bngl Chowk	0.2	2.0	2.1	*1.3*
Legend	*Range*			*0 – 5*

The absence of a pedestrian path makes this segment of a bicycle track mainly used as a pedestrian path. Therefore, many cyclists bicycle on the road. Observations show this is reasonably safe, since the traffic is slow due to bends in the road.

Details

This segment is measured the direction of Göanesh Khind Road. This 1.0 km segment has an effective width of 1.0 m, which should be between 1.8m to 3m (Pune Municipal Corporation, 2005). Cyclists pass a pedestrian and a signpost or lamppost on an average every 50 meters of this bicycle track. At an average intersection pass cyclists bollards to keep out other traffic than cyclists.

The quality observation conducted by the fieldworker indicates, the quality is comparable with segment three and four.

Future

Turning the bicycle track into a pedestrian path and making the road and intersections bicycle friendly might improve road safety for cyclists and keep the pedestrians of the road. This road could become bicycle friendly with traffic calming devices like speed bumps.

General observations

1. A straight bicycle route, like the Karve Road bicycle route, is more direct than a bicycle route with many turns, like the segments near Fergusson College. The detour is smaller.
2. At each intersection, there seems to be a lack of attention for cyclists, while intersections present most problems for safety and comfort for cyclists, which is confirmed by the Master Plan for BRTS Integrated with Cycle Network for PCMC (TRIPP - IIT Delhi & CIRT - Pune, 2008).
3. Uniformity of signage makes it easier for people recognize bicycle routes.
4. The finished bicycle routes show that Pune takes the bicycle routes serious.

5 Conclusions and Recommendations

Conclusions and recommendations highlight the experiences with the developed pilot survey.

Conclusions

The study developed a survey and survey instrument to measure the quality of bicycle routes in Pune, India. The quality of a bicycle route is measured in a structural way, balanced between efficiency and objectiveness. It clarifies the safety, directness and comfort degree of bicycle routes.

The results show the strong and the weak points of segments of bicycle routes. Ninety percent of the results are achieved with objective measurements of twenty parameters. Ten percent of the results are achieved through subjective observations, of the quality of the bicycle infrastructure by the fieldworker. The fieldworker conducts the survey by collecting data in the field with a PDA and GPS.

Of the six measured segments in Pune, the Karve Road bicycle route performs the worst; the bicycle track is levelled with and used as a pedestrian path. The isolated bicycle track, from Law College road to Fergusson College, performs the best; it is the only bicycle track of sufficient width.

Recommendations

The pilot survey is helpful for an indication of the quality of one bicycle route or a few bicycle routes. The analysis is relative simple and the number of parameters small, which decreases the time to conduct the survey. Unfortunately, this also decreases the quality of the results. A more extensive survey could be useful before improving a bicycle route, which is possible by, for instance, including extra parameters.

In addition, the survey could be improved, or used elsewhere by examining parameters. Parameters can be selected again to four criteria, keeping local circumstances in mind: indication of an aspect of quality (like safety), objectiveness, efficiency of measuring & analysing and variation in answers. However, as long as the same survey is carried out elsewhere, results can easily be compared.

Thirdly, when choosing parameters for the survey, it could be helpful to include coherence parameters. For example, a uniform layout could be relatively cheap be realised in Pune and increases the quality of bicycle routes.

Fourth, this survey measures the quality of segments compared to other segments, the relative quality. Research after the real quality of one segment could provide information about the real quality of all segments, the absolute quality.

Finally, the survey could be more efficient with a higher level of automation in the analysis. However, this could make the analysis and the questionnaire in Cybertracker more complicated. One way to obtain a higher level of automation is matching problem descriptions automatically to obtained survey data.

The survey data could also be used to obtain other information. For instances, an indication of the safety for cyclists of all intersections can be obtained.

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7 Appendix

Appendix A: Measurement handbook

The parameter below contains a parameter list of all used survey parameters, divided by type of measurement. The second paragraph in this appendix shows the properties and use of each parameter. The final paragraph explains the frequently used words of the Measurement handbook. Information from the Dutch Bicycle Route Inspection Method (Fietsersbond, 2005) and Designing for bicycle traffic (CROW, 2006) is used.

Parameter list

Description of each parameter

This paragraph presents the parameters that are measured in the field survey. A description of each parameter is given, the use of each parameter is indicated, and some remarks of the parameters are shown.

The first sub-paragraph explains the parameters measured at specific points. The second sub-paragraph explains the parameters measured at intersections. The third sub-paragraph explains the event parameters and the last sub-paragraph shows the parameters, which are measured once each segment. See chapter 3.2 for an explanation of each type of parameter.

1. Measuring at points

Two photographs are made, first in the front direction and second in the rear direction of the bicycle route

1.1 Lighting

Lighting enables the cyclist to see other traffic and barriers.

- Is there lighting present at the bicycle route?

Values: Not, partly, complete

Remarks:

• **Complete** is the presence of at least 1 lamppost, which stands alongside the bicycle route itself. At a road with 2 separated bicycle tracks, the 2 lampposts stands on both sides of the road or one lamppost stands at the middle of the road.

• **Partly** is the presence of a lamppost near the bicycle route. If the lamppost is knocked over (flat on the ground), it should be able to reach the bicycle route. At an intersection with separated bicycle tracks, that should be in the direction, which is measured.

• **Not**: No lamppost present, or present so far removed from the bicycle path that turned, the post is not at the beginning of the track.

(Safety, points)

1.2 Roadside flatness

A flat roadside might prevent accidents, when there is poor sight or when a cyclist needs to make a swerve.

Measure the percentage of roadside flatness of the route

Values: 0%, 1-33%, 34-66%, 67-99%, 100%

Remarks:

0% it is not possible to cycle over the roadside

1-33% when there is a lowering of at least 5 cm, an extreme soft or muddy soil, or a boulder ground.

67-99% when there are 1-3 holes in the roadside of the cycle route in 25 meters

100% is a high quality roadside flatness, it is possible to cycle over the roadside at both sides of the bicycle track

(Safety, points)

1.3 Car parking next to a bicycle route

When a door opens next to the bicycle route, this might cause an accident.

This is a small problem at separated tracks, since there is physical separation between the road and the bicycle track. The survey in Pune only measures separated bicycle tracks, therefore this parameter is not analysed.

