Optimal Strategic Plan for Sustainable Urban Transport System in Kathmandu City Centre

Using Decision Support Systems

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
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<tr>
<td>CBIS</td>
<td>Computer-Based Information Systems</td>
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<td>DM</td>
<td>Decision Maker</td>
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<td>DSS</td>
<td>Decision Support Systems</td>
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<td>GMAA</td>
<td>Generic Multi-Attribute Analysis</td>
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<tr>
<td>JICA</td>
<td>Japan International Cooperation Agency</td>
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<tr>
<td>KSUTP</td>
<td>Kathmandu Sustainable Urban Transport Project</td>
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<tr>
<td>MEERCI</td>
<td>Measurement of Experience in Environment from Results of Core affect Investigation</td>
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<tr>
<td>MOPE</td>
<td>Ministry of Population and Environment</td>
</tr>
<tr>
<td>NAC</td>
<td>Nepal Airlines Corporation</td>
</tr>
<tr>
<td>NCC</td>
<td>Nepal Chamber of Commerce</td>
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<tr>
<td>PM10</td>
<td>Particulate Matter 10</td>
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<tr>
<td>RONAST</td>
<td>Royal Nepal Academy of Science and Technology</td>
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<tr>
<td>STI</td>
<td>Sustainable Transport Initiative</td>
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<td>SUT</td>
<td>Sustainable Urban Transport</td>
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<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
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Abstract: There are many factors associated with an urban environment that enrich or diminish the experience of the environment. These factors have a significant influence on how an urban morphology is appraised within the social, economical, and environmental framework. One of such factors is the urban transport system that represents the mobility of the people and accessibility to public services. This thesis is an assessment of a current transport system in Kathmandu city centre in comparison to Kathmandu Sustainable Urban Transport Project (KSUTP) promoted by Ministry of Physical Planning and Works in cooperation from Asian Development Bank (ADB). The study aims to find the optimal strategic alternative between the current system and KSUTP. The focus area is the historic city centre, because of its cultural, historical, architectural, and aesthetical significance.

Two methods are used for two different purposes; first to measure people’s appraisal and second, to evaluate action alternatives. Measurement of Experience in Environment from Results of Core affect Investigation (MEERCI) is used to measure people’s appraisal and experience of the urban characters of Kathmandu city centre. The results from this survey will provide a background on people’s assessment of the city environs, and collected data from field work will be used in Generic Multi-Attribute Analysis (GMAA) model to determine the best strategic plan for developing sustainable urban transport system for Kathmandu city centre. The hard facts and figures are collected from authorities, ministries, and previous researches, which is then entered into the model to evaluate the optimal alternative.

It is concluded that improvements in the current transport system in Kathmandu city centre, with the implementation of KSUTP, will result in better environment for the local population, local economy, public services, and transport facilities. In short, the quality of life will be enhanced with an upgrade in the urban transport system.

Keywords: urban, environment, transport system, sustainable development, GMAA, decision-making, MEERCI, Kathmandu.

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Summary: Most of the rapidly urbanizing cities in the developing countries face unprecedented challenges in their societies, environments, and economies. These challenges exert extensive stress on the present ecosphere, habitat, and the relations between inhabitants and the environment. One of the challenges is concerned with the expansion of transport amenities within a limited land area of a city. Uncontrolled urbanization results in unsustainable transport system and negative impacts on the environment of a city. Kathmandu city is one of the rapidly urbanizing cities that faces difficulties in managing its urban transport system. However, in recent years, ADB and government authorities have taken steps to recuperate the present urban transport system, to make it environmentally sustainable and publicly accessible.

This thesis is a measurement and assessment of strategies for sustainable urban transport system for Kathmandu city centre. The aim of the study is to find the optimal strategic plan to be implemented to improve the transport sector. The study is carried out in two phases. The first survey intends to measure people’s appraisal and experience of the urban environment in Kathmandu city centre using MEERCI as a method. The second phase involves the assessment of the results from the first survey, and collection of hard data (facts and figures from authorities) to investigate the congruency of people’s assessment with collected data. The collected data is entered in the GMAA model to evaluate the alternatives – current system and KSUTP. After all the necessary data is entered into the model, the results represent consensus with the public opinion that the current transport system is not sustainable, and needs to be improved at various levels – socio-culturally, environmentally, economically, policy-wise, and public perception-wise – to be sustainable.

