Social Media and Crowd Sourcing to Evaluate and Compare Priorities and Preferences for Sustainable Transportation System

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APPROVAL

This is to certify that the dissertation entitled "**Social Media and Crowd Sourcing to Evaluate and Compare Priorities and Preferences for Sustainable Transportation System**", by Md. Asif Hasan Anik has been approved fulfilling the requirements for the Bachelor of Science Degree in Civil Engineering.

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DECLARATION

I declare that the undergraduate research work reported in this thesis has been performed by me under the supervision of Assistant Professor Dr. Moinul Hossain. I have exercised reasonable care to ensure that the work is original and has not taken from the work of others.

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ABSTRACT

To ensure that decisions are made reflecting public needs, public participation has become an indispensable part of transportation planning process. Social media and crowd sourcing are gaining popularity day by day to interact and engage with the general public in various sectors. Though this approach has high potential, its application has been so far been quite limited in the field of transportation planning. This research aims to evaluate the possibility to conduct public participation through the use of crowd sourcing and social media in transportation planning. For this, it uses social media to engage with general people to identify their views on sustainable transportation system. Based on this, it designs an online questionnaire survey to ascertain and prioritize various aspects of sustainable modes of transport, e.g., walking, cycling and public transport environment through Analytic Hierarchy Process (AHP). The questionnaire was spread through social media. A total of 80 general public and 10 transport experts responded to the questionnaire. Through this, the study identifies and compares the perception of general road users and transportation experts regarding sustainable transportation. The outcome suggests that both the groups put highest priority for public transport followed by walking and bicycling. However, the survey responses show variations between general public and expert's opinions in prioritizing components of these modes of transport. Based on the survey, according to general public, for a developed public transport special facilities for women and children, monitoring devices for surveillance purpose must be provided in the transport while the transportation experts thought is to give the behavior of transport operators and neatness of transport the highest priority. To achieve a positive sidewalk environment the general road users think provision of street amenities like toilets and dustbins, prohibiting hawkers on footpath should be given highest priority while experts have given provision of evening lights and seating facilities at bus stations highest importance. In case of bicycling, both the general road users and experts prioritized provision of separate crossing system for cyclists, speed monitoring system and evening lights on roads as the most important necessities for achieving a proper bicycling environment. This information is expected to be highly beneficial for both the academicians and practitioners from relevant backgrounds.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 Background

1.1.1 Sustainable Transportation and its importance

Sustainability means meeting the needs of the present without compromising the ability of future generation to meet their own needs (World Commission on Environment and Development, 1987). Extending this concept to the field of transport will imply that transportation systems should be developed in such a manner so that it contributes to provide mobility to people without compromising the needs of future generation. Black (2010) attempted to define a sustainable transportation system as one that provides transport and mobility with renewable fuels while minimizing emissions detrimental to the local and global environment and preventing needless fatalities, injuries and congestion. The definition highlights that sustainability is not just being environmentally responsible but transport still needs to achieve its role of providing mobility, safety and comfort. Another simpler definition is given by European Union Council of Ministers of Transport suggesting sustainable transportation system is one that is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as a balanced regional development.

Transport has an impact in shaping the urban areas and dweller's lifestyles (Karim, 1998). Efficient and effective urban transportation system is a mean to both promoting urban development and providing adequate access, mobility and ease to the urban dwellers. Transport can release working capital from one area, which can be used more productively as fixed capital elsewhere (Karim, 1998). The inadequacy of transport facilities are one of the major bottlenecks to so0cio-economic development of the major cities and national integration (Mannan et al., 2001). A sustainable transportation system of a city assists in economic and social development of the city life. Economists have argued that for assisting overall economic development an appropriate transport planning is needed.

Transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and carbon dioxide emission (World Energy Council, 2007). Greenhouse gas emissions from transport are increasing at a faster rate than any other energy consuming sector (Ribeiro et al., 2007). The social costs of transport include road crashes, air pollution, physically inactivity, along with time taken away from the family while commuting, vulnerability to fuel price increases, etc. Traditional transport planning aims to improve mobility, especially for vehicles, and may fail to adequately consider wider impacts. However, the real purpose of transport is access to work, education, goods and services, friends and family and there are proven techniques to improve access while simultaneously reducing environmental and social impacts, and managing traffic congestion (Litman, 2003). Communities which are successfully improving the sustainability of their transport networks are doing so as a part of a wider program of creating more vibrant, livable, sustainable cities.

1.1.2 Public involvement for achieving sustainable transport

Transport infrastructure lasts for decades, which means that the decisions that the local and national governments make today will have long-lasting impacts on urban development and form, as well as climate. (UN Sustainable Development Knowledge Platform, 2016).General public are the main users of transportation infrastructure .If there remains a gap between the policy makers and local people in participating in the planning process, the development projects that are implemented today may not achieve its desired efficiency in the long run.

Current planning examples in Europe like Stuttgart or Bucharest, where controversial urban development projects led to mass protests, show that planning processes without public legitimation can be blocked and, in the worst case, even prevented. In Stuttgart, people protested against the huge urban renewal project “Stuttgart21”. In Bucharest, large parts of the historical center were supposed to be demolished for road construction. Both projects lacked public participation and communication with the public and media. Both cases show as well that public’s rejection initiated a broad discussion about the planning

and also to changing of plans. Therefore, urban transport planning needs more, better and also added active involvement procedures.

Citizens should be involved in several planning phases such as in the identification of transport and mobility problems, in specifying the vision and objectives, in the strategy development process, in suggesting possible solutions and also during the identification and evaluation of those solutions (Rupprecht Consult Guideline, 2013). Involving citizens in planning is a fundamental duty of local authorities to improve decision-making and it has been stipulated as a requirement by European Union directives and international conventions (United Nations Economic Commission for Europe, 1998).

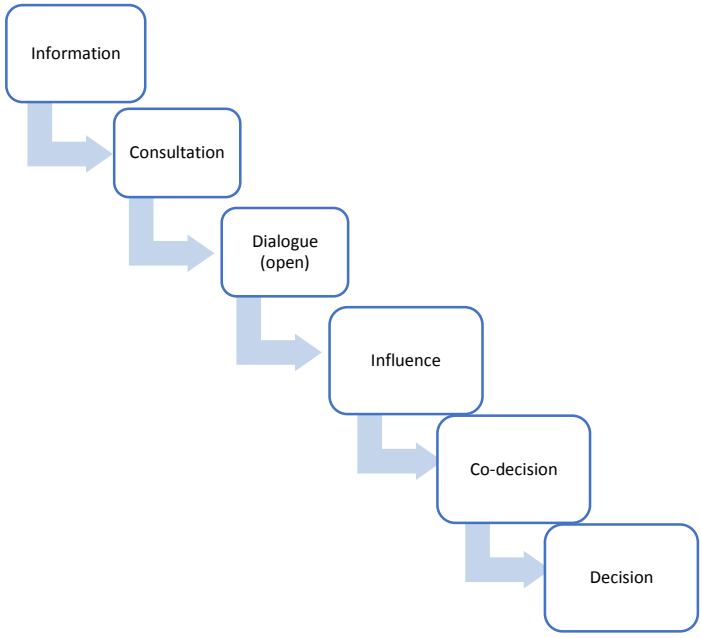


Figure 1: Chances and potential of participation for better transport planning (Hilmar Sturm, 2011/12)

1.1.3 Public participation in the planning process

Public participation is a proactive process in which governing bodies strive to find innovative ways to identify and engage the affected public, provide a wide variety of opportunities for interested parties to become involved, and create a meaningful process that is transparent and ensures effective communication about how public contribution influences decisions. It is also important that a public participation process be continuously evaluated and improved to ensure that under-represented communities are given a voice (Holmes, 2011).

There is no single formula or approach to public involvement. Any open public involvement process should provide opportunities for the community to be involved during all phases of the planning and decision making processes. For successful public involvement, planners should consider the public's comments and demonstrate how they influenced decisions or explain how they were otherwise addressed.

Public participation is an integral part of the transportation process which helps to ensure that decisions are made in consideration of and to benefit public needs and preferences. Early and continuous public involvement brings diverse viewpoints and values into the decision-making process. This process enables agencies to make better informed decisions through collaborative efforts and builds mutual understanding and trust between the agencies and the public they serve. Successful public participation is a continuous process, consisting of a series of activities and actions to both inform the public and stakeholders and to obtain input from them which influence decisions that affect their lives. The public, in any one area or jurisdiction, may hold a diverse array of views and concerns on issues pertaining to their own specific transportation needs. Conducting meaningful public participation involves seeking public input at specific and key points in the decision-making process issues where such input has a real potential to help shape the final decision or set of actions. Public participation activities provide more value when they are open, relevant, timely, and appropriate for the intended goal of the public involvement process.

1.1.4 Social media as a tool for public participation

Introduction of new media provide new opportunities to involve most citizens and civic organizations in the planning process. By using internet, grassroots participants, with their ever-increasing power can significantly influence urban planning practices and can increase the public's awareness of planning participation through the social learning process. The development of ICT in the 1970s led to the rise of the network society, which has transformed almost every aspect of the world (Castells, 1996). It is facilitated by the development of Social Network Sites (SNS), such as Facebook, Google+, LinkedIn, Twitter, and Weibo .As new media for information sharing and broadcasting, Social Network Sites are internet-based communication platforms that have some common characteristics, such as public or semi-public forums and the sharing of information (Boyd and Ellison, 2007).

SNSs can also facilitate a more transparent and accountable public decision-making process, due to the availability of more information (Chadwick and May, 2003; Ho, 2002). For instance, public authorities post planning information on their websites, informing and communicating with the majority of citizens. This can lead to an extensive interaction between public authorities and citizens. An almost real-time information exchange and a more equal network structure are formed based on SNSs, breaking traditional social boundaries (Mandarano et al., 2010). Any agent can initiate a real-time participative process, and the influence of a planning event can extend beyond spatial and social boundaries. Social media also provide new platforms for the communication between the government and actors from society. In a way, they push the government to communicate with citizens, civic organizations, and experts. The traditional government-led planning system finally has some space for public participation. (Deng et al., 2015)

Many transit agencies have begun to incorporate social media into their marketing and communications strategies. Reasons for doing so vary, but goals for using these channels include communicating with current riders, reaching out to potential riders, developing stronger community connections, and enhancing the agency's branding and messaging. Some organizations also use social media applications to support customer service and to obtain feedback from stakeholders on services and programs. Table 1.0 compares the

characteristics of traditional media and social media. As the figure shows, media approaches are centralized and focus on delivering one or more messages to customers. Social media methods are collaborative and rely on sharing information and soliciting feedback for their effectiveness.

Table 1.0: Comparison between traditional and social media

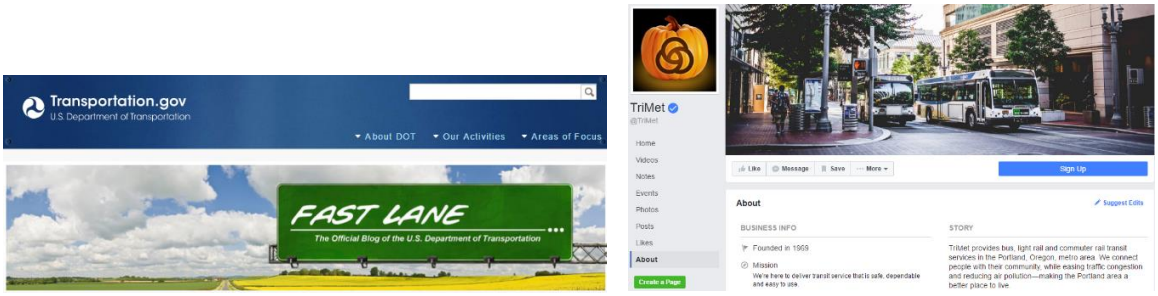
Traditional Media	**Social Media**
Customer	Collaborator
Talk to	Talk with
Selling	Sharing
Voice=Company	Voice=Citizen
More expensive	Less expensive
Professional media outlets	User-generated content
Push marketing	Pull marketing
Broader market	Targeted market
Static content	Evolving content
Short lived	Long life
One sided	Multiple options

(Source : Bregman., & Susan, 2012)

Social media are still relatively new (Facebook was launched in 2004, for example, and Twitter came along two years later). Hence, there is not yet a large body of academic research on their efficacy in planning process. Instead, much of the relevant information about how people and organizations are using social media can be obtained from online sources. These include blog posts, websites, conference presentations, and online journals and publications covering technology and governance. Transit agencies are not alone in their use of social media. Agencies and officials at all levels of government, from city hall to the White House, use social media. According to the Human Capital Institute, 66% of government agencies used some form of social networking in 2009, and 65% of those used more than one tool. LinkedIn, Facebook, and Twitter were the most commonly used web-based tools among these agencies (Human Capital Institute, 2010).

The Urban Transportation Monitor (UTM) surveyed transportation organizations about their use of social media (The Urban Transportation Monitor, 2011*)*. They asked what social media platforms they used and about half of the UTM respondents named Facebook (54%) and Twitter (51%); 37% used YouTube. Just over half (51%) said they used another application. Twitter was most commonly used for brief communications and service updates. Facebook was used for announcements and service updates, but also for meeting notices, community-building, and branding. YouTube videos covered a wide range of topics, including how-to-ride notices, community-building, and branding. YouTube videos covered a wide range of topics, including how-to-ride. State departments of transportation reported using Web 2.0 technologies to provide information and to build communities around transportation issues. A few agencies also used collaborative Web 2.0 apps such as Mashups, Wikis, SharePoint sites, Google groups, and Google documents for planning and administration. (U.S. Department of Transportation, 2010)

Figure 2.0 illustrates some examples of social media tool used in transportation sector



(a) (b)

Figure 2.0: a) United States Transportation Department using social media in transport planning (Source: https://www.transportation.gov/blog/fastlane), **b)** Providing transportation services using social media by Oregon Government (Source:https://www.facebook.com/pg/TriMet/about/?ref=page_internal)

1.2 Problem Statement

When planners exclude or do not adequately address citizen concerns through dependence on top-down ‘‘participatory’’ methods, they fail to activate parts of the system, particularly civil society organizations friendly to innovation and the new paradigms essential to achieving sustainable transport (Sagaris, 2014).If we don’t think about citizens as planners in their own right, but as mere participants at specific points in a planning stages, it will not open the way to more effective strategies for new innovations in transport. Challenges and difficulties related to safety, mobility and equity humanity faces today in the streets may be left unnoticed by the public authorities in the planning process of a transportation infrastructure.