Values: 0, 1-3, 4-10, 11 or more

There should be space between a bicycle route and a parked car created by a shock strip. A vehicle is a car when it has at least four wheels and a motor.

Physical separated bicycle track:	minimal distance of at least 30 cm
Alongside parking:	minimal distance of at least 75 cm
Other parking:	minimal distance of at least 100 cm

- Measure the number of wrong parked cars at 25 meters length next to the bicycle route in the direction heading

(Safety, points)

1.4 Mixed road space or separated bicycle track

Separated tracks are generally safer for cyclists, since these tracks lower the interaction with high-speed traffic. However, the effect of the separated track will be contrarily, if there is a poor connection with an intersection. Moreover, separated bicycle tracks are only useful at particular traffic intensities and speeds.
Since this parameter is too complicated, it is not analysed.
Values: mixed, separated, mixed and separated, n/a
A mixed bicycle route means a road without bicycle track.
Bicycle tracks are roads, paths or marked lanes designated for use by cyclists from which motorised traffic is excluded.

- Measure the stretch of road type for 25 meters

(Safety, point)

1.5 Width of the bicycle track

At a wide bicycle track cyclists are able to take care of imperfections in the track by cycling around them, cyclists can cycle next to each other and cyclists can pass each other. The more narrow the bicycle track, the more unsafe.

- Measure the effective width

Remarks:
Effective width is width of the bicycle track minus 25 cm penalty, if it is not possible to cycle over the roadside of the bicycle track. Max. a penalty of 50 cm (This is a simplified measure than the official ‘Profiel van vrije ruimte’ or ‘Free roadside profile’ (ASVV,2004)).
0 means the width is not measured
During the analysis you have to mark if the bicycle track is two-way or one-way, note this in the event section after measuring the first width.
If a track changes from two-way to one way, or from one-way to two-way you have to note this in the note section, this is an event.
(Safety, points)

1.6 Cyclists on the road when a bicycle track is available

If the quality of the road is clearly better than the quality of the bicycle track, cyclists may use the road instead of the bicycle track. In the end cyclists decide if the quality of the track is good or not. If cyclists use the bicycle track a lot, the bicycle track will be of good quality. However, this research is mainly about the physical quality of the tracks and not about the cyclists’ opinion. This parameter will not be analysed.

- Is there a cyclist bicycling at the road alongside of a bicycle track at 25m alongside the bicycle path in the direction heading?

Value: 0, 1, 2, 3, 4-5, 6-9, 10 or more, n/a
(Safety, comfort, points)

1.7 Safety of road for cyclists

This parameter is linked to question 1.6. Since this parameter is subjective, it is not analysed.

If the answer is 1 or higher at question 1.6, have a quick look, if the quality of the road in terms of traffic safety.

- Is the road safe for bicyclists?

Values: Clearly yes, slightly yes, slightly no, clearly no, n/a
Remarks:
When the road is safe and comfortable for cyclists, there may be no need for a bicycle track for cyclists.

Safety
The cycling-infrastructure guarantees the road safety of cyclists and other road-users. Minimising conflicts, minimising the outcome of conflicts, allowing interaction between road users and providing safety margins are important. For example, a separated bicycle track next to roads can increase safety.
(Safety, points)

1.8 Comfort of road for cyclists

This parameter is linked to question 1.6. Since this parameter is subjective, it is not analysed.
If the answer is 1 or higher at question 1.6, have a quick look, if the quality of the road in terms of traffic safety.

- Is the road comfortable for bicyclists?
- Value: Clearly yes, slightly yes, slightly no, clearly no, n/a

Remarks:
When the road is safe and comfortable for cyclists, there may be no need for a bicycle track for cyclists.

Comfort
The cycling-infrastructure enables a quick and comfortable flow of bicycle traffic. Minimising energy consumption and avoiding inconvenient manoeuvring are important. Sufficient maintenance is an example of increasing comfort.
(comfort, points)

1.9 Delay & safety due to barriers

Barriers can be difficult to see in the dark, can slow cyclists down and ask attention of the cyclist. The cyclist has less attention for the driving task.

- What kind of barrier is in 25m length of the bicycle track?

Values are in the first column of the table below.

Barrier	Barrier	Type of barrier
n/a	n/a	-
Structural barrier	Structural barrier	Structural
Temporary barrier	Temporary barrier	Temporary
Very temporary barrier	Very temporary barrier	Very temporary
Building	Building	Structural
	House	Structural
	Shop	Structural
	Stall with fixed pitch	Temporary
	Stall without fixed pitch	Very temporary
Posts or bollards	Posts or bollards (This will not be analysed here)	Structural
Signpost or lamppost	Signpost	Structural
	Lamppost	Structural
Parked vehicle	Empty Vehicle	Very temporary
	Empty Motorized vehicle	Very temporary

	Car	Very temporary
	Two-wheeler	Very temporary
	Bicycle	Very temporary
Pedestrian	Pedestrian (This will not be analysed here)	Very temporary
Cable or small pipe	Cable	Temporary
	Small pipe	Temporary
Wall, fence or hedge	Fence	Temporary
	Wall	Structural
	Hedge	Temporary
Large hole	Large hole	Temporary

Remarks:

- This parameter is measured three times and appears three times at the PDA.
- If there are more than three barriers at the point, choose first:
  -Pedestrians
  -Posts
  Choose second:
  -structural
  -temporary
  -very temporary
  Note the objects in the note section.
- If there are more than one of the same barriers, choose just one barrier.
- Try to choose the most specific description of the barrier from the list.
- A barrier should be on the bicycle route.

- **Structural barriers** permanent buildings and trees.
- **Temporary barriers** are building site, stalls with a fixed pitch, undergrowth, billboards.
- **A very temporary barrier** is a wrong-parked (freight) car, a vehicle for temporary road construction, a bus or people.
- **n/a** means there is no barrier on bicycle track
- **Large hole,** a gab of at least 15 cm deep, 50 cm width and 50 cm long

(Directness, points)

1.10 How much delay gives a barrier

This question is linked to question 1.9.

- How much delay gives the barrier?

Values:

The cyclist has:

to get of his bicycle
to leave the bicycle route
cannot cycle with two people side by side
to slow down
no delay
n/a
(Directness, points)

1.11 Number of posts or bollards

This question is linked with question 1.9.

Posts (or bollards) are used at cycle paths to exclude auto traffic and two-wheelers. For cyclists they cause inconvenience to pass.