The study focuses primarily in the historic city centre of Kathmandu, because of its historical and economical importance. The results from both surveys and GMAA analysis show that KSUTP is the best strategic plan to implement improvements in transport sector of the city centre. These improvements will benefit the local government, the local residents, the local economy and the surrounding environment. As a consequence, there is an overall increase in living conditions for the local population. These upgrades will also account for a pleasant experience of the city centre.

Keywords: transport, Kathmandu, urban, sustainability, GMAA, MEERCI, urbanization.

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1. Introduction

Urban planning is a complex procedure involving a comprehensively overarching plan for the development of a designated region. Such a plan inherently includes many different aspects of a society such as social, economical, physical, environmental, and cultural. A city’s physical infrastructure forms the backbone of the city, and drives much of the economic activities and productivity of the city. One of such backbones is the transport system that plays a vital role in the quality of life, social equity, and environmental conditions. Transport system also has a significant impact on the natural and man-made urban environments. Unregulated and uncontrolled growth of vehicles is one of the major reasons for the degeneration of urban environments. Various negative impacts such as air pollution, lack of visibility, noise pollution and disturbances, health problems like chronic bronchitis and respiratory diseases, road accidents, social disintegration, and psychological distress are some of the commonly observed consequences of poor transport system. These are the main problems addressed in this thesis, summarized as a poorly managed transport system of the city can result in a wide range of social, economical, health, and environmental problems.

A systemic improvement on transportation framework of the city is a necessity in many major cities in the world. An upgrade in the public transport sector can have significant impact on traffic congestion, air quality, urban environment, and people’s experience of the city. A sustainable urban transport (SUT) is required which can potentially reform the urban transport network, and consequently enhance the city’s environment. However, such systemic development requires political commitment, administrative capacity, economic resources, and communal responsibility to execute and produce prolific outcomes beneficial to the city, its people and its environment. A systematic upgrade of transport system demands critical decisions by the policy makers; and often such decisions are to be made taking into consideration numerous factors of a society such as public space, traffic volume, commercial activities, operational costs, cultural norms and values, and social capital. It is difficult to assign dominance of one factor upon another, however critical or influential each factor is. But negligence of one factor may result in an incomplete assessment of the problem, and thus may not produce a comprehensive strategic solution for the issue at hand.

Therefore, decision-making process often involves a thorough analysis of costs and benefits of different attributes of the development plan. However, traditional single criteria analysis is often limited in scope and utility because such analysis is primarily focused on maximizing benefits and reducing costs. Cost-benefit analysis does not, however, take into account other non-dominating attributes that have influence on the decision-making process. Decisions in urban transport development refer to multiple, usually conflicting criteria. The difficulty to address these multiple conflicting criteria with a simplified cost-benefit analysis led to development of several multi-attribute decision making systems. These decision support systems are based on additive multi-attribute utility model that provide better understanding of inherent problems of multi-criteria decision-making process. Such in-depth understanding of the features of decision-making in urban planning can facilitate decision makers with insights on various alternative strategies and their consequences.
1.1 Objective of the Study

The thesis has two major objectives. The first objective is to measure people’s experience and their emotional response to their urban environment, in particular their evaluation of the current transport system in Kathmandu city centre in Nepal. The public evaluation of the environment is based on their affective appraisals and experiences. The results from people’s response will be used to represent the background of current situation of urban transport in Kathmandu city centre. The measurement is performed with a measuring method – Measurement of Experience in Environment from Results of Core affect Investigation (MEERCI)[1]. This measurement represents people’s emotional response to the characters of their urban landscape within a selected area.