Taking a more strategic approach to participation, through greater awareness of civil society and its role within the general ecology of actors in a given planning environment, opens a significant path forward (Sagaris, 2014). If we cannot involve general public in planning process of a city`s transportation projects there may remain a gap between the professional`s and citizen`s views and demands to achieve a better, efficient, and sustainable transportation system.

Proponents of participatory research and development approaches claim that they are dynamic and flexible ways of gathering information about, with and by local people and their conditions and livelihoods. Participatory approaches are flexible, process-oriented methodologies. They combine guiding principles, core concepts and sets of interactive techniques which have been developed to better realize high levels of community participation in official development programs and, more importantly, to give local people greater control over the process of development. According to the now voluminous participation literature, when first developed during the late 1970s and early 1980s, these methodologies were concerned primarily with gathering accurate and detailed information efficiently. At that time, the emphasis was on the word “rapid” for the purposes of “appraisal” or “diagnosis” of local problems and priorities, and most of the analyses and actions were controlled by outside researchers and development agents.(Mitlin et al., 1995)

According to FAO, constraints of conventional participatory methods are: (1) The political conditions/power structures of the country and project area; (2) Legislative obstacles; (3) Administrative obstacles; (4) Socio-cultural impediments; (5) Other impediments are: the isolation and scattered habitat of the poor, their low levels of living and heavy workloads especially of the women. Furthermore, their weak health conditions, low level of education and of exposure to non-local information, ignorance of their rights to self-organize groups and lack of leaders and know-how to move in this direction in order to promote their interests. (Deere and Leon, 2003).

New approaches in interactive web tools, social media and new kinds of end devices like smart phones provide new opportunities for planning administrations to crowd source information and collect local knowledge that is valuable for informed environmental planning decision. Furthermore, such networks can help the public to learn more about the local environmental issues and thus be able to make a more informed opinion about sustainable planning decisions (Krätzig and Warren-kretzschmar, 2014) . Social Networking Sites (SNS) like Facebook, MySpace, Twitter, and Pinterest are web-based services that allow individuals to: 1) construct a public or semi-public profile within a bounded system; (2) create a list of other users with whom they share a connection; and (3) view and edit their list of connections (Boyd and Ellison, 2007)

In open government, the Internet and social media offer opportunities to enhance communication during the planning and decision-making processes. However, the limitations of their use in the formal planning process must also be recognized, especially in their practical application. (Krätzig and Warren-kretzschmar, 2014).

Bangladesh is no different from other developing countries with a huge population of 156.6 million residing in 65 cities and towns (World Bank, 2016). There are no national policies to promote walking and cycling and no policies to promote investment in public transportation here. (Toroyan, 2009). Our study area, Dhaka, the capital of Bangladesh is the most densely populated city of the world with population of around 15 million and over 150,000 people living in per square miles (UN world population day survey, 2015). Dhaka ranks as one of the poorest in the world in terms of gross national income per capita of

$470 (Toroyan, 2009). As a result, public investment in urban transport infrastructure may rank very low compared to the need for other public needs such as health care, education, housing and sanitation. Dhaka has been an attraction to landless rural poor who see it as a source of income because of services they cannot find in their home villages. Migration from rural areas to the city has a long-term impact on travel patterns, thereby placing an increasing burden on the existing inadequate public transport services. (Mannan et al., 2001). So in this situation we can say, Dhaka city is badly in need of a sustainable transport system with a proper and long term national transport plan involving the responsible citizens of the city in the decision making and planning process.

1.3 Purpose and Objectives

1.3.1 Purpose

The purpose of this research is to involve citizens using social media in the planning of a sustainable transport system of a city. First to derive qualitative criteria and alternatives relevant to the road user decision making process using social network sites. Then quantifying those attributes and evaluating the priority and preferences of the sustainable transportation system by the method of Analytic Hierarchy Process (AHP). Presenting a method to involve general public in the government decision making process, this study shed lights on the importance of a user-centered needs-assessment approach to better understand road user behavior and their views about the sustainable transportation infrastructure.

1.3.2 Objective

The objective is to deduce road user need hierarchies for three different sustainable transportation systems from supplied posts and shared views by road users in a Social Networking Site. Proposed three systems are: (1) positive sidewalk environment, (2) cycling as a transport and (3) efficient public transportation. Then to develop a survey

questionnaire applying AHP method to extract and evaluate subjective judgement of road users.

The final aim is to compare and prioritize environmental attributes of walking, cycling and public transport that are perceived to encourage the road user to participate or not participate in using that scheme. The comparison is to be done by analyzing and studying the feedback the citizens give through the survey questionnaire.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview

There is growing interest in sustainability and its implications for transport planning (Litman and Burwell, 2006). Sustainability planning (also called comprehensive planning) considers society's overall, long-term goals. It means that local, short-term decisions are consistent with strategic, regional and global, long-term goals. (Litman, 2011) .Improving the participatory aspects of urban mobility plans, including definition and implementation can benefit from the support originated from the use of social media by Public Authorities in planning, dialogue and policy implementation (Chiara, 2015) .The following parts will describe the role of sustainability, public participation and use of social media in general projects as well as transport planning of a region.

2.2 Sustainability and Transportation Planning

Transportation planning must be in sustainable way so that it may properly deal with the challenges which are faced by the urban environment and transport. 'Effective, transport planning requires long-term vision to plan financial requirements for infrastructure and vehicles, to design incentive schemes to promote high quality public transport, safe cycling and walking and to coordinate with land-use planning at the appropriate administrative levels. Transport planning should take account of safety and security, access to goods and services, air pollution, noise, greenhouse gas emissions and energy consumption, land use, cover passenger and freight transportation and all modes of transport. Solutions need to be tailor-made, based on wide consultation of the public and other stakeholders, and targets must reflect the local situation (European Parliament Council Comission, 2016).

Within the context of transportation planning, the term "sustainable" can also refer to a plan itself – whether its objectives are achievable in view of the various financial, political and technical factors that will ultimately influence its success. 12 principles are given below under three themes that reflect the links between transportation planning and its sustainability, the need to view transportation holistically, and the desire to enable successful implementation.

Table 2.0 : Themes and principles for sustainable transportation planning

Transportation and Community Sustainability	**A Transportation System Perspective**	**The Way Ahead**
Principle 1	Principle 5	Principle 9
Integrated transportation & land use planning	Take a strategic approach	Provide implementation guidance
Principle 2	Principle 6	Principle 10
Protect environmental health	Consider all modes	Provide financial guidance
Principle 3	Principle 7	Principle 11
Incorporate social objectives	Manage transportation demand	Measure performance

Principle 4	Principle 8	Principle 12
Support economic development	Manage transportation supply	Create a living plan with public involvement

Source: (Sustainable, Planning, Need, More, & Transportation, 2007)

2.3 Public Participation in Transportation Planning Process

Public participation is based on the belief that people whose lives are affected by transportation planning and investment decisions have a right to be involved in the decision-making process and influence choices that are made. Directly engaging citizens in this process promotes successful problem solving, yields diverse voices and new ideas, and gives the public a sense of ownership of the developed solutions. (Mid America Regional Council, 2013)

Public participation in transport planning is a recent trend though here is an increasing number of cases in Europe where the public is involved in the decision-making process. The context of transport planning has changed dramatically in recent years, raising some difficult challenges but also creating new opportunities for public involvement. (Krätzig and Warren-kretzschmar, 2014)

According to Booth and Richardson (2001), transport planning is still characterized as democratic deficit with top-down participation strategies. Particularly, the involvement of common citizens is limited to informing and consulting local communities, rather than encouraging more active participation and partnership in the planning and decision-making process (Bickerstaff et al., 2002).However, involving the public is a key factor in enhancing a change in the attitude and behavior of people towards more sustainable modes of transport (Banister, 2008). Public acceptability is essential for successful implementation of radical change, and must therefore involve community and stakeholder commitment in the process of discussion, decision-making and implementation. In order to create public

acceptability of sustainable mobility, it is necessary to explain the need for change in behavior and convince the citizens of the importance of their contribution (Banister, 2008).

Some examples of public involvement in transport management include: in Switzerland, where consultation managers were employed to work on an effective forum for participation; in Germany, where transport strategy round tables were held; in France, where public consultation on regional transport plans were initiated; and in the UK, where public acceptability for congestion charging in London was achieved through extensive consultation of all involved parties (Hall, 2010; Bickerstaff et al., 2002; Banister, 2008).

2.4 Social media in Transportation Planning

Using social networks to interact with the general public today is becoming more and more frequent even in the public sector. Improving the participatory aspects of urban mobility plans, including definition and implementation can benefit from the support originated from the use of social media by Public Authorities in planning, dialogue and policy implementation. The panorama of the use of social media exploited by local authorities is very complex and varies from one city or country to another: while some cities have been using social media in structured way for many years, other cities have just started. In general, much needs to be done to improve the understanding of the social media revolution in public administration and this policy note would like to contribute to this. At the same time, there is a growing interest among local authorities who use social media not only to rapidly increase their visibility to a wider audience using limited resources, but also to create an additional communication channel and a useful, direct information exchange with citizens (Chiara, 2015).

Following, several examples and case studies, on how digital technology and social media can make a real difference to engagement with residents, and also offer tangible savings:

(1) CDOT: COLORADO DEPARTMENT OF TRANSPORTATION to the maximum effort practicable, makes public information accessible in electronic formats via

the Internet and uses innovative techniques to communicate complex information and improve comment solicitation. Through the use of a combination of text, video, audio, and interactive elements, the Internet can be an excellent tool to communicate with the public. CDOT makes the maximum use of its website: www.codot.gov

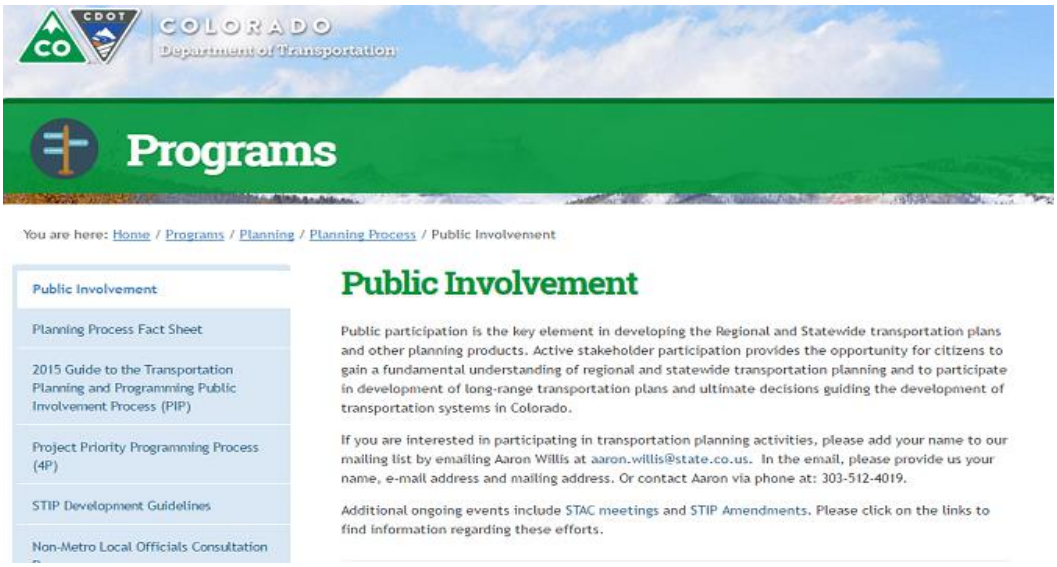


Figure 3.1: Colorado department of transportation website (Source: www.codot.gov)

(2) THE MUNICIPALITY OF GDYNIA IN POLAND is very active in the use of social media. The city has different Facebook accounts all linked to the City of Gdynia (with more than 83,000 likes), and is also using contents for the social media channels. For sustainable mobility, Gdynia has a specific Facebook Twitter, YouTube and Instagram. Gdynia has a dedicated press team responsible for managing the account directly connected to the mobility website, created within the DYN@MO project. For Gdynia the most important achievement of the use of social media involves disseminating events, giving visibility to the mobility campaign and collecting feedback and opinion on the mobility plan of the city.

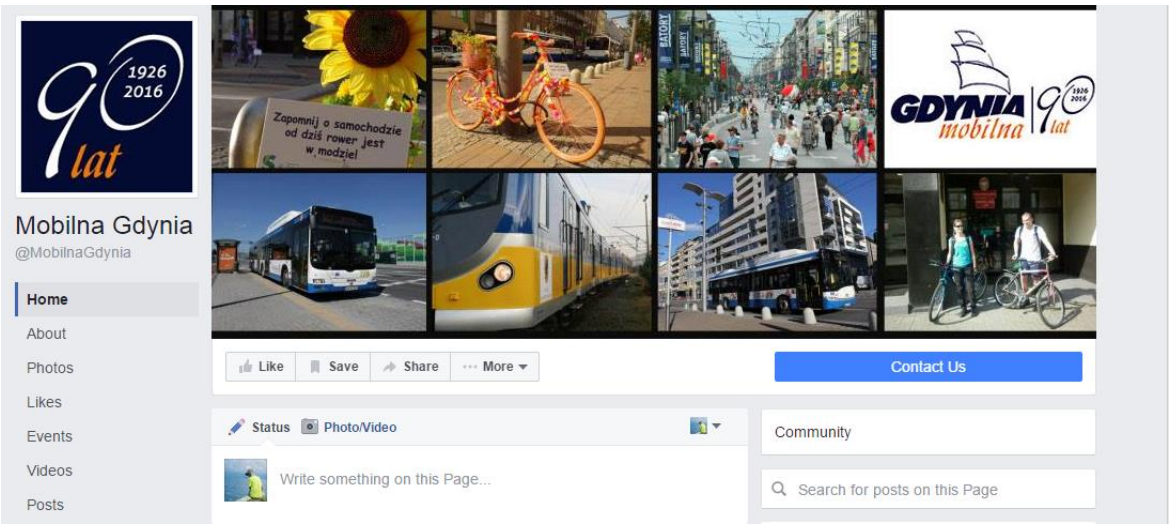


Figure 3.2: Facebook account of Poland's sustainable mobility assistance

(Source :https://www.facebook.com/MobilnaGdynia www.mobilnagdynia.pl)

2.5 Methods in Multi-criteria Decision

Various organizations are using various business strategies to analyze the impacts of various factors and to modify their present condition. There are many methods that can assume the likely impacts and opportunities to change the existing situation. SWOT, DPSIR, TOPSIS, AHP, ANP are some of the methods. These strategic methods help an organization to analyze the external environment, assessing the internal capabilities and finally to determine the strategies needed to implement.