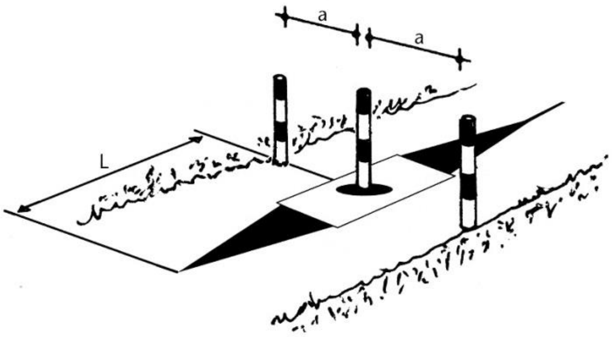
Values: 0, 1, 2, 3, 4

Remarks:
Clear signposting and traffic signs could make posts less necessary.
If a number of posts make a barrier to keep out cars, it will count as one post.
N/a is not used when there are no posts.

- Measure the number of posts at 25 meters length in the heading direction.

(Comfort, points, intersection)

1.12 Number of useful posts



This question is linked to question 1.11.
Values: 0, 1, 2, 3, 4
Remarks:
When there is no other way to keep motorized traffic out of bicycle track, while there is a big change that motorized traffic will enter the bicycle track, posts are useful.
Posts are not useful if they stand apart from each other for more than 180 cm, when cars can drive around them, at the start of a bicycle track which cannot be used as a shortcut for cars, and when the tracks can tell you that people drive around it. When posts are closer than 150 cm they are useful, however a carrier tricycle cannot pass (Routekeuring, 2005).
Posts includes bollards.
N/a is used when there are no posts.
(Comfort, points, intersection)

1.13 Pedestrians on the bicycle track

This question is linked to question 1.9.
Pedestrians at the bicycle track could cause delay for cyclists.

- Are there pedestrians walking on the bicycle track during 1 minute at the 25 meter in the direction heading?

Value: 0, 1, 2, 3-4, 5-9, 10 or more.
Remarks:
If the quality of the bicycle track is clearly better than the quality of the pedestrian path, pedestrians may use the bicycle track instead of the pedestrian path. Therefore, the pedestrian paths should be of good quality.
(Directness, points)

1.14 Quality of the pedestrian path

If the pedestrian path is of low quality, pedestrians might walk on the bicycle route.
If the number is 1 or higher at question 1.13 have a quick look at the quality of the pedestrian path.

- Can two people walk next to each other at the pedestrian path?

Value: clearly no, slightly no, slightly yes, clearly yes, no pedestrian path, n/a
Remarks:
Clearly no means it is only possible to walk with one person at the time or less.
No pedestrian path means there is at least at one meters in the walking direction no pedestrian path.
(Directness, points)

1.15 Bicycle route surface quality

For the road surface is minimising the energy consumption by a smooth surface important.
Values: 0%-25%, 26%-50%, 51%-67%, 68%-100%

Remarks:
Cyclists have no suspension, which makes them sensitive to a good road surface. When cyclist pay disproportionate much attention to the imperfections in the road, they pay less attention to the traffic / bicycling task.

- Measure the smoothness of the surface

- **0%-25%** means surface where some cyclists get of their bicycle or have to leave the bicycle route
- **26%-50%** means at least a lowering of 6 cm, an extreme soft or muddy soil, or a boulder ground.
- **51%-66%** means at least a lowering of 4 cm, mud, branches.
- **67%-89%** means at least a lowering of 2 cm, mud, a cobble stones ground, some leaves or some small branches.
- **90%-100%** means good pavement, no dirt.

(Comfort, point, intersection)

2. *Measuring at intersections*

Make four photographs of the bicycle route, first photograph of the front. An intersection starts 3.5m before and ends 3.5m after the actual intersection.

2.1 Lighting

See 1.1

(Safety, intersections)

2.2 Roadside flatness

See 1.2
(Safety, intersections)

2.3 Shape of intersections

A roundabout generally is safer than other intersection types. This parameter is not analysed since the safety depends on the design of the roundabout.

- Measure the shape of an intersection

Values: +, T, Y, >+, O-four branches, O-three branches, O-five branches or more
\+ is an intersection with four branches
T is an intersection with three branches
Y is an intersection with three branches, with the branches not 90 degree apart from each other
>+ is an intersection with more than four branches
O is a roundabout
(Safety, intersection)

2.4 Distance from the bicycle route to the roadway

The distance from the bicycle path to the roadway (a) has an impact on the visibility of the cyclists (Figure 6). The more space there is between the roadway and the bicycle path, the better the car driver can see cyclists, because the angle is smaller. However, if the distance from the bicycle path to the roadway is shorter it could also be safer, since the car driver is closer to the cyclist.
Values: 0-0,2m, 0,2-0,9m, 1 meter or more, n/a

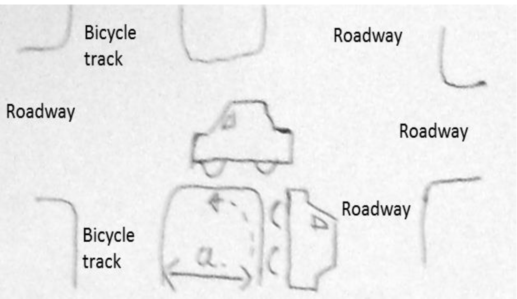


Figure 6

Remarks:
The distance between the bicycle path and the roadway is measured on the side of the bicycle intersection, where the left turning cars drive over the bicycle track. That may in some cases, be on the other side of the intersection. For example, if a two-way cycle track is at the right side of the road. The distance to the roadway will be measured by setting the steps of 1 meter.
Where no separated bicycle track is present, must be chosen for the n/a value, for example at a mixed profile.