The second objective of the study is to assess the optimal strategic decision for the urban transport system in Kathmandu city centre. The assessment of alternatives will investigate different attributes under different criteria such as environmental, social, and economical. Based on these attributes and their utilities, the optimal alternative action is determined. In specific, the focus is on the analysis of the current system and the upgrade of transportation system. The application of Generic Multi Attribute Analysis (GMAA)[2] in determining the optimal alternative for transport system planning improves the quality of decisions by negotiating, quantifying, and communicating the priorities. This method enables decision makers to reconsider uncertainty and incomplete information about various attributes and their preferences of a certain strategy.

1.2 Scope of the Study

The thesis has its focus, specifically, on the transport sector of an urban environment. The assessment of present system and proposed development under the urban development plan for Kathmandu city centre can be used to evaluate the best alternative actions for designing the Kathmandu city plan. The results from the survey on public appraisal of their environment within selected areas can be used while designing urban landscapes, and making improvements in the environment. People’s experiences are valuable information to consider while planning and creating a sustainable community. The application of multi-attribute decision support system can generate reliable evaluation of alternative strategies, and thus can make decisions more rational, explicit and efficient. As a case, Kathmandu city represents many of the rapidly urbanizing cities in the world that are in need of a comprehensive city plan that has features of sustainability, mobility, identity, and prosperity.

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1 Measurement of Experience in Environment from Results of Core affect Investigation (MEERCI) was method developed by Lena Steffner in her doctoral thesis. This method is used to measure public experience of their urban environment based on their affective appraisals. For further information, refer to her doctoral thesis “Evaluation of Urban Environments: A method to measure experience”, Lena Steffner, Lund University, Sweden, 2009.

2 A Generic Multi Attribute Analysis (GMAA) system was developed by Antonio Jiménez, Sixto Ríos-Insua, and Alfonso Mateos at the Technical University of Madrid, Spain. Their article “A generic multi-attribute analysis system” of 2004 describes how this method can be applied in real world scenarios. This system is a PC-based decision support system (DSS) based on an additive multi-attribute utility model. For further information, refer to Jiménez et. al, 2004. A generic multi-attribute analysis system, Computers and Operations Research 33 (2006) 1081 – 1101.
1.3 Hypothesis

The main hypothesis underlying the thesis is that upgrading the current transport system to a sustainable urban transport system can improve the quality of life, living conditions, air quality, and economic progress in an urban environment. In many of the developing countries, rapid urbanization and growth of major cities is a common phenomenon, thus resulting to unmanaged urban environment, and unregulated transport sector. Improvements in such transport sector towards sustainable transport system can generate benefits for the society and the environment.

1.4 Methods

To perform an in-depth analysis of potential alternative actions for transport system in Kathmandu city centre, it is necessary to review the hard facts as well as people’s perception of their urban environment. Therefore, two different methods were applied to measure these two mutually exclusive data. Two separate surveys were conducted in Kathmandu in January and April in year 2012. The first survey in January measured people’s emotional response to a particular landscape in Kathmandu’s historic centre (city centre). The questionnaire used photos of the locations with multiple choice questions and open-end questions (Annex 9). The survey results are contingent on people’s personal experience of the area over time and their emotional state of mind at a given particular time of survey. Nonetheless, the externalities and the characters of the surrounding environment such as streets, green space, congestion, services, structures, and aesthetics have a considerable influence on the responsive human individuals. These external factors conjure effective depiction of an individual’s state of being at a particular landscape at any given time. The dispositions from the public are used in MEERCI to generate illustrative graphical circumplex that represent the percentage of people in a spectra of emotions. Each of the circumplex graphs demonstrate how a population respond with varying emotional states in relation to differing urban landscapes and their features. The survey results provide an overview of the status quo of urban amenities in Kathmandu city centre. People’s satisfaction and impression of their environment gives a backdrop of present situation as experienced by the local population in Kathmandu.