SWOT is a popular business strategy which implies to Strength, Weakness, Opportunities and Threats. It helps to determine the strengths and weaknesses of an organization as well as the opportunities and the threats an organization may face. It is a qualitative method to determine the best way to achieve future growth. SWOT analysis does not have any particular rules or method to evaluate as the strengths, weaknesses, opportunities and threats for different companies will be different. It actually can be used as a guide for the organization and often considered as the first step of strategy analysis. The important stakeholders and other representatives' work together to perform the SWOT analysis so that all the important factors come out.

PESTLE is another qualitative method to identify the external factors which have impacts on the operation of an organization. PESTLE analysis includes Political, Economic, Social, Technological, Legal and Environmental factors. There are some common variations of PESTLE which are ETPS, STEP, STEEPLE, PEST, STEPE, STEEPLED. (Team FME) PESTLE cannot be applied to measure the quantitative dimensions which are the first problem of using this method. Secondly, the factors are measured by brainstorming independently. So some factors may have great impact while other important factors have limited impact for the organization (Ihsan, 2012).

AHP implies to Analytic Hierarchy Process which was developed by Thomas L. Saaty in early 1970's. It is a quantitative multi-criteria decision making approach. It assists complex decision making by using a set of pairwise comparison matrix. It also can be used to determine probable solution for real life cases. It determines the relative importance and gives a ranking to the alternatives. It evaluates the importance based on some criterions.

TOPSIS is another simple multi-criteria decision making method which was first introduced by Yoon and Hwang. It includes both qualitative and quantitative framework to evaluate the relative importance. It takes into account all kinds of subjective and objective criteria. It is an easy and straight forward process. (Bhutia et al., 2012)

CHAPTER 3
METHODOLOGY

3.1 Study area Dhaka

Traffic system in Dhaka is known as heterogeneous traffic system due to the wide variation in the operating and performance characteristics (motorized, non-motorized, slow moving, first-moving) of vehicles that enhance severe congestion and pollution especially in road intersection (Karim et al., 1998). The existing transportation system may become a bottleneck for the development of the city. Here, footpaths are occupied by car parking, garbage, construction materials and rubbish. No national plans for cyclists such as dedicated lanes and other safety measures. Condition of public transport are deplorable due to lack of priority and attention. So people are shifting to other modes like private transports, rickshaw and others increasing cars, congestion, pollution, fuel consumption, accidents and social discrimination. Over 3,00,000 rickshaw are run in Dhaka which are the major contributor of congestion in roads. Rickshaw and car consumes 40% of road area each while they transport only 20% and 5% people respectively (Efroymson and Bari, 2005).This is a major wastage of existing less road space which can be termed as the main reason of traffic congestion in Dhaka city. Traffic jam and poor transport conditions are a substantial constraint for the increase of economic development and international trade here.

The most efficient way to travel to short distances is by cycle or foot and the most efficient way to travel to long distances is by public bus or train (Efroymson and Bari, 2005). So Dhaka city is badly in need of sustainable transportation systems giving attention to pedestrians, cyclists and public transport. If simultaneously roads were narrowed and a positive sidewalk environment along with proper cycling infrastructure is ensured, people would gradually discover that they only waste time by driving, and more people would

choose to walk or cycle. Besides, if a good system of public transport like bus or mass rapid transit system existed to go farther, people would never need to drive. As a result, private vehicle growth in the streets will be restricted and gradually drop-off. Traffic jams would decrease significantly, air and noise pollution would decline, there will be required less travel cost and time and our streets would be safer both in terms of fewer accidents.

3.2 An approach to involve public participation

A series of tasks have been performed to fulfill the research needs and stated objectives.

The overall workflow is showed in Figure 4.0

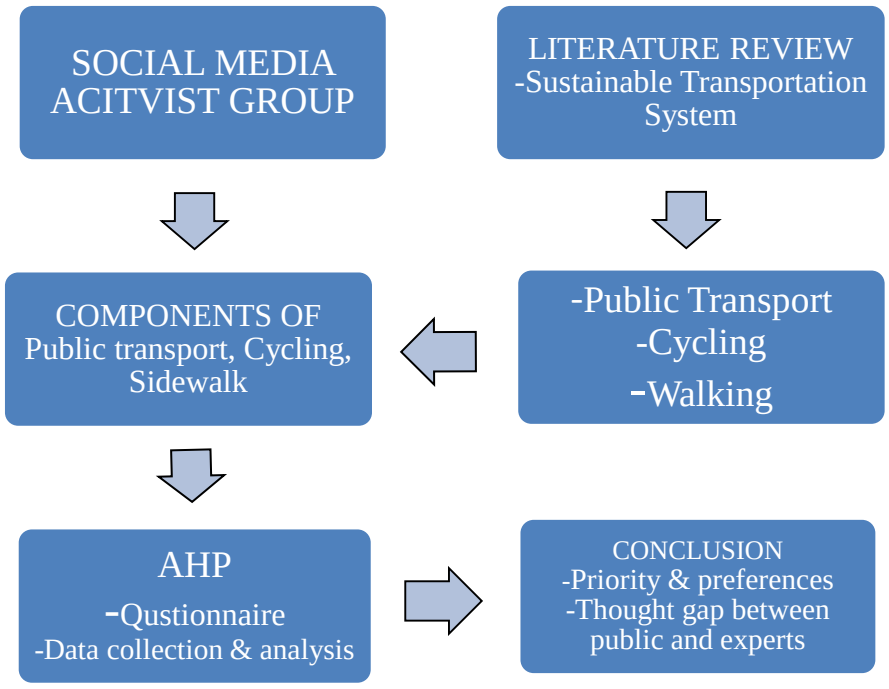


Figure: 4.0 Overall workflow of the methodology

3.2.1 Social media activist group and preparation of questionnaire

Using Dhaka, Bangladesh as the case context, a survey questionnaire was developed to elicit the subjective judgment of road users. The criteria and alternatives of road user need hierarchies of the questionnaire were derived from a public group in a social networking site, Facebook. From posts, views and opinions of general public regarding transportation problems and possible solutions in that group, road user need hierarchies and hierarchies of environmental attributes was established. Then the online questionnaire was provided to and filled up by the members of that group who responded the most.

The Analytic Hierarchical Process was used as an appropriate instrument to model the survey questionnaire. The assumption is that each criterion could be fulfilled by a concrete set of alternatives (i.e. environmental attributes). 17 alternatives were derived to reach the goal of a positive sidewalk environment while 4 criteria for the basis of decision making of individuals. Similarly 22 alternatives and 5 criteria were deduced to achieve improved public transportation and 9 alternatives and 3 criteria for positive cycling environment as a sustainable transportation system of Dhaka city.

The end goal was to do consistent and rational comparison across criteria as well as alternatives. By using AHP method the relative numerical weight or priority for each criteria or alternative based on the responses of road users were derived on elements that contribute towards achieving the goal of a sustainable transportation system.

In figure 5.0 we can see the Facebook discussion group named ‘BD ROAD SAVERS’ used to extract data for this study. It had over 3000 active users sharing posts and views related to transportation problems and possible solutions.

Figure 5.0: Facebook discussion group used to deduce transportation problems of Dhaka city (Web link: https://www.facebook.com/groups/855287761258451/)

3.2.2 Using AHP methodology to prioritize and evaluate road user preferences

The online questionnaire survey was considered as the most appropriate instrument to elicit comparison and prioritization of road user needs and environmental attributes. The survey inquired about (1) the respondent's socio-demographic profile, (2) their preference between two paired comparisons of criteria and environmental attributes.(3) their preferences between three proposed sustainable transport system of Dhaka city. In point 2 and 3 survey participants were asked to choose between paired comparisons (e.g. A and B) using a scale value from 1 to 9. A choice of 1 meant that the survey participant expressed an equal sense of preference between A and B while a choice of 9 proximate to B meant

that the participant expressed an extreme sense of preference for B over A and vice versa. Moreover, it is assumed that if A is weakly preferred to B and B is weakly preferred to C, consistent decision makers should have absolutely preferred A to C. Also, the default priority for each criterion and alternative is equal to each other, and will sum up to 1. The relative weight or priority value of each criterion and alternative, both at the local scale (local priority value within a criterion) and global scale (global priority value) were derived based on survey participants' series of pairwise comparisons.

Figure 6.0: A member of the social media group sharing his views about the problems occurring due to flyover construction in the city.

(Web link : https://www.facebook.com/groups/855287761258451)

Table 3.0: Intensity of importance with explanations for AHP comparison

Intensity of importance	Definition	Explanation
1	Equal importance	Two items contribute equally to the objective
3	Moderate importance	Experience suggests that one be slightly favored over the other
5	Strong importance	Experience suggests that one be strongly favored over the other
7	Very strong importance	Item strongly favored and its priority demonstrated in practice
9	Absolute importance	Importance of one over another affirmed on highest possible order
2,4,6,8	Intermediate values	Used to represent compromise between priorities listed above

Source: (Saaty, 2008)

For example, choose the relative importance of Safety consideration over Mobility concerns in evaluating the Cycling as a sustainable transportation system for Dhaka. If Safety consideration should be strongly prioritized then assign a value of 5, which stands for strong importance in Saaty's scale, by encircling the number or placing a tick mark on it.

Mobility	9 8 7 6 5 4 3 2 1 2 3 4 (5) 6 7 8 9	Safety

For conducting a comparison of six alternatives, 36 comparisons must be compared in order to fulfil the Equation's 1 matrix. However, the importance intensity of each alternative to itself is one and comparison of alternative B to A is the invert of alternative A to B. Therefore, 15 comparisons on each criterion are needed to fill the eigenvector matrix and doing the evaluation.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{16} \\ \vdots & \ddots & \vdots \\ a_{61} & \cdots & a_{66} \end{bmatrix} \quad \textbf{(1)}$$

Equation 1: Eigenvector matrix of comparisons, adopted from Tam et al. (1997).

For identifying the normalized principal eigenvectors which are the weights of alternatives, several mathematical steps must be taken and the first step is normalizing the eigenvector matrix. In order to normalize the eigenvector matrix, it has to be multiplied to invert of each column summation as shown in Equation 2.

$$w = \sum_{j=6}^{j=1} a_{ij} = [w_1 \quad \cdots \quad w_6] \quad \textbf{(2)}$$

Equation 2: Operator equation of matrix for normalizing, adopted from Tam et. al (1997). Which, the matrix form is shown in Equation 3.

$$\mathrm{A}/w = \sum_{j=6}^{j=1} a_{ij}.{w_j}^{-1} = \begin{bmatrix} a_{11} & \cdots & a_{16} \\ \vdots & \ddots & \vdots \\ a_{61} & \cdots & a_{66} \end{bmatrix}.[1/w_1 \quad \cdots \quad 1/w_6] = \begin{bmatrix} a_{11}/w_1 & \cdots & a_{16}/w_6 \\ \vdots & \ddots & \vdots \\ a_{61}/w_1 & \cdots & a_{66}/w_6 \end{bmatrix} \quad \textbf{(3)}$$

Equation 3: Matrix normalizing, adopted from Tam et al. (1997).

After normalizing, the weight of alternatives can be calculated by Equation 4.

$$W_j = \frac{1}{n}\sum_{j=6}^{j=1} a_{1j}/w_j = \begin{bmatrix} a_{11}/w_1 & \cdots & a_{16}/w_6 \\ \vdots & \ddots & \vdots \\ a_{61}/w_1 & \cdots & a_{66}/w_6 \end{bmatrix}.\begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}.n^{-1} = \begin{bmatrix} \frac{1}{n}\sum_{j=6}^{j=1} a_{1j}/w_1 \\ \vdots \\ \frac{1}{n}\sum_{j=6}^{j=1} a_{6j}/w_6 \end{bmatrix} \quad \textbf{(4)}$$

Equation 4: Normalized principal eigenvector, adopted from Tam et al. (1997).

3.3 Questionnaire distribution and data collection

Survey participants were selected from the members of the social media group who were the most active giving posts, sharing views, problems and offering solutions in it. Both the time and the budget were limited to conduct the survey to a geographically dispersed population. These survey participants were given to fill up the online questionnaire survey form through internet.