- Measure the distances between the bicycle route and the road at an intersection

(Safety, intersection)

2.5 Number of lanes to cross

The more lanes to cross, the more complex the intersection is for the cyclist (and other road users), the less safe.
Values: 1, 2, 3, 4 , 5, 6 or more lanes
Remarks:
How many lanes do the cyclists cross? An intersection is the intersection of 1 branch (see frequently used words) which may consist of multiple lanes.
A one-way road is always 1 lane wide, except when multiple lanes are created with painting on the road. However, if the road is wider than 7 meter, and there are no lanes painted, a lane is counted for every four meters.
(Safety, intersection)

2.6 Sight at intersection while approaching

The better the cyclists see the traffic, the better they can interact and act safe in traffic.
For the sight of cyclists, it is important to see the intersecting traffic at the intersection.
Values: good, moderate, poor
Remarks:

- How well is the sight at the intersecting traffic?
  Good sight while approaching:A sight while approaching of about 75 metres at 50 kilometres per hour
- A sight while approaching of about 50 metres at 40 kilometres per hour
- A sight while approaching of about 25 metres at 30 kilometres per hour

Poor sight while approaching

- A sight while approaching of about 75 metres at 70 kilometres per hour
- A sight while approaching of about 50 metres at 60 kilometres per hour
- A sight while approaching of about 25 metres at 50 kilometres per hour

Moderate is between good and poor. Use this value as little as possible.

To determine sight only temporary and structural obstacles count. Very temporary obstacles are not counted.

- **Structural barriers** include a bend in the road, permanent buildings, relief and trees.
- **Temporary barriers** are building site, stalls with a fixed pitch, undergrowth, billboards, and parked cars if parking is permitted by the presence of parking spaces or parking boxes, or the absence of a parking ban.
- **A very temporary barrier** is a very wrong-parked car or a vehicle for temporary road construction.

(Safety, intersection)

2.7 Maximum speed of intersecting cars

The higher the speed of vehicles are, the more unsafe.

The values: 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 100, unknown, n/a
Remarks:
The maximum speed for motorized traffic driving on the section of the intersecting road.
-Measure the speed with a speedgun or a stopwatch 25 meters away from a lamppost or sign.
The lower the speed is, the greater the chance to anticipate, the smaller the change for accidents. In addition, if the speed is lower, the consequences of an accident are smaller. Last, the subjective safety is better if cars drive slower.
(Safety, intersection)

2.8 *Maximum speed of parallel cars*

The higher the speed of vehicles are, the more unsafe.
The values: 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 100, unknown, n/a
Remarks:
The maximum speed for motorized traffic driving on the section of the parallel road.
-Measure the speed with a stopwatch, 25 meters away from a lamppost or sign.
The lower the speed is, the greater the chance to anticipate, the smaller the change for accidents. In addition, if the speed is lower, the consequences of an accident are smaller. Last, the subjective safety is better if cars drive slower.
(Safety, intersection)

2.9 *Delay & unsafe due to barriers*

See 1.9.
(Directness, intersection)

2.10 *How much delay gives the barrier*

See 1.10.
(Directness, intersection)

2.11 *Number of posts*

See 1.11.
(Comfort, intersection)

2.12 *Number of useful posts*

See 1.12.
(Comfort, intersection)

2.13 *Road surface*

See 1.15.
(Comfort, intersection)

2.14 *Is there a traffic light present at the intersection?*

The values: yes, no
Remarks:
This is value is not analysed.
(Directness, intersection)

2.15 *Waiting time at traffic lights: average green time*

The longer a traffic light is green, the faster a cyclist can travel.
Measure the average green time (seconds):

Values: 0-5, 5-10, 11-20, 21-30, 31-40, 41-50, 51-60, more than 60, n/a

Remarks:

- The waiting time is determined by measuring 2 red and green times cycles or up to 10 minutes measuring. If after 1 cycle a great regularity is discovered, the fieldworker can stop.
- Orange is green group.
- When a traffic light is not crossed, for example, at an exit to the right, of course no waiting times can be measured.

(Directness, intersection)

2.16 Waiting time at traffic light: Measure the average red time (s)

Waiting at a traffic light causes delay. The longer cyclists have to wait, the bigger the change they do not wait until the traffic light turns green. The goal of the Dutch city Utrecht is to keep the waiting time for cyclists below one minute.

Values: 0-20, 21-40, 41-60, 61-80, 81-100, 101-120, 121-180, 181-240, 241-300, more than 300, n/a

(Directness, intersection)

2.17 Delay at non-traffic light: Time to pass the intersection without delay (s)

Waiting at an intersection causes delay.

-Measure the total time to cross the intersection without delay at a non-traffic light intersection.

Values: 1-3, 4-6, 7-10, 11-15, 16-20, 21-30, 31-60, 61 or more, n/a

Remarks:

Delay at non-traffic light = Average time to pass the intersection - Time to pass the intersection without delay

This parameter is about the average time in the passage of 1 branch (this allows multiple lanes) without delay. This must be measured during the rush hour. From a number of observation intersections, there is no need to establish the delay time:

- Delays are mainly measured at busy intersections.
- Delay times are not to be established at roundabouts with cyclists in the primacy.
- Delay times can be estimated at an intersections of busy main roads with an insignificant quiet roads, and at side roads to the right at an insignificant quiet road.
- Delay times have to be established at intersections of priority roads and side roads to the left with normal traffic density, and roundabouts with bicycle not in the priority.
- If there is very little intersecting traffic , the delay time is set at 1 second.
- If there is drop wise traffic, the delay time is set at 3 seconds.

intersection starts 3,5 meters before the actual intersection and ends 3,5 meter after the actual intersection.

- Measure the total time from the intersection without delay.

(Directness, intersection)

2.18 Delay at non-traffic light: Average time to pass the intersection (s)

This question is linked to question 2.17.

Values: 1-3, 4-6, 7-10, 11-15, 16-30, 31-60, 61-120, More than 120 seconds, n/a

Remarks:

Method of working:

• The time is measured how long cyclists take to cross the intersection. There is a solid start and end point. These are as close as possible to the intersection but before the point at which speed starts decreasing. There can be measured in both directions. If there are few cyclists in the field during the peak hour, the fieldworker itself can ride one-way and back.

(Directness, intersection)

3. Measuring of events

Two photographs are made, first in the front direction and second in the rear direction of the bicycle route

3.1 Event

Since not all information about bicycle routes is gathered by parameters, a fieldworker can make an event at an exceptional situation. This is especially meant for barriers at or around the bicycle route which disproportional influence the quality of the bicycle route, and for administrative purposes. The end and begin of a bicycle route is an event.

4. Measuring at a segment

Measuring at a segment takes place at a bicycle with a Pocket computer and GPS. Possible aspects to measure are time to bicycle a segment or global quality aspects.