The second fieldwork, in April 2012, was a general public survey and a fact-finding research, primarily focusing on current transport system of Kathmandu. The general public survey measured people’s assessment and expectations from city’s transportation and various sectors affected by it such as accessibility, urban space, social capital, commerce, and historical architecture. Other hard facts such as air pollution, road accidents, traffic volume, and maintenance costs were acquired from various authorities in Kathmandu. The results from the survey and obtained facts were entered into GMAA and utility functions were assigned to each attribute. The component utility graphs, simulations, and ranking of multiple alternatives serve an overview of the problem at hand, and various solutions. The multiple objectives are often conflicting and therefore, the optimal strategy is highly contingent on the overall utility of each alternative proposition. The materialization of both soft facts – survey results, and hard facts – data collected from authorities, is performed using GMAA. A detailed description of each of the methods will be presented in methodology section of the thesis.
1.5 Outline of the thesis

The thesis is divided into six sections. The first part introduces the problem, the objectives, the scope, and the methods used in the study. The second section outlines a background on the current situation of transport system in Kathmandu city centre. The results from the first survey portray people’s reaction to their urban environment, and serve a setting for Kathmandu urban transportation. Section three delineates the methods used in the study, and assesses the validity and reliability of the research. This section will also present the limitations of the methods and study in general. Findings and results from the survey, computational graphs and simulations will be explained in section four of the paper. Followed by analysis and discussions of the findings and the graphs, and their implications on the selection of alternatives for the transport system in Kathmandu will be discussed in section five. Finally, conclusions and recommendations for the optimal alternative actions will be presented in section six of the thesis. Bibliography and appendices are attached thereafter.
2. Background of Kathmandu City

Kathmandu Valley comprises of three districts: Kathmandu, Patan, and Bhaktapur; and each district has a core municipal city area and a rural outskirt around the city. The Valley’s cities are closely interconnected with urban road infrastructure, and their population share common urban amenities and mobility facilities. Kathmandu Valley houses a population of 1.74 million people (as of end of 2011) in its 666 square kilometers (sq. km.) area. The city of Kathmandu locates at an altitude of 1350m above the sea level with an area of 50.8 sq. km. Administratively, the city is divided into 35 wards (administrative areas); 12 of which are located within the city’s historic centre. The city’s historic core consists of the wards numbered from 17 to 28, covering a total area of 2.75 sq. km. and has a population of approximately 116,885 people (as of end of 2011). The average population density of the city is about 4,408 people per sq. km., where as the average density of the city centre is about three times higher (13,225 people per sq. km).³

Anciently, Kathmandu city was designed and developed with three major urban clusters – Kathmandu, Patan, and Bhaktapur – to harbor a population of 410,995 (1952/54)⁴, less than four times the current population (year 2011). Consequently, the road networks and transportation system in general were constructed to meet the need of only 196,777 people who resided in the city centre of Kathmandu. In the 1950s, many developmental projects reshaped the urban structure of the city – one of which was the vehicular roads connecting the city centre to other rural territories. However, a massive expansion of haphazard growth and uncontrolled settlements occurred from the mid-1980s. These changes in the urban morphology and demographics are attributed to internal migration, land-use patterns, ecological imbalance, and lack of regulation and policies by the government.⁵ Figure 1 illustrates the modern day Kathmandu (2008) showing land use patterns, transport routes, and urban/rural regions. The ancient road networks and building infrastructures were not designed taking into consideration the rapid large-scale urbanization in the recent years. As a result, the existing transport infrastructure fails to support the volume and intensity of traffic and pedestrians.

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2.1 Current Transport System in Kathmandu

At present, mobility in Kathmandu city is essentially dependent on road networks. There are, however, future plans to investigate the feasibility of metro rails in Kathmandu. But the implementation and construction of such development to come into effect will need considerable planning and resources. Accessibility to transport services is critically challenged by traffic congestion, vehicular and pedestrian volume, unmanaged traffic and inadequate infrastructure, and in parts, public attitudes and preferences of private to public transport. This situation is further compounded by non-compliance of traffic regulations, limited improvements of roads by authorities, growth in the number of private vehicles, air pollution, and declining investment/interests by both private and public sector. The vehicular and pedestrian traffic is increasing in a geometric proportion; however, the road networks are not improved or widened to meet the current demand. The increasing number of traffic related accidents and slower speed of vehicular transportation is directly attributed to increase in private motorcycles and unregulated traffic management at large.