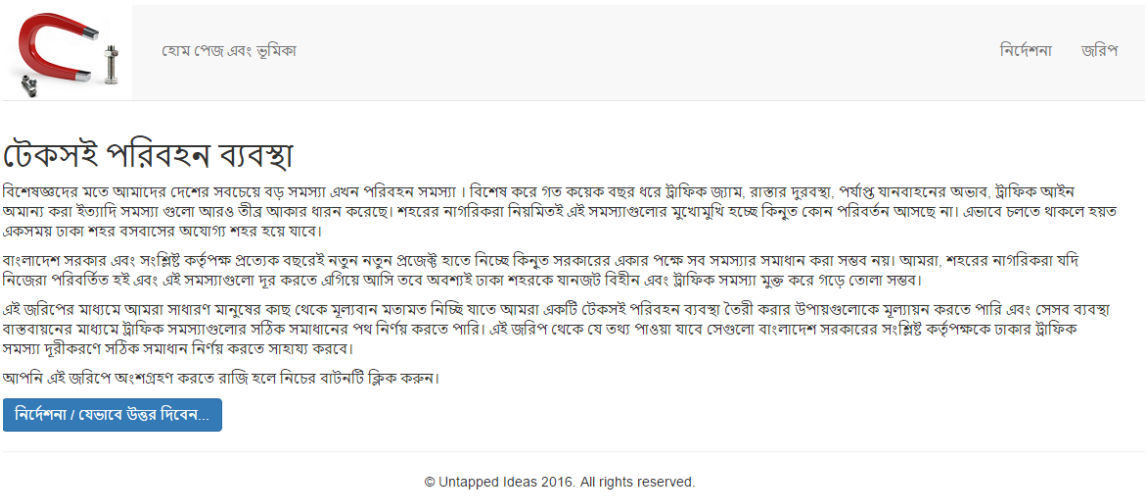


Figure: 7.0 Online Questionnaire (Link: https://ahpsurvey.untappedideas.com/).

By analyzing their feedbacks, the preferences of sustainable transportation system was determined and evaluated. However, it can provide important and crucial insights about citizen needs, preference, and prioritization. Before the questionnaire survey was provided, the investigator conducted a pilot test to determine the degree of difficulty of the questions being asked, establish the length of time to answer the questionnaire and determine level of response of respondents so as to ensure effectiveness, reliability and validity of the

questions. A total respondent sample size was 65. Results were, therefore, could not be generalized to the whole population.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This section explains the results of the survey, which include the overall socio-demographic characteristics and road user need hierarchy of the sample in Dhaka. As the feedbacks were collected by online survey questionnaire, the results of the survey, therefore, do not represent population from all levels, especially the result may lack the participation of the citizens who do not have access to internet.

4.2 Socio-demographic characteristics of respondents

In this study, the empirical context is Dhaka which is the capital of Bangladesh. The unit of analysis is the overall road users of Dhaka. This city is burdened with a huge population of almost 15 million people (UN world population day survey, 2015).

To understand accurately a comparison of variables, the demographic profile of the sample as represented in Table 5 are based on percentages rather than actual values.

Majority of the survey participants were male (male to female proportions 87 to 13). There was also a significantly young population cohort with more than half of the participants belonging to the 18–25 age group and 80% were still studying. So it appears that young generation people are the most enthusiastic and active in expressing their ideas and reacting to transportation problems. This age group of our society can be involved in future in planning and decision making process of infrastructure development projects of the city.

Table 4.0 Socio demographic characteristics of respondents.

Attributes	Categories	City sample N= 80(%)
Gender	Male	87
	Female	13
Age range	<18	4
	18-25	76
	25-40	14
	40+	4
Education	<College	7
	College	5
	Undergrad	75
	Graduated	17
Employment	Employed in office	19
	Self employed	5
	Unemployed	76
Car ownership	Family car	36
	Personal car	8
	Do not own car	56

A significant proportion of the respondents were unemployed (76%). So it appears that mainly unemployed people are more active in participating in the planning process to make their problems addressed. This demographic profile is far from representative of the overall population but is generally expected given the presence of many tertiary academic institutions within Dhaka.

4.3 Results for road user need hierarchies

The section shows the global priority values of alternatives of different modes of transport. The weights of alternatives resulted from the responses of experts and general public is compared in every bar chart. To reach the goal of achieving positive footpath environment, cycling environment and public transport environment as a sustainable transport mode for Dhaka city, an integrated model of the criteria and alternatives illustrating the global priority value for all the criteria and the local priority values for each alternative is illustrated in the appendix 1.

4.3.1 Results for highest prioritized Sustainable Transportation

According to survey responses of both general public and experts, it appears that public transportation is the most prioritized transport (55.5% by experts and 54.7 by general public) among three followed by walking (30.5% by experts and 26.1% by general public) and cycling (14.1% by experts and 19.1% by general public). It proves that, in context of a developing country like Bangladesh a sustainable public transport system can provide a mode of transport that can facilitate the overgrowing population's traffic demands most efficiently. The global priorities of weights for the three mode of transport are given in Figure 8.1.

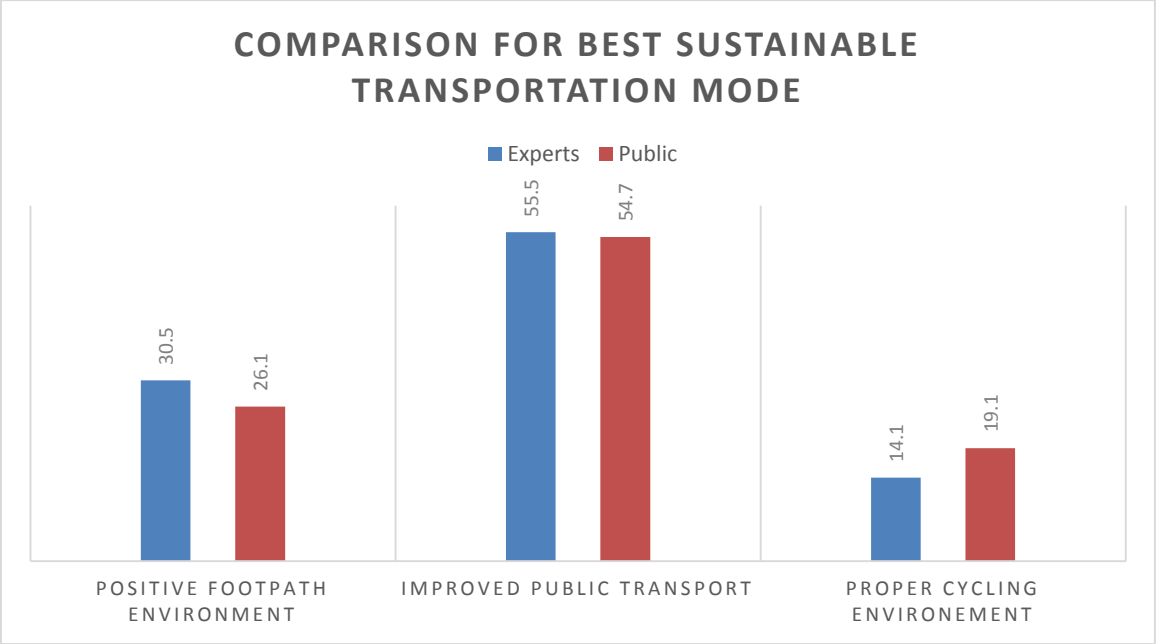


Figure 8.1: The global priorities of weights for the three mode of transport

4.3.2 Results for the pedestrian need hierarchy

Pedestrian's walking experience is formed by how pedestrians engage with the sidewalk environment. This, in turn, gives rise to pedestrian perception on environmental attributes that contribute to a positive sidewalk environment. The results of the global priority of weights for all alternatives are given in Figure 8.2 .The results of the AHP clearly present the three alternatives with the highest priority values include: toilets and dustbins provided (8.1%), no hawkers on footpath (7.7%), and facilities for disabled people (6.6%), traffic signals (6.4%), evening lights (6.2%), enough free space (6.2%), wider footpath (6.1%) where necessary. Where the experts think that evening lights provision (13.5%) and seating facilities at stations (11.3%), facilities for disabled people (8.9%), evening lights (6.9%), shed providing roads (5.9%) should be given highest priority. So it appears that, there remains a gap between expert's and general citizen's way of thinking about positive sidewalk environment.

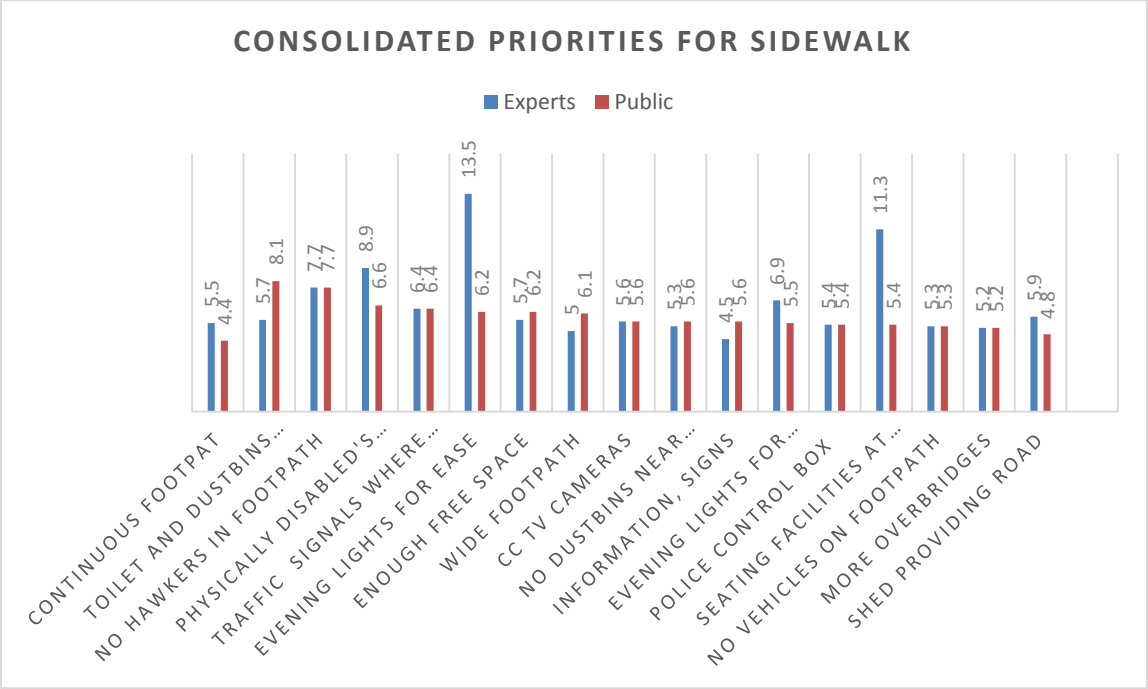


Figure 8.2: The global priorities of weights for the positive sidewalk alternatives.

Within a given pedestrian need (at the criteria level), the local priority for each alternative can also be elicited (shown in Appendix A). This then provides a ranking of alternatives within each criterion. This information is useful when evaluating sidewalk attributes at the criteria level, for instance, when comparing between the preference for continuous sidewalk and wider sidewalk as a possible contributory element towards realizing mobility.

4.3.3 Results for the cycling need-hierarchy

Given the compact size and inter-connected urban areas, cycling can be an attractive recreational activity and alternative mode of transport for short distance commute. The results of the global priority of weights for all cycling alternatives in descending order are given in Figure 8.3. The three alternatives with the highest priority values include: Separate crossing (19.9%), Evening lights (19.1%), Speed monitoring (15.7%), parking facility (13.2%), traffic signals provided (12.0%), enough free space (9.7%). On the other hand the

experts thought is also the same as the general citizens as they given priority to the same alternatives. So, here we find consensus between the experts and public.

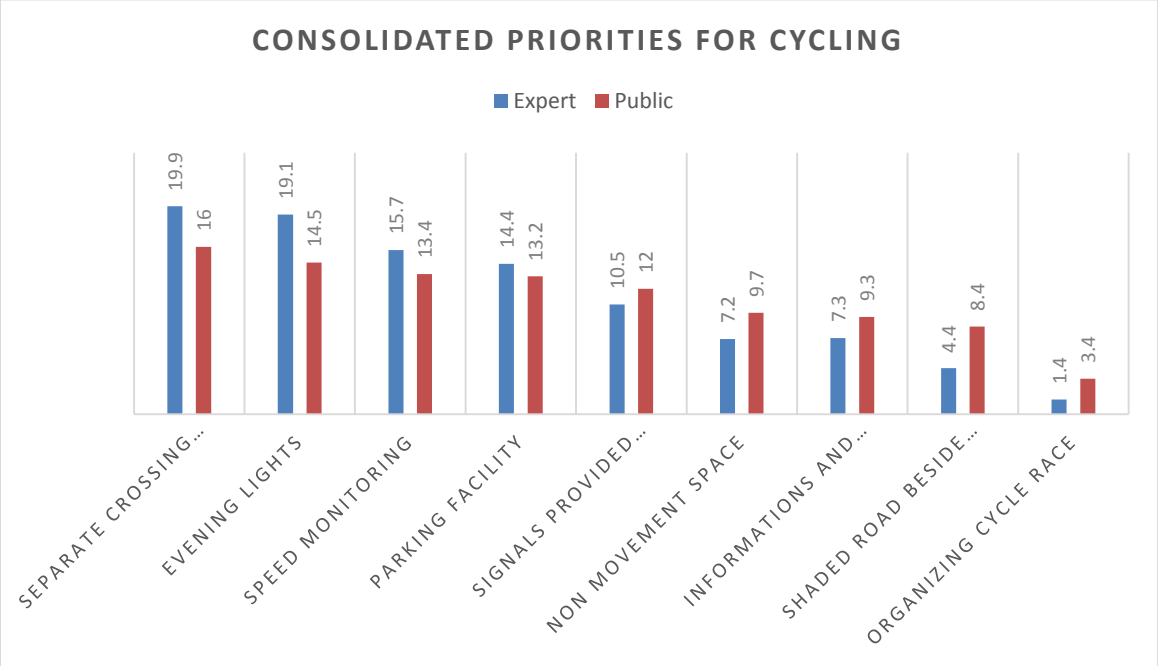


Figure 8.3 The global priorities of weights for the proper cycling environment alternatives.

4.3.4 Results for the public transport need-hierarchy

The results of the global priority of weights for public transport alternatives are given in Figure 8.4. From the results we can see the alternatives with the highest priority values are: Women and children facilities (9.93%), CC TV Camera (8.97%), reduced student fare (7.3%), proper license giving system (6.48%), neat and clean transport (6.33%). Here a major difference was found between the results of public and experts is that experts think that behavior of drivers and conductors (12.5%) and neat and clean transport (11.8%), Women and children facilities (10.5%), bus stoppage fix and monitoring (6.6%) are most important for a sustainable public transport.