4.1 Quality observation

This question is linked to question 4.2.
Fieldworkers have many observations during the measurements, which are not captured by the parameters. They give marks for the quality of the bicycle infrastructure, considering these observations.
The fieldworker has to give a mark, as objective as possible, scale 1 to 9 about the quality of the bicycle path.

4.2 Opinion of the fieldworker

Fieldworkers explain their mark.

Frequently used words

Bicycle intersection

An intersection for cyclists alone (and sometimes pedestrians) to a priority road (a road where the cyclists have no priority). A right turn to a solitaire bicycle track is also a bicycle intersection.

Bicycle track

Bicycle tracks are roads, paths or marked lanes designated for use by cyclists from which motorised traffic is generally excluded.

Bicycle route

Bicycle routes is a signposted, described or otherwise facilitated routes for recreational or commuter purposes.

Branch

To see if different road lanes belong to the same branch there are criteria.

These do belong to the branch:

I. Lanes which lay alongside each other
II. Lanes which are separated trough a middle roadside
III. Lanes which have different traffic lights

These do not belong to the branch:

I. Lanes which are separated trough a middle road-side and the traffic is on the other side not heading in the opposite direction
II. When the middle road-side is wither than 20 meters
III. When the intersections are separated through a bridge, a subway or a fly-over.
IV. When the priority for the cyclists changes at the new roadway

Driving Task

Cycling needs attention from cyclists, for example to watch out for other traffic. If cyclists have to pay attention to other things, they pay less attention to the driving task.

Intersection

A place where two roads or two tracks cross.

Intersection with a priority road (when the road should be crossed)

When you approach a priority road and you do not have right of way (priority road is the same as a road with priority).

Intersection with traffic light

A traffic light is only a observation intersection when it is passed by the route (left turns can be free). A service road with a side-road to the left with at the main road a traffic light is no observation intersection; all roundabouts with a traffic light are intersections with traffic lights.

This type of intersection we call ‘traffic light’.

Observation intersection:

1. Observation intersections are intersections, where the cyclists have no priority, and intersections where it is of greater importance that the intersections are well regulated.
2. In general all intersections are measured, however if a side-road of a priority road has low traffic during peak hour, it is not an observation intersection. Low traffic is less than one vehicle every 10 seconds.
3. If the route does not cross an intersection because of a turn left, it is no observation intersection.

Segment

Segments are parts of bicycle routes. A segment is about 2 km and the start and end point are chosen with respect to details of the infrastructure. The aim is to choose the start and end point in a way, which results in as much coherence as possible during one segment.

Side-road to the left

If you turn left at a priority road (Note: Dutch cars drive at the right side of the road, in contradiction to Indian cars).

Appendix B: Not used parameters

Like the parameters from the 'Measurement handbook' indicate the parameters in the 'Not used parameters' an aspect of quality (safety, coherence etc.) of a bicycle route. The parameters, which are shown in this appendix are not used in the survey in Pune. This is mainly due to a not sufficient value for one or more criteria, which are explained below and in paragraph 3.1. This appendix explains how each parameter is weighted to the criteria and the parameters itself. After explaining the criteria used to weight the parameters, the not used parameter list, and the explanation of each not used parameter is shown.

Criteria for selecting parameters

After gathering parameters, the parameters are selected to four criteria. The legend explains the criteria. See paragraph 3.1 for further explanation.

Legend:

++++

First +	Indication of an aspect of quality (like safety)
Second +	Objectiveness
Third +	Efficiency of measuring & analysing
Fourth +	Possible variation in level of answers

Symbolism:

+ indicates good score

= indicates normal score

- indicates poor score

Variation in level of answers indicates whether a parameter has different answers at different locations.

Legend: criteria for selecting parameters	
First +	Indication of an aspect of quality (like safety)
Second +	objectiveness
Third +	efficiency of measuring & analysing
Fourth +	possible variation in level of answers

Not used parameters

The list parameter list below shows, which parameters are not used in the survey in Pune and shows an indication why the parameters are not used. The criteria are explained in the previous paragraph.

Legend: criteria for selecting parameters	
First +	Indication of an aspect of quality (like safety)
Second +	objectiveness
Third +	efficiency of measuring & analysing
Fourth +	possible variation in level of answers

Description of each parameter

The sub-paragraphs below show a description of the not used parameters. In addition is indicated why a parameter not is used, using the criteria explained in the first paragraph.

The first sub-paragraph discusses the not used parameters at a point of a segment. The second sub-paragraph discusses the not used intersection parameters. The third sub-paragraph discusses the not used event parameters. The last sub-paragraph discusses the not used data analysing parameters. Note that some parameters are not fully clear, since they are removed from the Measurement handbook in an early stage.

1. Measuring at points of a segment

1.1 Axis marking +++-

This is never present at one-directional bicycle tracks, which are mainly present in Pune.

Axis marking: (discontinuous) line between the two-ways cycle traffic

- Measure the axis marking (Values: Yes, No, n/a)

There is a lower risk for accidents when there is axis marking, since axis marking provides guidance for cyclists.

(Safety, points)

1.2 Side marking -++-

This is rarely present at separated bicycle tracks.

Side marking: (discontinuous) line between road and cycle path

- Measure the presence of side marking (Values: Yes, No, n/a)

There is a lower risk for accidents when there is side marking, since marking provides guidance for cyclists and other road users.

(Safety, points)

1.3 Mixed road space design in relation to speed regime -++-

The speed maximum is similar at most roads, 40 km/h in Pune.

Roads in built-on land with a speed maximum between 30 km/h and 80 km/h should have bicycle facilities. A mixed road space design means there are no bicycle facilities present at the road.

- Has the road a mixed road space design and a higher speed maximum than advised?

Values: Yes, partly, no

Remarks:

- **Partly** is the presence of mixed road space and not everywhere a speed maximum of 30 km/h or lower.
- **Partly** is a speed maximum higher than advised and not everywhere a mixed road space.

(Safety, points)

Legend: criteria for selecting parameters	
First +	Indication of an aspect of quality (like safety)
Second +	objectiveness
Third +	efficiency of measuring & analysing
Fourth +	possible variation in level of answers

1.4 Object free space =+=+

Object free space is not considered to be the most important problem, priority is the bicycle track itself.