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As of year 2011, Kathmandu city has roughly 214.69 km of roads, circumscribed by a 27-km Ring Road around the city.\(^7\) According to the Department of Transport Management, the number of registered vehicles in Kathmandu city in 2003 was 23,143. However, the number of vehicles registered in the city has increased exponentially from 23,143 to 249,219 during 2003-2010 – which is more than half of the vehicles registered in the whole country in last seven years.\(^8\) The increment in vehicles, both for private and public purpose, indicates that the newly built roads of Kathmandu do not bear the capacity to handle such traffic volume. Much of the increment in the vehicles is reported to be two-wheeler motorbikes. In year 2010/11, the Valley recorded registration of 69,484 motorbikes out of total 82,204 vehicles. Most of the vehicles registered in the district ply in the urban centers of the Valley, prominently in Kathmandu city centre. A more skewed reality demonstrates that public transport vehicles (19% of total registered vehicles) meet most of the public mobility demand (57% of total demand) while motorcycles (42% of total vehicles) meet only 6% of the total public travel demand.\(^9\) Since 2001, the excessive increase in the purchase of motorcycles is due to the financial services such as easy credits promoted by local finances and banks (KSUTP Final Report 2010, p. 3).

With the discontinuation of government operated transport services, exclusively private owned vehicles of low and high occupancy provide public transport services. Approximately 2000 private operators own about 1560 buses and minibuses, 1800 LPG and battery-operated 3-wheelers, 2500 micro buses, and 3700 taxies for public transport in the city. However, these vehicles are neither regulated nor systematically assigned to a particular route/s. Due to management and maintenance problems, the state-operated Sajha Yatayat buses and electric trolley buses are in poor conditions, and are not operated for public service. Microbuses and minibuses constitute the public transport in the city centre; however, they are also the main reason for congestion and accidents because of haphazard driving. (Dhakal 2006, pp. 34-35)

There is a lack of reliable statistics on current average traffic speed. Except the studies by JICA (1993), no other systematic studies have produced findings of significance. According to JICA (1993), the average traffic speed was 20-30 km per hour, while Ale (2004) estimates a decrease in traffic speed over the last decade to be less than 20 km per hour. At present there are traffic lights at 11 junctions in the city, and in over 60 other junctions, the traffic police manages the traffic manually. Nonetheless, management of vehicles and movement of pedestrians by a single traffic individual do not effectively manage the traffic at a given location.

\(^7\) The total length of roads in Kathmandu is reported to be 214.69 km by the Department of Roads of Nepal in its Road Statistics Report 2011. The average road density is mentioned to be 54km/100 sq. km. Online available on http://www.dotm.gov.np/en/page/52/53/ (accessed on April 9, 2012)


2.2 Parameters Affected by Existing Transport System

The current transport system in Kathmandu is a multi-faceted system that is inefficient and ineffective. As a consequence, a diverse range of domains of the society is adversely affected. Transport mobility and infrastructure are the most apparent factors bearing the brunt of the situation. Apart from them, air quality, traffic safety, social capital, service accessibility, commerce, architectural erosion, and historic heritage are some of the gravely affected components of the city.

There is a varying range of available data on air quality of Kathmandu city, depending on the seasons, time and location of measurement. Different scientific studies found different concentration of Particulate Matter 10 (PM10) in Kathmandu, which ranged from as low as 59-127 µg m⁻³ (Karmacharya and Shrestha, 1993) to as high as 197-775 µg m⁻³ (RONAST, 1992). However, a recent study measured the ambient PM10 and occupational PM10 levels according to the months of four different seasons at ten different sites in the city, classified on low/high traffic zones and periods of the day. The study showed that the average ambient PM10 level for the city in a year is 640±224 µg m⁻³ (where 224 µg m⁻³ is the standard deviation). Similarly, the average occupational PM10 level was 822±295 µg m⁻³. (Majumder et. al. 2012, p. 134)