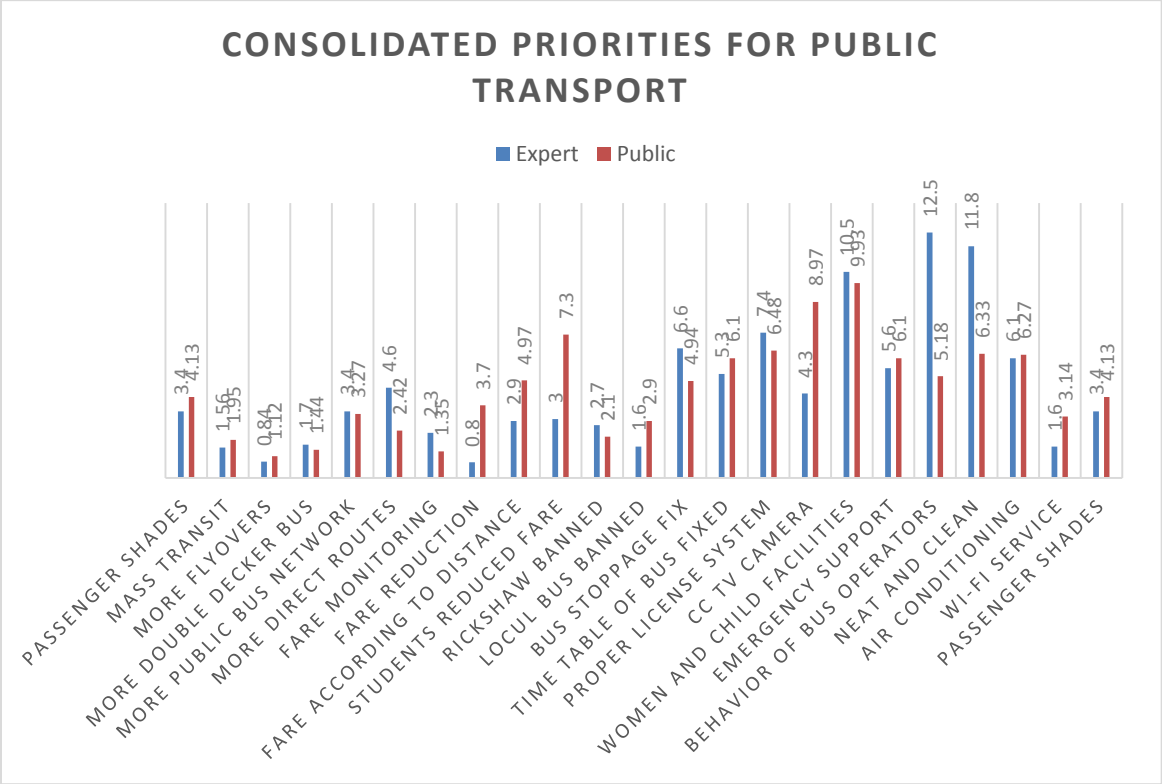


Figure 8.4 The global priorities of weights for the proper cycling environment alternatives.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

The concept of sustainable transportation system of a city expects most trips being made by walking, bicycle or public transport in a safe, secured, convenient, affordable and timely manner with leaving very few trips for car. This study encourages a public participation through social media to understand the concept of sustainable transport held in mind by transportation professionals and the general road users. For this, the sustainable transportation system concept was built around three modes – walking, bicycling and public transport (bus), and their various criteria were identified through the participation in social network (Facebook). Finally, the weights of each criterion were evaluated by applying AHP where the data was collected through an online survey with general road users and transportation professionals as respondents. The participants, who were road users, were mostly young male undergraduate students who heavily depend on public transport for their daily trips.

Results from this research point out the importance of examining potential strategies in improving conditions for walking, cycling and public transport in cities, especially if the aim is to encourage more people to use footpath, cycle and public transportation to travel to their destinations and decrease number of private vehicles on the streets.

5.2 Key insights for road users

In this study, three road user need hierarchy models were developed which drew on the perceived needs of citizens and established how these needs may be met through a series

of environmental attributes that is presumed to support and encourage walking, cycling and use of public transport. This section interpret the response results of the general road user.

5.2.1 Key insights for pedestrian

This study indicates the need of pedestrians for safer and more secure pedestrian walking environment. Majority of the respondents perceived protection as the most important criterion (33.4%). Therefore, the provision of safer and secure pedestrian environment is important and potentially critical characteristic of making walking environments more pedestrian friendly (Mateo-Babiano, 2016). Another interesting insight gathered from the results of the survey is that provision of toilets and dustbins on appropriate locations of footpath (8.1%) and no hawkers in footpath (7.7%) are considered as the most important attribute of sidewalk environment. Problems of footpath are deeply rooted problems as people of all ages are found here working as hawkers, dumping human wastes making footpaths unable to walk and creating barriers for the pedestrians and discouraging them to use the footpaths. This study may draw the attention of the government and the powerful sections of society to the seriousness of these problems.

5.2.2 Key insights for cyclists

Cycling as a mode of transport has gained interest at all levels in the last years, is an expression of the will to make a fundamental change. Cycling as a lifestyle choice will be a major step towards a green, clean and livable environment for all. Maximum number of survey respondents highlighted the need of cyclists for policies, planning and design practices to ensure safe, secure and risk free cycling environment (45%). Segregation of cyclists from fast or frequent motorized traffic is necessary to provide a safe and welcoming cycling environment. The general public and experts both pointed out evening lights, separate crossing system and proper signaling system as most important environmental attributes of cycling pathways. As, traffic signaling system was highlighted in the responses for pedestrian need also, we can clearly see the importance of signals in

the streets felt by the people (12%). How traffic signals are designed and implemented directly impacts cyclists (Clark & Page, 2002). For instance, poorly adjusted vehicle detector systems, used to trigger signal changes, may not correctly detect cyclists. The need for roadside lighting in the evening (14.5%), and separate crossing system (16%) was also prioritized to ensure a dependable and protective cycling environment. So these results can draw attention of the policy makers to the needs for proper cycling environmental attributes which have the highest priorities.

5.2.3 Key insights for public transport users

Road user's concern for safety (36%) and customer service (21%) of public transport proves that people are more afraid to use public transport for the lack of enough safety measures and good quality transport service. The less priority value of cost criterion indicates that general public will not mind to give an extra charge to ride on a more safe, mobile and convenient mass transport. The most important alternatives determined by participants were women and children facilities (9.93%), provision of cc TV camera (8.97%). Women are facing harassment in different level, and continually struggle to find space and access to transportation. Facilities like reserved seats in transport and special bus service only for women can be provided to solve this problem. Besides providing monitoring measures like cc TV cameras will give safety assurance to the passengers. These steps can be a major boost to provide a more efficient, effective and reliable urban public transport system.

5.3 Key insights for transportation experts

In the feedback results of transportation experts we can see that the experts prioritized public transport as the most feasible transport mode where behavior of bus drivers and conductors, neat and clean transport was considered as the most important element for achieving it. Seating facilities at stations and evening lights was considered as the most important element for achieving a positive environment for walking, the mode with the

second highest weightage value. Finally, for establishing cycling as a sustainable transport mode fort the city, the experts think that separate crossing system, speed monitoring should be given highest priority.

From these results it appears that the most practical problems that occur to commuters daily are not that much reflected in the results of transportation expert's feedbacks. Behavior of bus operators in case of public transport, seating facilities at stations for pedestrians which had the highest weightage values are mainly luxurious needs rather than essential necessities for road users. So it appears that, the irregularities faced by the general road users and their demands are not really pondered by the transportation experts.

5.4 Thought gap between experts and public

From the feedback results it appears that there exist a gap in thinking between experts and general road users. For certain criteria it is found that the opinion of experts and general public varies a lot while ranking alternatives .In fact variations are also found between expert and public individual's feedback results. The survey responses were aggregated and analyzed through SWOT-ANP model. Appendix 3 and 4 present the responses in a series of pairwise comparison matrices.

The comparison between survey responses of transportation experts and general road users are showed in Table 5.0

Table 5.0 Comparison between survey responses of general public and experts.

Type of Transport	Expert Respondents (Highest Priority)	General Public Respondents (Highest priority)	Expert Respondents (Least Priority)	General Public Respondents (Least priority)
Public Transport	Behavior of bus operators, Neat and clean transport	Women and children facilities, CC TV Camera	Fare reduction, More flyovers	More flyovers, Fare monitoring
Cycling	Separate crossing, Evening lights, Speed monitoring	Separate crossing, Evening lights, Speed monitoring	Enough free space, Shaded road beside footpath	Information and signs, Shaded road beside footpath
Walking	Evening lights, Seating facilities at bus stations	Toilets and dustbins provided, No hawkers on footpath	Police control box, No vehicles on footpath	More over bridges, Continuous footpath

5.5 Limitations and future scope

It is important to bear in mind that this was undertaken in the context of a developing Asian city and within a given sample and therefore may not be applicable to another context and do not represent the whole population. As social media and online questionnaire was used in this study it did not incorporate the views of the people having no access to internet. So, if we can include that group of our society the results will be more representative for the total area under study. Besides, if we can involve the people living under poverty and deprived of basic needs, the demands of people of every sectors will be reflected in the final plan of transportation projects. In future we can also take survey feedbacks from the policy makers and make a comparison of general public, experts and planners to see how much of the general people's necessities are reflected in the final plans of projects.

The results of this study are therefore significantly relevant to planning and policy, particularly in a developing city context. This study evaluates the role of social media as a public participation tool in the decision making process of transportation planning of a country. It introduces a method to involve public to achieve a sustainable transportation system of a city and to elicit priorities and preferences for attaining them. It will also provide a way to make ranking and compare between different criteria and alternatives of a transportation plan or a project. For planners in future, this study will assist to incorporate necessities of road users as public input in the planning process not limited to only transportation sector.

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APPENDIX A

Road User Need Hierarchies

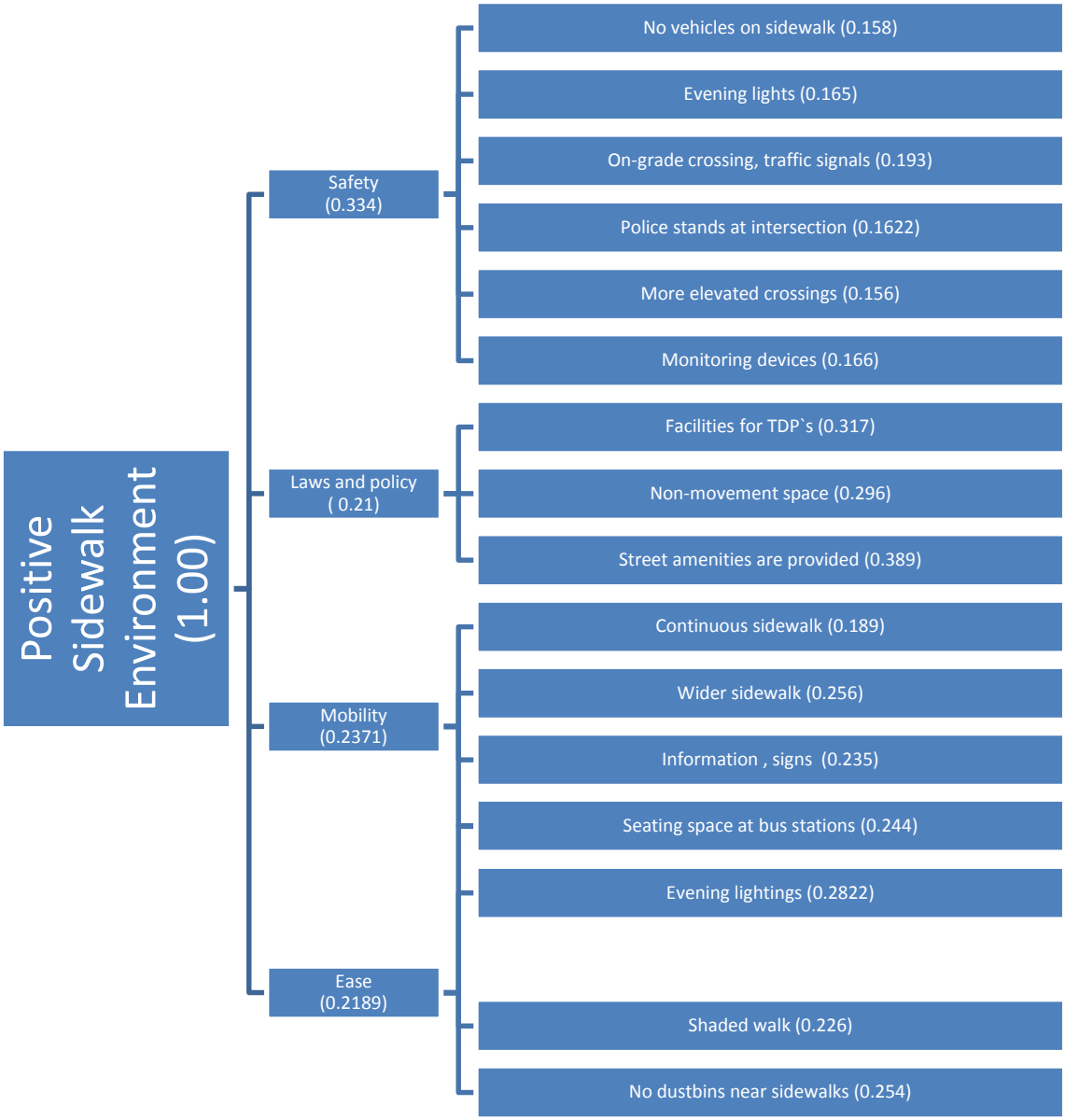

Figure A.1: Hierarchical tree of pedestrian needs (criteria) with global priority values and environmental attributes (alternatives) of general public respondents.