50 Centimetres from the bicycle route should be no objects (like traffic signs, lampposts, commercial signs or traffic lights cases)

- Measure the number of posts and objects which are nearer than 50 cm from the bicycle track which are visible

Values: No, 1-2, 3-10, 11 or more

(safety, points)

1.5 Social security =+=+

Social security gives information about the attraction of bicycle tracks and is important for cyclists since they are more venerable than motorized traffic. However, social security is difficult to measure and the physical condition of a bicycle route has priority.

Social security is the degree in which people freely can move around without a threat of violence. A smart special layout of the area has a great influence at both the subjective social security (are the surroundings experienced safe) and the objective social security (the change of violence or the threat of violence). The presence (of the type) of buildings and the sight on the surrounding area are used to measure social security. Note that social security is extra important, when bicycle routes are constructed not at main roads or at solitaire bicycle tracks.

Surroundings

Linked with social security

The values: Houses, businesses / stores, businesses / stores / homes, undeveloped

Remarks:

This feature has to do with social security and is linked with distances, and hearing distances, and sightlines to buildings. The following approach:

• **Houses**: there is at least one house at the route, there has to be a sight from the house at the routes and / or the house is located at hearing distance from the intersection.

• **Companies / stores**: the same directive as for housing but now toward companies or stores. Also one company or shop is visible at the route or is within hearing distance.

• **Companies / stores / houses**: idem.

• **Undeveloped** is the absence of buildings. Around the intersection is located on all sides only forest, pasture, field or water. When there are still buildings at some distance, than those buildings lie outside hearing distance (cry) from the intersection. The hearing distance is obviously smaller in noisy and / or major intersections.

(Attractiveness, points)

Sight on the surroundings

Linked with social security

The values: good, reasonable, poor, n/a

Poor sight at the environment is rated poor by cyclists. The sight on the surroundings will be rated poor if the stretch of road is grown over or if objects higher than 1,25 meter are present within 3 meters of the border of the road. Distances of 3 to 10 meters of the road are rated reasonable.

(Attractiveness, points)

Legend: criteria for selecting parameters	
First +	Indication of an aspect of quality (like safety)
Second +	objectiveness
Third +	efficiency of measuring & analysing
Fourth +	possible variation in level of answers

Social unsecure route parts
Linked with social security
The social security of a route part without occupied buildings and with a poor sight at the surroundings is remarkable less, than the social safety of a route part without buildings with a good sight on the surroundings.

1.6 Quality of the road compared to bicycle track +--+

This parameter is not objective since it is the opinion of the fieldworker.
Linked to 1.6 Measurement handbook.
Is the quality of the road (in terms of safety, directness and comfort) better than the quality of the bicycle track?
Value: Clearly yes, slightly yes, slightly no, clearly no
Remarks:
Clearly yes means the road is of better quality in terms of safety, directness and comfort than the bicycle track.

1.7 Quality of the pedestrian path compared to bicycle track +--+

This parameter is not objective since it is the opinion of the fieldworker.
Linked to 1.13 Measurement handbook.

- Have a quick look of the quality if the bicycle track is better than the quality of the pedestrian path.
- Make 2 pictures of the pedestrian path next to the bicycle track

Value: clearly worse, slightly worse, slightly better, clearly better (1, 2, 3, 4)

2. Measuring at intersections

2.1 Object free space ++-+

See parameter 1.4.

(Safety, intersection)

2.2 Traffic light conflict Free ++==

The small number of traffic lights make the analysing difficult due to a low number of values.
The values: yes, no, n/a
Remarks:

- **Conflict Free** is that green is for the bicycle and the other lights are adjusted in a way that during the intersection for cyclists no other traffic will encounter them.
- **N/a**: for example when an intersection is a one-way road.

(Safety, intersection)

2.3 Waiting lane at an intersection =+==

This parameter is difficult to analyse due to very different road designs in Pune.
The values: Spacious, tight, sufficient, pcwl, n/a
Remarks:

- This feature is the lane of cyclists who are not in the priority. An important criterion is whether the cyclists, while they are waiting at a lane, block the road for other traffic.

Legend: criteria for selecting parameters	
First +	Indication of an aspect of quality (like safety)
Second +	objectiveness
Third +	efficiency of measuring & analysing
Fourth +	possible variation in level of answers

- The most common situations are waiting lanes, where (mopeds and) cyclists are intersecting on a separated bicycle track, or (mopeds and) cyclists in the same direction, heading left. For cyclists, who may turn left is often no separate provision in the form of an early exit to the left. Sometimes it is precisely this turn, which causes the lane for waiting, tight.
- In the absence of an early exit to right for the left-turning cyclists, the width of the lane is of interest. That fact provides the opportunity or they can pass the waiting cyclists.
- Over: If the lane to wait is at least 3 bicycles long and 3 bicycles wide (there is space for 10 bicycles).
- Tight: If the lane to wait is less than 1 bicycle long or if cyclists are not able to stand side by side (there is space for at maximum 1 bicycle).
- Sufficient: If the lane to wait is approximately 2 bicycles long and at least 3 bicycles wide (there is space for 6 bicycles).
- fcwl stands for front cycle waiting lane. This is the lane for waiting for cyclists before the row waiting cars. For this feature, we measure just the presence, not the quality. If the quality is low, this must be mentioned in the note section.
- **N/a**:
  - cyclists in the primacy
  - no conflict, this is only the case if there are no bicycle tracks intersecting and there is no exit to the right.
  - an exit to the right through an early exit

(Comfort, intersection)

2.4 *Direction heading =+=+*

For cyclists is heading right more unsuspected and difficult than straight or left. However, this parameter is the best to be measured in combination with the intersection density for the analysing (see parameter 5.4).

Values: straight, right, left, other

- Measure the direction the route is heading at the intersection

(Safety, intersection)

2.5 *Sleeping policemen (E4) ++==*

There is a small number of sleeping policemen in Pune. Sometimes they are built to protect cyclists, and sometimes they are a hindrance to cyclists, which makes it complicated to analyse.

Values: 0, 1, 2 or more

Sleeping policemen ask attention of the driver. At a priority intersection, there should be no sleeping policemen at the bicycle route. The research measures ‘half’ sleeping policemen. One whole sleeping policeman counts as two.