Occupational PM10 refers to the monitored measurement of PM10 level during the traffic hours, while ambient PM10 level refers to the air quality without operational traffic at the site of measurement. Figuratively, the level of PM10 set by the World Health Organization (WHO) for a healthy habitat is 20 µg m⁻³, and the national standard for entire country of Nepal is 120 µg m⁻³. According to KSUTP Final Report, the measurements from the roadside monitoring stations read an average of 200 µg m⁻³ PM10 level for the city of Kathmandu (KSUTP 2010, p. 4). Despite the variations in the measurements of PM10 level in the city, it is clearly evident that the level of PM10 is significantly more than the habitable standards. According to Ministry of Population and Environment (MOPE), Nepal, any site exceeding the benchmark level of 425 µg m⁻³ PM10 is considered hazardous. This unhealthy living conditions results in nearly 7000 premature deaths, 2106 cases of chronic bronchitis and an annual cost of 21 million USD attributed to air pollution. The main reasons for transport related air pollution are emissions from vehicles (37%) and suspended road dust (25%). (World Bank 2007, p. 32)

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The increase in traffic related road accidents is another indicator of current transport conditions in Kathmandu. The Metropolitan Traffic Police reports 3998 road accidents in year 2011/12, of which 304 are reported seriously injured and 114 deaths. In the last ten years, the number of road accidents has more than doubled from 2180 in 2002/03 to 4914 in year 2010/11. The highest rate of accidents is among the motorcycles. Despite the increase in public and private vehicles, the mismanagement and arbitrary operation of public vehicles in random routes cause delay in accessibility to public services and transport services (KSUTP 2010, p. 3). Expensive travel fares on transport services is another prime factor that creates social disparity among groups of varying income levels. Many low-level income households cannot afford to use public transport services (KSUTP Final Report 2010, p. 5). Though there are no studies carried out to measure the level of erosion of historical buildings, monuments, statues, and other culturally significant sites, however, increased air pollutants and noise disturbances are attributed for present erosion of such architectures. Natural erosion accounts for a very minimum percentage in comparison to human-induced causes (Pant & Dongol 2009, p. 8). This degeneration of historical sites corresponds to the loss of cultural heritage of the city. Another major set back on the current transport system is the inconsideration for pedestrians. The walking alleys and pathways are poorly maintained, and the conditions in the city centre have seriously declined over the last decade (KSUTP 2010, p. 5).

2.3 Kathmandu Historic City Centre

The old historic part of the city is the central of Kathmandu city that is densely populated and comprises of complex network of narrow roads and alleys, and substandard buildings. There are no separate lanes for pedestrians and vehicular traffic. Being the hub of economic activities, the historic core invites a large number of informal street vendors and squatters along the traffic corridors. Utility shops and uncollected garbage encroach the narrow streets. The city centre is also the main attraction among the international and domestic tourists because of the cultural and architectural heritage it embodies. The area, Kathmandu Durbar Square, was inscribed as a UNESCO World Heritage Site in 1979, and contains historical and cultural monuments and palaces, temples and shrines, courtyards and squares that depict ancient architecture and artistry of native Nepalese people residing in the Valley. At present, the city centre is divided into five categories as per land use zones: heritage, tourism, commercial, institutional, and residential (KSUTP Annexes 2010, p. 107) as shown in Figure 2. The roads are generally poorly maintained, and hence are not capable of bearing traffic volume of nearly 4,500 pedestrians per hour in any given location within the city centre. The movement of vehicular traffic in three hours during the peak evening hours (16:00 pm – 19:00 pm) was recorded to be approximately 24,600 motorized vehicles (KSUTP Annexes 2010, p. 103). These scenarios result in an environment that is not safe and convenient for the local residents and tourism alike. It also results in high levels of air and noise pollution in the area, and increase in the number of road accidents. Rapid urbanization and high land prices have led to increased population density and higher buildings. Building