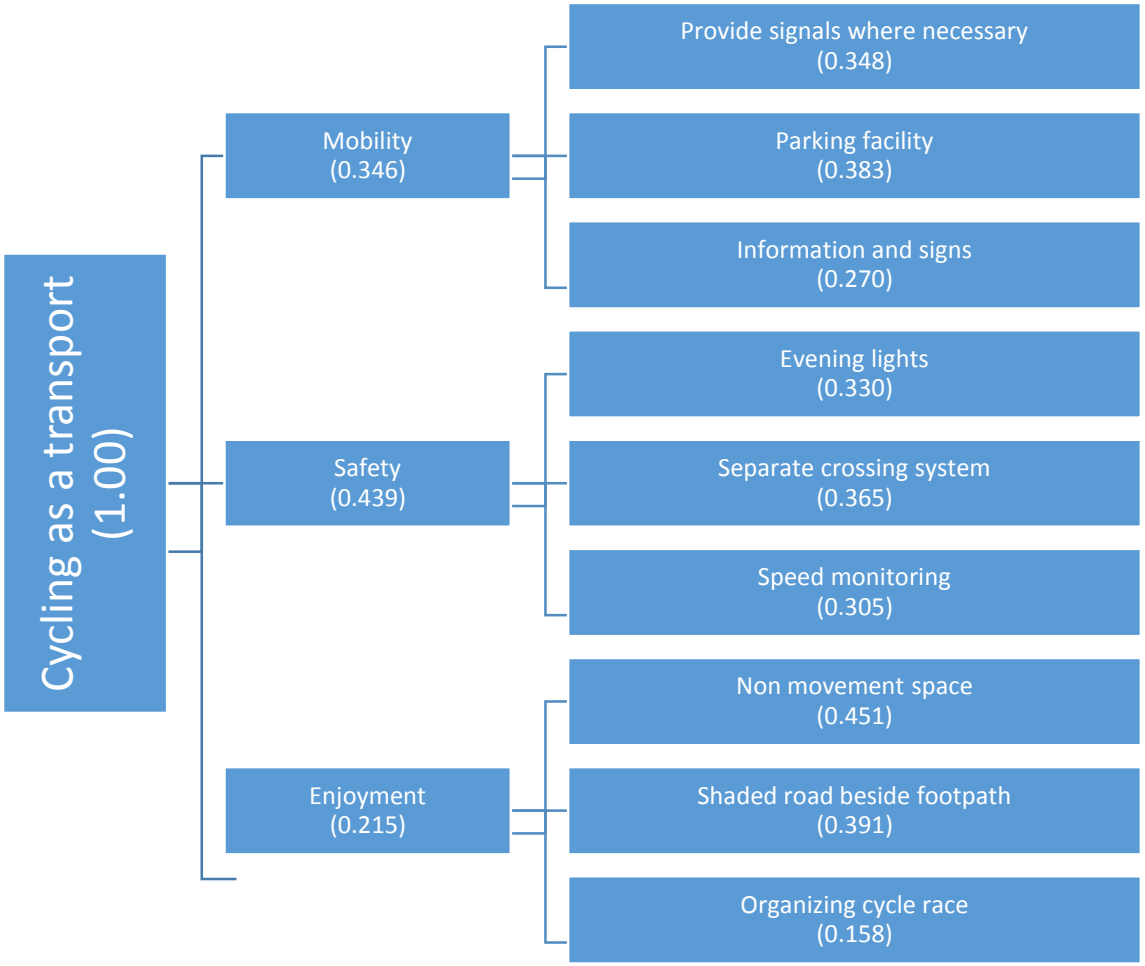

Figure A.2: Hierarchical tree of cycling needs (criteria) with global priority values and environmental attributes (alternatives) of general public respondents.

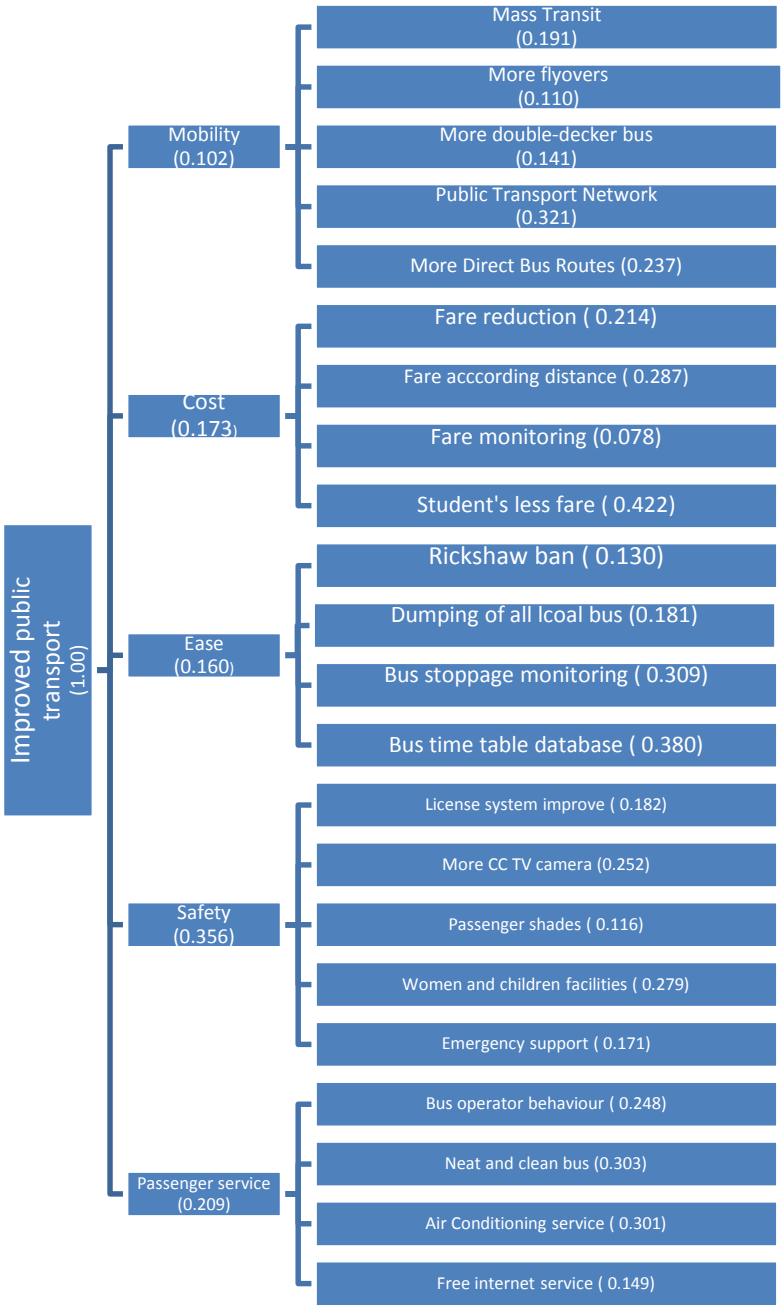

Figure A.3 : Hierarchical tree of public transport needs (criteria) with global priority values and environmental attributes (alternatives) of general public respondents.

APPENDIX B

QUESTIONNAIRE

Which One is the Best Sustainable Transport Mode?

Positive sidewalk environment	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Proper cycling environment
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Improved public transport

Proper cycling environment	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Improved public transport

Option 1: Creating a Positive Sidewalk Environment

Safety	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Laws
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Mobility
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Ease

Laws	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Mobility
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Ease

Mobility	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Ease

(a) Safety

No Vehicles on Sidewalk	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Providing Evening Lights
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	On-grade crossing, traffic signals
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More elevated crossings
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Police stands at intersection
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Monitoring devices

Providing Evening Lights	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	On-grade crossing, traffic signals
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More elevated crossings
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Police stands at intersection
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Monitoring devices

On-grade crossing, traffic signals	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More elevated crossings
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Police stands at intersection
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Monitoring devices

More elevated crossings	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Police stands at intersection
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Monitoring devices

Police stands at intersection	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Monitoring devices

(b) Equity:

Facilities for Disabled	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Enough free space
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Toilets, dustbins provided

Enough free space	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Toilets, dustbins provided

(C) Mobility:

Continuous Sidewalk	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Wider sidewalk
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Information , signage
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	No Hawkers on sidewalk

Wider sidewalk	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Information , signage
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	No Hawkers on sidewalk

Information , signage	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	No Hawkers on sidewalk

(D) Ease:

Transport stops	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Providing evening lights
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Shaded walk
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	No dustbins near sidewalk
Providing evening lights	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Shaded walk
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	No dustbins near sidewalk

Shaded walk	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	No dustbins near sidewalk

Option 2: Cycling as a transport

Mobility	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Safety
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Enjoyment

Safety	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Enjoyment

(a)Mobility

Parking facility	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Traffic signals provided
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Information , signage

Traffic signals provided	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Information , signage

(b) Safety:

Evening lights	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Separate crossing system
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Speed monitoring

Separate crossing system	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Speed monitoring

(c) Enjoyment:

Enough free space	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Shaded road
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Organizing cycle races

Shaded road	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Evening lights
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Organizing cycle races

Option 3: Improved public transportation

Mobility	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Cost
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Ease
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Safety
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Passenger service

Cost	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Ease
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Safety
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Passenger service

Ease	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Safety
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Passenger service

Safety	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Passenger service

(a) Mobility

Sample question for comparing the first two alternatives for Mobility criteria (Mass transit versus providing separate lanes for public bus): What is the relative importance of Mass transit when compared to providing separate lanes for public bus when considering mobility concerns?

Mass transit	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More double decker bus
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More flyovers
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More public bus network
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More direct routes of bus

More double decker bus	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More flyovers
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More public bus network
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More direct routes of bus

More flyovers	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More public bus network
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More direct routes of bus

More public bus network	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	More direct routes of bus

(b) Safety:

Proper license giving process	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Security guards at bus stations
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Enough lighting at passenger shades
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Facilities for women and children in bus
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Emergency support

Security guards at bus stations	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Enough lighting at passenger shades
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Facilities for women and children in bus
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Emergency support

Enough lighting at passenger shades	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Facilities for women and children in bus
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Emergency support

Facilities for women and children in bus	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Emergency support

(c) Cost:

Fare monitoring	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Fare reduction and control
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Fare according to distance
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Less fare for students

Fare reduction and control	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Fare according to distance
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Less fare for students

Fare according to distance	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Less fare for students

(d) Ease:

Rickshaw ban	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Bus arrival and departure timetable database
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Dumping of all existing local bus
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Bus stoppage monitoring

	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Dumping of all existing local bus

Bus arrival and departure time table	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Bus stoppage monitoring

Dumping of all existing local bus	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Bus stoppage monitoring

(d) Passenger Service

Behavior of bus operators	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Neat and clean transport
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Air conditioning service
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Free internet service

Neat and clean transport	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Air conditioning service
	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Free internet service

Air conditioning service	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Free internet service

APPENDIX C

Pairwise Comparison Matrix of Expert Respondents

The survey responses are aggregated and analyzed through sSWOT-ANP model. Appendix 3 and 4 present the responses in a series of pairwise comparison matrices. Here, each cell is in a form: xi, …., xj:m,…; ($\bar{x}$, σ) where xi stands for value of the responses chosen by only one respondent, and xj:m represents response xj chosen by m respondents. Also, $\bar{x}$ and σ represent the average and standard deviation of the response values for each pairwise comparison. For example comparison between positive sidewalk environment and cycling as transport is expressed as -9,-8,-7,-3, 1, 6, 7,-6:3;(-3.1, 5.78). It suggests that values -9,-8,-7,-3, 1, 6 and 7 are chosen only once; value -6 are chosen by three respondents. Also, the average and standard deviation of all responses for this pairwise comparison are -3.1 and 5.78 respectively.

Table C.1: Comparison between best sustainable transport modes

Eco	Positive sidewalk environment	Cycling as a transport	Improved public transport
Positive sidewalk environment	1	-9,-8,-7,-3,1,6,7,-6:3;(-3.1,5.78)	-7,6,8,9:3,7:2,5:2; (5.8,4.76)
Cycling as a transport		1	7,8:3,9:4,5:2; (7.7,1.57)
Improved public transport			1

Table C.2 : Option 1 - Positive sidewalk environment

Eco	Safety	Laws	Mobility	Ease
Safety	1	-6,8,1,-4,1,-9,-7:2,7:2;(-.1,7.3)	-5,8,-8,-3,5,-9,9,7,-7:2; (-1,7.3)	-8,8,-7,-5,1:2,9:2,7:2; (2.9,2.7)
Laws		1	4,8,1,-9,-8,-7:2,5:3; (-.3,6.7)	-3,3,-7,-1,9,7:3,8:2; (2.2,6.5)
Mobility			1	-8,7,-3,5,9,6,8,-4,1:2; (2.2,5.6)
Ease				1

Table C.3: (a) Positive sidewalk environment- safety

Eco	No vehicles on sidewalk	Evening lightings	Traffic signals provided	More over bridges	Police control box at intersections	Monitoring devices like CC TV camera

No vehicles on sidewalk	1	-6,1,-5,9:3,8:2,5:24.3,5.8)	-7,1,5,4,-68,3,9:3;3.5,5.97)	-8,9,5,6,-9,-6,1:2.-7:2; (-1.5,6.67)	-5,1,-2,7,-7,-8,6:2,-9:2;(-2,6.55)	-2,1,5,6,8,7:3;(2.3,6.27)
Evening lightings		1	-5,8,8,-9,3,-7:3,1:2; (-3,5.79)	-8,7,1,-6,-9,-4:3,-7:2; (-4.1,4.82)	7,-6,3,-9,-3:2,-5:2,-8:2;(-3.7,5.1)	-2,7,5,-3,-6,-9-8,1:3;(-1.3,5.31)
Traffic signals provided			1	5,2,4,-8,-9,1:2,-3:3;(-1.3,4.74)	7,-7,6,1,-8,5:3,-9:2;(-.4,6.95)	1,4,-3,-5,8,-6,7:2,5:2;(2.3,5.23)
More over bridges				1	-7,-6,-2,-5,3:2,5:2,-8:2;(-2,5.48)	-4,1,5,3,4,-2,7.-6,8:2;(2.4,5.02)
Police control box at intersections					1	6,-5,7,5,-6,-2,4,8,1:2;(1.9,4.95)