- Measure the number of half a sleeping policemen/km

(Comfort, intersection)

Legend: criteria for selecting parameters	
First +	Indication of an aspect of quality (like safety)
Second +	objectiveness
Third +	efficiency of measuring & analysing
Fourth +	possible variation in level of answers

2.6 Wind discomfort =++=

Since the wind changes day to day this is difficult to measure & analyse. There seems to be no wind problem in Pune. Continuous wind on long distance causes less speed and discomfort. Bicycle routes should have as little wind as possible.

- Note how many km has discomfort of wind

2.7 Give priority +++-

Cyclists have normally no priority at intersections. The value would be the same at most measurements.
Values: Yes, no, from the primacy removed, equivalent traffic light, n/a
Remarks:
Should there (yes) or (no) right of way been given at the intersection.

- From the primacy removed means that the roadway in the priority is and not the bicycle route.
- At an intersection with traffic lights, the situation is measured as if the traffic lights were off.

(Directness, intersection)

2.8Auto and bicycle connected request =++-

Cyclists have normally no other traffic lights than motorized traffic. The value would be the same at most measurements.
The values: yes, no, n/a, unknown
Remarks:

- **Auto and bicycle connected request**: request for green for cars (it may exist in combination with preregistration loops) is connected with request for cyclists in the same direction. The point is that the bicycle is also green as no one presses the button.

(Directness, intersection)

2.9Traffic island +++-

The number of traffic islands is very small in Pune.
Values: yes, no, not sufficiently deep
Remarks:

- Is there at the bicycle intersection (yes) or (no) a traffic island present, of at least one bicycle length long?

A traffic island makes the distance to cross smaller.
(Safety, intersection)

2.10 Slopes +=++

Slopes are difficult to measure.
A steep slope lowers the comfort.
Values: 0-5%, 6-15%, 16% or more

- steep slopes

2.11 Stop frequency at intersections ++-+

Measuring the stop frequency is time consuming and difficult to analyse.
Percentage of cyclists out of three, which stop at each intersection.
Values: 0%, 1-33%, 34-66%, 67-99%, 100%, n/a
(Directness, intersection)

Legend: criteria for selecting parameters	
First +	Indication of an aspect of quality (like safety)
Second +	objectiveness
Third +	efficiency of measuring & analysing
Fourth +	possible variation in level of answers

4. Measuring at a segment

A measurement at a segment means the measurement is conducted once each segment.

4.1 Time: average speed ++-+

This is time consuming since each segment has to be bicycled for this parameter.
The closer the bicycle speed is to the standard cycle speed, the faster the cyclists travel, the better the directness.

- Measure 1 times the cycle speed, with a standard cycle speed of 15 km/h

(Directness, segment)

5. Measuring with data analysing

5.1 Make a detour factor +=-+

The analysing is at an advanced level and time consuming.
Make a detour factor: difference between a straight distance and the bicycle route length. The route length should be max 1.2 times the straight distance.

- Measure the distance of each detour from the main road with a mileage counter
- Compare this with the actual distance

(Directness, data)

5.2 Number of quality changes +=-+

Complex and time consuming, data analysing is needed to measure this parameter.
Quality changes at a bicycle route are undesirable in order to recognize the bicycle route. The 'Routekeuring' uses four characteristics:

- Stretch of road type (bicycle track, mixed profile, etc.)
- Width of the stretch of road (for the bicycle) (at least 30 cm difference)
- Pavement
- Auto parking facility at the left side

Analysing the data of measured points gives a fair idea of the number of quality changes. At each measuring point the stretch of road type, width of the stretch of road, pavement and auto parking facility are measured.
(Coherence, data)

5.3 Speed maximum at the road =+-=

This data is not available for this research.

- From available road data

(Safety, data)

5.4 Intersection density++-+

Measuring the intersection density is time consuming.
The more intersections a km are at the bicycle route, the more delay due to intersections.

- Measure the number of intersections/km
- Measure the number intersections with only one side-road

(Directness, data)

Appendix C: Calculations

Finding the safety, directness and comfort degree

To find the absolute safety, directness and comfort degree there is a three-step calculation.

The score of an aspect of quality for one segment (Q):

1. Each value is linked to a result value
2. Formula 1 is used to calculate P
3. Formula 2 is used to calculate Q

Formula 1: $P \quad = (\frac{\sum_{n=1}^{a} r_n}{a})$

Formula 2: $Q = \frac{\sum_{n=1}^{b} P_n * w_n * a_n}{\sum_{n=1}^{b} w_n * a_n}$

Legend

Unity	Variable	Explanation
P	Average score for one parameter	The average result value for one parameter
Q	Score of aspect of quality for one segment	For example safety, directness and comfort
a	Number of values for one parameter	
b	Number of parameters for one aspect of quality	
W	Weight of parameter	
R	Result value	A number linked to a value to grade the value
	Parameter	A survey question
	Survey data	The result spreadsheet of the questionnaire
	Value	Answer of a survey question

Explanation:

1. Each value is linked to a result value (scale 0 - 10), in order to grade answer of the questionnaire. The result value indicates if it is a good or poor value. The grading do not composite one meter of low quality bicycle route, completely with one meter of high quality bicycle route.

Legend of the influence of the result value to the parameter

9	The value has excellent influence
7	The value has a good influence
5	The value has average influence
2	The value has poor influence
0	The value has serious influence

For example the value ‘no’ at the parameter ‘Lighting at the bicycle route’ has a result value of 0.

2. Formula 1 is used to calculate P
   For instances, the average result value of the ‘Lighting’ parameter is calculated at one segment, which is 3.

3. Formula 2 is used to calculate Q
   The importance of a parameter in the aspect of quality depends on the weight and the number of values for this parameter. The more measurements and the higher the number of values, the better the indication of the parameter is. The weights are explained in appendix D.

   For instance, the average result value 3 for ‘Lighting’ is multiplied with the

Unity	**Variable**	**Explanation**
$Q_{Relative}$	Relative aspect of quality	For example a safety degree of one segment, compared to other segments.
Q	Absolute aspect of quality	For example a safety degree of one segment, at a scale of zero to five.
$Q_{Minimum}$	Lowest absolute aspect of quality of all segments.	For example, the lowest present absolute safety degree of all segments at a scale of zero to five could be one.
$Q_{Maximum}$	Highest absolute aspect of quality of all segments.	For example, the highest present absolute safety degree of all segments at a scale of zero to five could be four.

weight for ‘Lighting’ and the number of times ‘Lighting’ is measured at the segment. This is calculated for all the safety parameters the same way. From this is the average safety degree of the segment calculated.