17 The figures were collected from Metropolitan Traffic Police, Kathmandu during the second field visit in April 2012.
regulations and developmental plans are not complied with, and there are no apparent conservation plans for the preservation of architecturally and culturally significant buildings and monuments. Except from the recent Kathmandu Sustainable Urban Transport Project by the Ministry of Physical Works and Planning/Asian Development Bank (ADB), there have been no parallel efforts neither from the governmental or non-governmental organizations to preserve and develop the city’s historic core.¹⁹

Figure 2: The historic city centre of Kathmandu city showing different land use zones. [Source: KSUTP 2010, Annexes 5.3, p. 107)

¹⁹ Kathmandu Sustainable Urban Transport Project (KSUTP) is partly loaned and partly funded by Asian Development Bank in cooperation with the Government of Nepal and its related ministries. KSUTP started its operations in phases from 15th April 2010 once the report was submitted to Ministry of Physical Planning and Works. Kathmandu Metropolitan City Office has been assigned the work of developing and regenerating the old historic city centre by making it vehicle free pedestrian walkable area. Detailed explanation of the project outline and future developments is explained in the report – KSUTP Final Report and Annexes, 2010.
2.4 Public Appraisal of Kathmandu City Centre

The previous sections provided an overview of the present transport system in Kathmandu city centre. The figures and illustrations generate a hard outlook on the situation; and since most of the data are collected and assessed by experts and officials from different organizations, these facts and figures have tendencies to serve only a partial or one-sided perspective on the state of affairs. Nevertheless, the hard facts show that there is a serious degeneration of Kathmandu’s urban transport system, resulting into a wide range of social, economical, and environmental problems. However, a measurement of people’s assessment of their own environment is essential to understand and comprehend the problem from a unit individual level, and generalizing the understanding to a larger population.

A survey was carried out in January 2012 in Kathmandu, to measure people’s affective appraisal and experiences of urban transport in the city centre. Different characters such as streets, city design, greenery, public space, building types, and many others influence the psychological impression of the experienced environment on the people. Environmental psychologists argue on the importance of environmental factors in shaping personal orientation and behavior to a great extent. People’s response to their urban setting represents a consensus of the resident population, and thus evaluates people’s satisfaction/dissatisfaction towards the environment. A questionnaire with multiple choice questions and open-ended questions for nine different locations within Kathmandu city centre was designed (Annex 9). Each location was illustrated by a photograph showing various urban characters, and participants would choose the emotional response they feel at that particular location under portrayed circumstances. The questionnaire is attached in the annex section (Annex 9).

The results were then assessed using MEERCI and the generated graphs depict overall impression of people’s appraisal of urban landscape of the city centre. A total of 26 people responded to the questionnaire with critical comments and feedback for the improvement of urban morphology and structures. The following figures demonstrate how people feel about a certain location in the city centre. The number of people is quantified in percentage of the total sample population. Figure 3 and 4 show how people’s emotions can change according to the environment they experience. Place 1 – Sundhara is a congested, over crowded, polluted, and unmanaged site with excessive vehicular and pedestrian traffic; in contrast, place 2 – Kathmandu Durbar Square (Basantapur) is a pleasant, calm, clean, open-spaced public square with historical architectural buildings and managed utility vendors. The figure 3 denotes that 61.54% of the sample population feel irritated experiencing the environment of Sundhara, and nearly 50% feel uncomfortable. On the other hand, 53.85% feel interested, 42.31% pleasant, and 23.08% restful at Kathmandu Durbar Square (Basantapur) as shown in Figure 4. The graphical presentation of other sites are attached in the annex section (Annex 4), however an overall graphical layout of the survey results exhibits people’s assessment of the nine sites based on their encounter with urban amenities as demonstrated in Figure 5.

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Figure 3: People’s response to their appraisal and experiences in place 1 – Sundhara, Kathmandu.