Monitoring devices like CC TV camera						1

Table C.4: (b) Positive sidewalk environment- laws & regulations

Eco	Facilities for disabled people	Enough free space	Toilets , dustbins provided where necessary
Facilities for disabled people	1	-6,3,-5,7,-4:2,-9:2,6:2;(-1.5,6.35)	5,-4,8,-6,-9,3,-5:2,-3:2,; (-1.9,5.4)
Enough free space		1	-6,3,8,-2,1:2,7:2,-7:2; (.5,5.85)
Toilets , dustbins provided where necessary			1

Table C.5 : (c) Positive sidewalk environment- mobility

Eco	Continuous footpath	Wider footpath	Information, signage on roads	No hawkers on footpath
Continuous footpath	1	4,1,-3,-5,5,8,6,-7:3;(-0.5,5.97)	6,-7,1,7,-5,-4,5,4,9,-6;1,6)	-7,-3,6,-8,-9,8:2,9:3;(2.2,7.9)
Wider footpath		1	-4,7,-3,-5,5,-9,1:2,6:2-;(-2.0,5.2)	6,5,9,7,1:6;(3.3,3.13)
Information, signage on roads			1	8,-7,3,9,-8,-9,7:2,5:2;(2.0,7.12)
No hawkers on footpath				1

Table C.6 : (d) Positive sidewalk environment- Ease

Eco	Evening lighting	Sitting facilities at stations	Shaded road	No illegal dustbins near footpath
Evening lighting	1	-3,-7,3,1,-9,5,7:2,-5:2;(-0.6,5.96)	-6,7,-3,8,1,-5,9,-7:3;(-1.0,6.68)	4,-8,9,-3,7,-9:2,-7:3; (-3.0,6.98)
Sitting facilities at stations		1	-4,-6,1,-8,,3,6,-9,-7,-5:2; (-3.4,5.02)	6,-6,9,-9,7,-4:2,-8:3; (-2.5,7.03)
Shaded road			1	5,-8,-6,9,-9,7:3,-5:2 (0.2,7.33)
No illegal dustbins near footpath				1

Table C.7 : Option 2- Improved public transport

Eco	Mobility	Cost	Ease	Safety	Passenger service
Mobility	1	-4,7,-8,4,1,-5:3,9:2;(0.3,6.52)	-3,-6,1:2,5:2,6:2,9:2;(3.3,4.97)	3,6,8,-6,1,-5,5:2,9:2;(3.5,5.38)	-6,8,-5,6,4,9:5;(5.2,5.88)

Cost		1	-7,6,7,3,5,9,-2,1:3;(2.4,4.7)	-4,8,9,1:2,4:2,7:3;(4.4,4.06)	-6,8,6,4,7,9:3,1:2;(4.8,4.89)
Ease			1	6,8,-6,1,-8,9:2,7:3;(4.0,6.24)	5,7,-3,-6,1,6,8:2,9:2;(4.4,5.3)
Safety				1	5,-4,9,7,1:3,-7:3;(-0.3,5.97)
Passenger service					1

Table C.8 : Improved public transport – Mobility

Eco	Mass transit like metro rail	More flyovers	More double decker bus	More area under public transport network	More direct routes of bus
Mass transit like metro rail	1	1,-3,-8,-6:2,-9:5;(-6.7,3.37)	4,5,-5,-8,-9:6;(-5.8,5.57)	1,-5,5,4,8,-7,7:2,9:2;(3.8,5.73)	6,1,-5,-7,-6,1,-9,-8:3;(-3.5,6.49)
More flyovers		1	6,5,-8,8,1:2,7:2,-7:2(1.3,6.41)	-3,5,7:3,8:3,9:2;(6.5,3.54)	9,8,-8,7:3,-7:2,-5:2;(3.0,6.38)

More double decker bus			1	8,3,-6,1,-8,7:2,9:3;(3.9,6.35)	6,3,-6,5,1,7:3,9:2;(4.8,4.54)
More area under public transport network				1	-5,-7,8,-2,1:3,-9:2;(-2.7,5.48)
More direct routes of bus					1

Table C.9 : Improved public transport – Cost

Eco	Fare monitoring	Fare reduction and control	Fare according distance	Less fare for students
Fare monitoring	1	-8,-6,6,-9,-5:2,-7:4;(-5.5,4.2)	8,-8,-3,1,9,7,6:2,-6:2;(1.4,6.6)	-4,-7,6,-5,5,3:2,9:3;(2.8,6.09)
Fare reduction and control		1	7,3,5,2,9,1,4:2,8:2;(5.1,2.77)	-7,8,1,4,9,5

				:3,6:2;(4.2 ,4.5)
Fare according distance			1	3,6,1:3,-6:3,-8:2;(-2.2,5.12)
Less fare for students				1

Table C.10 : Improved public transport – Ease

Eco	Rickshaw ban on main roads	Local bus ban and more sitting bus service	Bus stoppage fix and monitoring	Bus arrival and departure timetable database
Rickshaw ban on main roads	1	-8,7,-3,5,1,-7,-4:2,-9:2;(-3.1,5.72)	-9,1,-3,5:3,9:4;(4.0,6.06)	7,-9,8,5,-4,-8,9:2,4:2;(2.5, 6.92)
Local bus ban and more sitting bus service		1	6,1:3,5:3,8:3;(4.8,2 .9)	7,-9,-2,3,5,9,6,-4,8:2;(3.1,6.0 8)

Bus stoppage fix and monitoring			1	-2,-7,-3,6,-8,2,1:2,9:2;(0.8,6.0)
Bus arrival and departure timetable database				1

Table C.11 : Improved public transport – Safety

Eco	Proper license giving process	Security guards at passenger shades	Lighting and monitoring devices at passenger shades	Facilities for women and children at transport	Emergency support service
Proper license giving process	1	-6,9,1,-7,4,1,-8:4;(-4.0,6.32)	3,-4,1:2,9:2,-7:2,-8:2;(-1.1,6.69)	7,-3,1,-4.-8:2,9:2,4:2;(1.1,6.54)	-6,9,7,-7,5,1,4,2,-8:2;(-0.1,6.57)

Security guards at passenger shades		1	6,-7,1:2,9:2,-6:2,5:2;(1.7,6.17)	-5,1,7,3,-2,9:3,5:2;(4.1,4.86)	7,5,-8,1:3,-7:2,9:2;(1.1,6.57)
Lighting and monitoring devices at passenger shades			1	-7,7,3,8,1:2,6:2,9:2;(4.3,4.97)	-8,7,-6,9,-9,1:3,3:2;(0.2,6.07)
Facilities for women and children at transport				1	6,-3,-6,-9,1:4,-4:2;(-1.6,4.38)
Emergency support service					1

Table C.12 : Improved public transport – Passenger service

Eco	Behavior of bus operators	Neat and clean transport	Air conditioning service	Free internet service
Behavior of bus operators	1	-7,7,-5,2,5,1:3,9:2;(-1.3,5.77)	-6,-3,5,1,-9:2,7:2,-4:2;(-1.5,6.15)	-5,-6,-8,-9:5,-7:2;(-7.8,1.48)

Neat and clean transport		1	-4,-7,5,-3,1:2,-5:2,-9:2;(-3.5,4.6)	1,-6,-7:2,-8:3,-9:3;(-7.0,2.98)
Air conditioning service			1	-3,-4,-6,1:2,-8:3,-9:2;(-5.3,3.89)
Free internet service				1

Table C.13: Option 3- Cycling as a transport

Eco	Mobility	Safety	Enjoyment
Mobility	1	3,-6,-8,1:3,7:2,9:2;(2.4,5.91)	-6,-9,7,6,1,8,-7,-5:3; (-1.5,6.4)
Safety		1	-8,-6,-7,-4,1:2,-9:4;(-5.9,3.98)
Enjoyment			1

Table C.14 : Cycling as a transport – Mobility

Eco	Traffic signals provided	Parking facility	Information, signage

Traffic signals provided	1	-7,8,3,1,9,5,6:2,-4:2;(2.3,5.58)	-7,8,5,-5,1:2,-4:2,-9:2; (-2.3,5.83)
Parking facility		1	-8,7,-3,6,1:4,-9:2;(-2.4,5.44)
Information, signage			1

Table C.15 :Cycling as a transport – Safety

Eco	Evening lights	Separate crossing system	Speed monitoring
Evening lights	1	6,-7,-3,-6,-9,1:2,7:3;(0.4,6.31)	6,-5,-9,1:3,7:2,-6:2;(-0.3,5.91)
Separate crossing system		1	-8,9,1:2,7:2,-5:2,-7:2;(-0.7,6.57)
Speed monitoring			1

Table C.16 : (c) Cycling as a transport- Enjoyment

Eco	Enough free space	Shaded road	Organizing cycle race
Enough free space	1	-6,-9,4,-5,1,8,-7:2,-8:2;(-3.7,5.89)	-5,4,-7:3,-8:3,-9:2;(-6.4,3.84)
Shaded road		1	5,-7,1:3,8:3,-5:2;(-3.3,4.83)
Organizing cycle race			1

APPENDIX D

Pairwise Comparison Matrix of Public Respondents

Table D.1 : Comparison between best sustainable transport modes

Eco	Positive sidewalk environment	Cycling as a transport	Improved public transport
Positive sidewalk environment	1	-9:2-8:2,-7:10.-6:8,-5:11,-4:4,-3:4-2:9,1:7,2:3,3:3,4,5:5,6,7:6,9:5;(1.23,5.33)	-9,-6:2-5,-4,-3,-2:2,1:8,2:5,3:12,4:4,5:15,6,7:7,8,9:18; (4.28,4.07)
Cycling as a transport		1	-9,-7,-6:2,-5:2,-4,-3,-2:7,1:5,2:6,3:4,4:5,5:18,6:5,7:8,8:2,9:11;(3.48,4.41)
Improved public transport			1

Table D.2 : Option 1- Positive sidewalk environment

Eco	Safety	Laws	Mobility	Ease
Safety	1	-9:4,-8:2,-7:4,-6:2,-5:12,-4:4,-3:8,-2:7,1:10,2:5,3:6,4,5,6,7:2,8:3,9:5; (-.95, 5.00)	-9,-8,-7:3,-6:5,-5:12,-4:4,-3:11,-2:5,1:7,2:3,3:9,4:2,5:5,6,7:2,9:5; (0.56,4.68)	-9:2,-8,-7:4,-5:11,-4:3,-3:6,-2:6,1:19,2:7,3:3,4:2,5,,6:2,7,8,9:6; (0.0,4.66)
Laws		1	-9:2,-8,-7:4,-6:3,-5:5,-4:3,-3:7,-2:5,1:14,2:4,3:8,4:5,5:5,6:2,7:5,8:4,9:5; (1.44,4.6)	-9,-7,-6:3,-5:4,-4:4,-3:9,-2:11,1:12,3:8,5:6,6:2,7:28:2,9:7; (0.86,4.51)
Mobility			1	-9,-8:3,-7:2,-6:3,-5:6,-4:3,-3:9,-2:6,1:11,2:5,3:3:8,4:2,5:5,6,7:2,8:2,9:5; (0.2,4.6)
Ease				1

Table D.3 : Positive sidewalk environment- safety

Eco	No vehicles on sidewalk	Evening lightings	Traffic signals provided	More over bridges	Police control box at intersections	Monitoring devices like CC TV camera
No vehicles on sidewalk	1	-9:3,-8:3,-7:2,-6,-5:3,-4:3,-3:9,-2:11,1:13,2:5,3:5,4:2,5:5,6,7:3,8,9:6;(0.06,4.82)	-9:2,-8:2,-7,-6:2,-5:2,-4:6,-3:5,-2:5,1:18,2:9,3:7,4:5,5:3,5:3,7:2,8,9:7;(1.03,4.56)	-9:2,-8,-7:3,-6:2,-5:4,-4:7,-3:3,-2:8,1:11,2:11,3:3,4:7,5:6,6:3,7:2,8,9:5;(0.68,4.64)	-9:2,-8,-7:4,-6,-5:4,-4,-3:7,-2:7,1:16,2:6,3:7,4:5,5:5,6,7:3,8:3,9:6;(1.06,4.73)	-9:2,-8,-7,-6:3,-5:2,-4:2,-3:8,-2:8,1:15,2:8,3:4,4:3,5:8,6:2,7:3,8,9:9;(1.39,4.76)
Evening lightings		1	-9:2,-7:2,-6:2,-5:3,-3:11,-2:7,1:17,2:7,3:8,4:5,5:5,6:3,7:3,8,9:4;(0.96,4.26)	-9,-7,-6:3,-5:2,-4:7,-3:9,-2:7,1:19,2:6,3:7,4:3,5:4,6:4,7:4,8,9:2;(0.61,4,05)	-9,-7,-6:3,-5:5,-4:3,-3:9,-2:9,1:17,2:6,3:6,4:4,5:5,7:3,8:2,9:5;(0.78,4.34)	-9:2,-7,-6:2,-5:3,-4:2,-3:10,-2:5,1:17,2:10,3:8,4:5,5:5,6,7:6,9:3;(1.01,4.10)
Traffic signals provided			1	-9:3,-8:2,-7,-6:2,-5:8,-4:2,-3:8,-2:11,1:16,2:5,3:4,4:4,5:3,6:4,7:3,8,9:	-9:4,-7:4,-6:2,-5:5,-4:4,-3:9,-2:9,1:9,2:5,3:10,4:3,5:5,6:1,7:3,	-8,-7,-6:3,-5:6,-4:4,-3:5,-2:7,1:2

				3;(-0.09,4.57)	8,9:4;(-0.09,4.82)	0,2:9,3:5,4:4,5:2,6:3,7:5,8,9:3;(0.75,4.12)
More over bridges				1	-9,-8:2,-7:2,-6:3,-5:5,-4:6,-3:10,-2:4,1:11,2:12,3:5,4:4,5:5,6,7:3,9:5;(0.25,4.53)	-9,-8,-7:3,-6:2,-4:5,-3:9,-2:14,1:11,2:4,3:12,5:6,6,7:5,8:2,9:2;(0.45,4.28)
Police control box at intersections					1	-7:2,-6:3,-5:6,-4:5,-3:8,-2:10,1:19,2:5,3:5,4:3,5:3,6,7:5,8:2,9:4;(0.45,4.31)
Monitoring devices like CC TV camera						1