From absolute quality to relative quality

The grade of the aspect of quality which is now calculated is absolute. The survey measures the relative quality. With the formula below the relative aspect of quality is calculated. More information about relative and absolute can be found at paragraph 4.1.

Formula 3: $$Q_{relative} = \frac{Q - Q_{minimum}}{Q_{Maximum} - Q_{Minimum}}$$

Legend

Appendix D: Weights of the parameters

Different weights are used to prioritise survey parameters, and the aspects of quality (like safety). For the survey parameters are the criteria: the excellence of the indication of an aspect of quality of the parameters, and the objectiveness of the parameters.

The criterion for the weights for aspects of quality is the number of measured parameters. In order to obtain the average value of the safety, directness and comfort degree, respectively, the weights 2, 2 and 1 apply. Comfort has a lower weight, since there are less comfort parameters compared to the number of safety and directness parameters.

Legend for excellence of the indication of an aspect of quality of a parameter

+	High, the parameter represents the aspect of quality
=	Normal, the parameter indicates the aspect of quality
-	Low, the parameter influences the aspect of quality positively

Legend for the excellence of the objectiveness of a parameter

+	High, the parameter is objective
=	Average, the perception of the fieldworker could influence the parameter.
-	Low, the parameter reflects the opinion of the fieldworker

In addition, the connection between the parameter and the indication of an aspect of quality is explained.

The weight is a value between 1 and 7, which represents the importance of a parameter for the quality of a bicycle route. These weights can be adjusted in the spreadsheet, which is accompanied with this study.

Legend for the weights of a parameter

7	High importance
3	Average importance
1	Low importance

Safety parameters				
	Aspect of quality	Objectivity		Weight
1.01 Lighting	+	+	Lighting enables the cyclist to see other traffic and barriers.	5
1.04 Mixed road space or separated bicycle track	=	+	Separated bicycle tracks are safer for cyclists, since these tracks lower the interaction with high-speed traffic.	3
1.05 width	+	+	At a width bicycle track are cyclists able to take care of imperfections in the track by cycling around them, cyclists can cycle next to each other and cyclists can pass each other. The more narrow the bicycle track, the more unsafe.	7
2.05 Number of lanes to cross	=	+	The more lanes to cross, the more complex the intersection is for the cyclist (and other road users), the less safe.	3

2.06 Sight at intersec-tion while approaching	+	=	The better the cyclists see the traffic, the better they can interact and act in traffic.	4
2.07 Maximum speed of intersecting cars	+	=	The lower the speed of intersecting cars, the greater the chance to anticipate, the smaller the change for accidents is. Also, if the speed is lower, the consequences of accidents are smaller, and the subjective safety is better.	3
2.08 Maximum speed parallel cars	+	=	The lower the speed of intersecting cars, the greater the chance to anticipate, the smaller the change for accidents is. Also, if the speed is lower, the consequences of accidents are smaller, and the subjective safety is better.	3
4.2 Quality observation of bicycle infrastructure	+	-	Fieldworkers observe the whole bicycle route, including observations which are not captured by the parameters. His observation degree counts for 10% of the safety degree.	3

Directness parameters				
Aspect of quality	Objectivity			Weight
1.09 Delay & safety due to barriers	+	=	Barriers can be difficult to see in the dark, can slow cyclists down and ask attention of the cyclist. Cyclists have less attention for the driving task.	5
1.10 How much delay gives the barrier	+	=	Barriers can be difficult to see in the dark, can slow cyclists down and ask attention of the cyclist. The cyclists have less attention for the driving task.	5
1.13 Pedestrians on the bicycle track	+	=	Pedestrians on the bicycle track can cause delay for cyclists.	5
1.14 Quality of the pedestrian path	=	=	If the pedestrian path is of low quality, pedestrians might walk on the bicycle route. This causes delay for cyclists.	2
2.15 Average green time of traffic lights	=	+	The longer a traffic light is green, the faster cyclists travel.	4
2.16 Average red time of traffic lights	=	+	Waiting at traffic lights causes delay. The longer cyclists are waiting, the bigger the change they do not wait until the traffic light turns green.	4
2.18 Delay at intersections without traffic lights	+	+	Waiting at an intersection causes delay.	6
4.2 Quality observation of bicycle infrastructure	+	-	Fieldworkers observe the whole bicycle route, including observations which are not captured by the parameters. His observations count for 10% of the directness degree.	5

Comfort parameters				
Aspect of quality	Objectivity			Weight
1.02 Roadside flatness	=	+	A flat roadside might prevent accidents, when there is poor sight or when cyclists need to make a swerve.	4
1.11 Number of posts or bollards	=	+	Posts (or bollards) are used at bicycle tracks to exclude car traffic. For cyclists they cause discomfort to pass.	3
1.12 Number of useful posts or bollards	=	+	When there is no other way to keep out motorized traffic of bicycle track, and there is a big change that motorized traffic will enter the bicycle track, posts are useful. Post are not useful if they do not keep out motorized traffic.	4
1.15 Bicycle route surface quality	+	+	For the road surface is minimising the energy consumption by smooth surface important.	7
4.2 Quality observation bicycle infrastructure	+	-	Fieldworkers observe the whole bicycle route, including observations which are not captured by the parameters. His observations count for 10% of the comfort degree.	2

Appendix E: Survey considerations

The considerations below indicate what the survey could and could not achieve.

Considerations

- \+ The survey can be used to evaluate bicycle routes
- \+ The survey indicates the strong and the weak points of bicycle routes
- \+ The survey enables comparison with other routes
- \+ The survey indicates results at segment level
- \+ The survey focuses on bicycle infrastructure
- \+ The survey is objective
- \+ The equipment costs for this survey are relative low
- \+ The survey can relative easily be adjusted
- \+ Survey results and data can be used for cycling inclusive planning decisions at network level
- o The survey is technical (especially compared to a focus group, which assesses the quality of bicycle routes, or to a questionnaire for citizens)
- \- The survey is in an early development state (pilot survey)
- \- The survey is time consuming
- \- The quality of the survey results is not clear
- \- The survey focuses on separated bicycle tracks instead of bicycle routes
- \- It could be necessary to adjust the survey before using it elsewhere
- \- Only people with a knowledge level to understand a relatively complicated survey can conduct the survey