Table D.4 : Positive sidewalk environment- laws & regulations

Eco	Facilities for disabled people	Enough free space	Toilets , dustbins provided where necessary
Facilities for disabled people	1	-9,-8:2,-7:2,-6:5,-4:6,-3:11,-2:8,1:14,2:5,3:6,4:3,5:3,6:3,7:2,8:2,9:2;(-0.33,4.33)	-9,-8,-6,-5:3,-4,-3:5,-2:5,1:11,2:6,3:16,4:2,5:12,6:2,7:7,8,9:5;(2.35,4.05)
Enough free space		1	-9:4,-8,-7,-6,-5:3,-4:3,-3:3,-2:3,1:21,2:10,3:9,4:6,5:2,6:3,7:4,8:2,9:5;(1.35,4.52)
Toilets , dustbins provided where necessary			1

Table D.5 : Positive sidewalk environment- mobility

Eco	Continuous footpath	Wider footpath	Information, signage on roads	No hawkers on footpath
Continuous footpath	1	-9,-5:4,-4:2,-2:7,1:9,2:10,3:11,4:6,5:8,6:2,7:3,8,9:6;(1.53,4.33)	-9:2,-7:5,-6:2,-5:4,-4:3,-3:6,-2:7,1:13,2:5,3:12,4:5,5:6,6:2,7:3,9:4;(0.65,4.50)	-9:2,-8,-6:2,-5,-3:5,-2,1:13,2:5,3:8,4:5,5:8,6:5,7:6,8:2,9:18;(3.55,4.67)
Wider footpath		1	-9:6,-8,-7:3,-6:3,-5:5,-4:2,-3:7,-2:4,1:20,2:8,3:9,4,5:3,6:5,7:2,8:2;(-0.2,4.56)	-9,1:78,7;(0.95,1.31)
Information, signage on roads			1	-9:2,-8,-7,-6:2,-5:2,-4:,-3:3,-

				2:7,1:10, 2:5,3:10, 4:4,5:9,6 ,7:5,8,9: 13;(2.34, 4.88)
No hawkers on footpath				1

Table D.6 : Positive sidewalk environment- Ease

Eco	Evening lighting	Sitting facilities at stations	Shaded road	No illegal dustbins near footpath
Evening lighting	1	-9:4,-8:2,-7:5,-5:5,- 4:2,-3:11,- 2:10,1:12,2:8,3:6,4: 3,5:4,6:3,7:2,8;2,9: 2;(-0.21,4.76)	-9:5,-8:5,-6:2,- 5:3,-4:3,-3:17,- 2:3,1:12,2:7,3:7,4 ,5:4,6,7:4,8:4,9:3; (-0.3,5.0)	-9:3,-8,-7:5,- 5,-4:5,-3:10,- 2:9,1:11,2:11 ,3:6,4:4,5:6,7 :3,8,9:4;(0.24 ,4.55)

Sitting facilities at stations		1	-9:2,-7:3,-6:4,-5:7,-4:6,-3:11,-2:6,1:11,2:4,3:10,4:3,5:5,6:6,7,8,9:3;(-0.44,4.40)	-9,-7:3,-6,-5:9,-4:2,-3:8,-2:2,1:17,2:5,3:11,4:7,5:6,6,7:5,9:4;(0.98,4.33)
Shaded road			1	-9,-8:2,-7:2,-6:4,-5:4,-4:5,-3:11,-2:8,1:18,2:4,3:4,4:3,5:6,6:2,7:3,9:3;(-0.15,4.34)
No illegal dustbins near footpath				1

Table D.7 : Option 2: Improved public transport

Eco	Mobility	Cost	Ease	Safety	Passenger service
Mobility	1	-9:2,-7:2,-5:6,-4:4,-3:13,-2:5,1:24,2:4,3:5,4,5:3,6:3,7:3,8,9;(-0.06,3.96)	-8,-7:3,-6,-5:2,-4:3,-3:10,-2:12,1:18,2:3,3:7,4:2,5:6,6:4,7:4,8,9:2;(0.56,4.10)	-9:2,-8,-7,-6,-5,-4,-3,-2:3,1:21,2:9,3:12,4:2,5:10,6:5,7:3,8,9:6;(2.36,3.98)	-9,-8:2,-7,-6:4,-4,-3:5,-2:5,1:22,2:6,3:7,4:4,5:7,6:2,7:2,8:4,9:6;(1.74,4,41)
Cost		1	-6:2,-5:2,-4:3,-3:10,-2:8,1:22,2:7,3:4,4:4,5:11,6,7:2,8,9:3;(1.18,3.64)	-6:2,-5,-4,-3:3,-2:5,1:26,2:6,3:9,4:2,5:13,6,7,9:10;(2.51,3.62)	-7:3,-6:2,-5,-4:4,-3,-2:5,1:24,2:6,3:8,4:9,5:6,7:2,8,9:7;(1.81,3.80)
Ease			1	-9:3,-5:2,-4,-3:5,-2:10,1:20,2:5,3:7,4:4,5:12,6:2,7:3,8,9:6;(1.7,4.3)	-9,-7,-6:2,-5:3,-4:2,-3:4,-2:4,1:20,2:6,3:16,4:4,5:4,6:3,7:3,8:3,9:4;(1.8,3.94)
Safety				1	-9:3,-8:2,-7:3,-6:5,-5:6,-3:7,-2:7,1:23,2:7,3:4,4:2,5:5,8:2,9:4;(-0.24,4.58)

Passenger service					1

Table D.8 : Improved public transport – Mobility

Eco	Mass transit like metro rail	More flyovers	More double decker bus	More area under public transport network	More direct routes of bus
Mass transit like metro rail	1	-9:11,-8:5,-7:5,-6,-5:11,-4:2,-3:11,-2:13,1:9,2:3,3,4:3,5,6,7,8:2,9;(-2.77,4.60)	-9:8,-8:6,-7:3,-6:3,-5:7,-4,-3:9,-2:7,1:9,2:8,3:6,4:2,5:4,6:2,7:2,9;(-1.8,4.89)	-9:5,-7:7,-6,-5:5,-4:5,-3:5,-2:5,1:9,2:5,3:10,4:4,5:7,6:3,7:4,8,9:3;(0.06,5.10)	-9:2,-7:5,-6:6,-4:2,-3:9,-2:7,1:11,2:6,3:9,4:2,5:9,6,7:3,9:6;(0.33,4.84)
More flyovers		1	-9:4,-8,-7:4,-6:4,-5:5,-4:6,-3:9,-2:5,1:9,2:7,3:8,4:4,5:4,6:2,,7:5,8,9:2;(-0.33,4.85)	-9:3,-7,-5:5,-4:8,-3:5,-2:4,1:9,2:6,3:11,4:8,5:7,7:4,8:2,9:7;(1.43,4.73)	-9,-8,-6,-5:3,-4:3,-3:8,-2:5,1:9,2:6,3:16,4,5:9,6,7:5,8;(2.15,4.48)
More double decker bus			1	-9:4,-8,-6:3,-5,-4,-3:4,-	-9:3,-7;2,-6,-4:4,-

				2:12,1:8,2:7,3:10,4:4,5:11,6:2,7:4,8:2,9:6,(1.58,4.73)	3:5,-2:6,1:11,2:7,3:10,4:2,5:11,6:7,7:7,8,9:4;(1.96,4.48)
More area under public transport network				1	-9:5,-7,-6,-5:8,-4:7,-3:8,-2:8,1:24,2,3:4,4:2,5:5,6,7,8,9:3;(-0.59,4.34)
More direct routes of bus					1

Table D.9 : Improved public transport – Cost

Eco	Fare monitoring	Fare reduction and control	Fare according distance	Less fare for students
Fare monitoring	1	-9:3,-7,-6:2,-5:4,-4:2,-3:5,-2:8,1:19,2:7,3:4,4:4,	-9,-8,-6,-5,-4:4,-3:8,-2:3,1:14,2:3,3:12,4:	-9,-7,-6:2,-4:3,-3:5,-2:8,1:13,2:6,

		5:3,6:2,7:10,8,9:5;(1.33,4.62)	7,5:5,6:4,7:5,8:3,9:8;(2.38,4.36)	3:9,4:3,5:10,7:4,8:4,9:11;(2.53,4.47)
Fare reduction and control		1	-9,-7,-5,-4:2,-3:10,-2:4,1:18,2:7,3:8,4:5,5:5,7:8,8,9:3;(1.01,4.14)	-7:2,-5:3,-4:2,-3:9,-2:6,1:17,2:7,3:13,4:3,6:3,8:3,9:7;(1.68,4.01)
Fare according distance			1	-8:3,-7:5,-5:5,-4:7,-3:6,-2:7,1:13,2:12,3:7,5:6,7:3,8,9:6;(0.39,4.64)
Less fare for students				1

Table D.10 : Improved public transport – Ease

Eco	Rickshaw ban on main roads	Local bus ban and more sitting bus service	Bus stoppage fix and monitoring	Bus arrival and departure timetable database
Rickshaw ban on main roads	1	-9:5,-7:3,-6:3,-5:7,-4:2,-3:7,-2:9,1:14,2:7,3:3,4,5:4,7:6,8,9:7;(0,5.20)	-9:5,-8,-7:3,-6:3,-5:7,-4:2,-3:7,-2:8,1:14,2:7,3:3,4,5:4,7:5,8,9:7;(0,5.20)	-9:2,-7:3,5:6,-4:2,-3:7,-2:4,1:9,2:2,3:15,4:4,6,7:3,8:2,9:11;(1.81,4.98)
Local bus ban and more sitting bus service		1	-9:3,-8,-7:2,-6,-5:4,-4:8,-3:4,-2:7,1:16,2:2,3:7,4:4,5:6,6:3,7:5,8:2,9:4;(0.75,4.80)	-9:2,-7:5,-6:2,-5:2,-3:5,-2:6,1:16,2:12,3:9,4:
Bus stoppage fix and monitoring			1	-2,-7,-3,6,-8,2,1:2,9:2;(0.8,6.0)

Bus arrival and departure timetable database				1

Table D.11: Improved public transport – Safety

Eco	Proper license giving process	Security guards at passenger shades	Lighting and monitoring devices at passenger shades	Facilities for women and children at transport	Emergency support service
Proper license giving process	1	-9:4,-7:13,-6,-5:11,-4:5,-3:9,-2:9,1:9,2:6,3:3,4:2,5:4,6:2,7,9:4;(-1.75,4.75)	-9:3,-7:6,-6:3,-5:8,-4:5,-3:5,-2:9,1:13,2:10,3:2,4,5:5,6:2,7:3,9:3;(-0.8,4.57)	-9:2,-7:2,-6,-5:5,-4:5,-3:6,-2:5,1:20,2:6,3:10,4:5,5:2,6,7:2,8:2,9:4;(0.55,4.28)	-9:2,-8,-7:7,-6,-5:4-4:5,-3:3,-2:13,1:14,2:7,3:4,5:6,6,7:2,8:2,9:4;(-0.13,4.61)
Security guards at passenger shades		1	-9,-6:2,-5,-4:2,-3:4,-2:12,1:19,2:4,3:9,4:5,5:5,6:3,7:6,8:3,9:4;(1.86, 3.98)	-5,1,7,3,-2,9:3,5:2;(4.1,4.86)	7,5,-8,1:3,-7:2,9:2;(1.1,6.57)
Lighting and monitoring devices at passenger shades			1	-7,7,3,8,1:2,6:2,9:2;(4.3,4.97)	-8,7,-6,9,-9,1:3,3:2;(0.2,6.07)

Facilities for women and children at transport				1	6,-3,-6,-9,1:4,-4:2;(-1.6,4.38)
Emergency support service					1

Table D.12 : Improved public transport – Passenger service

Eco	Behavior of bus operators	Neat and clean transport	Air conditioning service	Free internet service
Behavior of bus operators	1	-7,7,-5,2,5,1:3,9:2;(-1.3,5.77)	-6,-3,5,1,-9:2,7:2,-4:2;(-1.5,6.15)	-5,-6,-8,-9:5,-7:2;(-7.8,1.48)
Neat and clean transport		1	-4,-7,5,-3,1:2,-5:2,-9:2;(-3.5,4.6)	1,-6,-7:2,-8:3,-9:3;(-7.0,2.98)
Air conditioning service			1	-3,-4,-6,1:2,-8:3,-9:2; (-5.3,3.89)
Free internet service				1

Table D.13: Option 3- Cycling as a transport

Eco	Mobility	Safety	Enjoyment
Mobility	1	3,-6,-8,1:3,7:2,9:2;(2.4,5.91)	-6,-9,7,6,1,8,-7,-5:3; (-1.5,6.4)
Safety		1	-8,-6,-7,-4,1:2,-9:4; (-5.9,3.98)
Enjoyment			1

Table D.14 : Cycling as a transport – Mobility

Eco	Traffic signals provided	Parking facility	Information, signage
Traffic signals provided	1	-7,8,3,1,9,5,6:2,-4:2;(2.3,5.58)	-7,8,5,-5,1:2,-4:2,-9:2; (-2.3,5.83)
Parking facility		1	-8,7,-3,6,1:4,-9:2; (-2.4,5.44)
Information, signage			1

Table D.15: Cycling as a transport – Safety

Eco	Evening lights	Separate crossing system	Speed monitoring
Evening lights	1	6,-7,-3,-6,-9,1:2,7:3;(0.4,6.31)	6,-5,-9,1:3,7:2,-6:2;(-0.3,5.91)
Separate crossing system		1	-8,9,1:2,7:2,-5:2,-7:2;(-0.7,6.57)
Speed monitoring			1

Table D.16: Cycling as a transport- Enjoyment

Eco	Enough free space	Shaded road	Organizing cycle race
Enough free space	1	-6,-9,4,-5,1,8,-7:2,-8:2;(-3.7,5.89)	-5,4,-7:3,-8:3,-9:2;(-6.4,3.84)
Shaded road		1	5,-7,1:3,8:3,-5:2;(-3.3,4.83)
Organizing cycle race			1