Figure 4: People’s affective appraisal and response to their experiences in place 2 – Kathmandu Durbar Square (Basantapur), Kathmandu.
Figure 5 represents the percentage of people responding to different urban characters with a variety of emotions. Their emotional responses are characterized by the surrounding environmental features as illustrated in Figure 6. It is clearly evident from Figure 5 that a higher percentage of people show negative emotions experiencing their urban environment. Except from Kathmandu Durbar Square (Basantapur), all other places record for emotional response of irritation, uncomfortable, upset, tensed, and distressed. Only Basantapur area accounted for happy, pleasant and peaceful mood of the participants. A detailed tabular classification for each location is presented in the annex section (Annex 1). Figure 6 gives an overall impression of how the inhabitants of the city assess their experience of the city and its urban characters.

The survey results highlighted the difference between a managed and regulated place as Kathmandu Durbar Square opposed to a chaotic, over-crowded, unmanaged place like Sundhara or NAC Station. The results correspond to their preference of a safe, peaceful, pleasant and interesting urban atmosphere. The city centre accounts for the highest traffic volume in the city, and consequently, high commercial activities, risks of traffic accidents, congestion, and social coercion. All of these nine locations are in or at the periphery of the historic city centre. The present impression of the city centre and its mobility facilities demands for an improvement of the current system to improve the living conditions of the inhabitants. The results also showed people value historic heritage, architecture, and craftsmanship in the city centre as shown in Figure 6. However, there are some serious problems with accessibility, environmental disturbances and pollution, bicycle paths, pattern of the city, pedestrian walkways, and street furniture. The issues of accessibility of public mobility, air pollution, and walkways for pedestrians are already discussed in section 2.2, supported by hard facts and solid numbers. Those facts are further supported by people’s assessment of the
city’s environment, as outlined in the survey results. Other important issues emphasized by the public were parking facilities, maintenance of infrastructure, multimodal traffic system, vegetation and green spaces, water sources, street lighting and public services. The survey laid a ground for further research on these critical factors. A fact-finding research is necessary to collect data and quantify the variables and parameters for the measurement of each of these factors.

| ACCESSIBILITY; for public use and disabled |
| STREETFURNITURE; sofas and places to sit, |
| SCALE; size and proportion of buildings and |
| SPACE; spatial sensitivity |
| ADVERTISEMENT; signs |
| MAINTENANCE; of buildings |
| ANIMALS; for example birds |
| PARKING; cars, motorbikes and bicycles |
| TRAFFIC; cars, motorbikes, trucks and buses |
| MICROCLIMATE; local weather suhs as sun, |
| ENVIRONMENTAL DISTURBANCES; noise, |
| VEGETATION; greenery, trees bushes, flowers |
| WATER; natural or in fountains |
| PUBLIC SERVICE; schools, libraries, |
| LIGHTING; streetlighting and daylighting |
| CONSTRUCTION SITES; order and |
| BOUNDRIES; between public, half public and |
| BICYCLE PATHS; possibilities to bike |
| PATTERN OF CITY; organization of streets |
| MATERIAL; of building facades and on the |
| WORKPLACES; offices and crafts |
| VARIATION; contrast in the environment |
| MIX USE; variety of uses such as housing, |
| MAINTENANCE; of public space (streets and |
| CONTEXT; adaption between new and old |
| SEASONS; fit of design to winter, spring, |
| VIEW; outlook and scenery |
| ACTIVITIES; opportunities to be part of |
| COLOUR; harmonies and contrasts |
| PEDESTRIAN WALKWAYS; possibilities to |
| PUBLIC TRANSPORT; possibilities to go by |
| ART; sculptures, installations |
| COMMERCIAL SERVICE; shops and stores |
| ARCHITECTURE; craftsmanship in buildings |
| HISTORY; the historic heritage in buildings |

Figure 6: The urban characters that identify Kathmandu city centre, and people’s assessment of those characters of the city.
2.5 Kathmandu Sustainable Urban Transport Project (KSUTP)

Kathmandu Sustainable Urban Transport Project (KSUTP) a part of ADB’s extensive venture - Sustainable Transport Initiative (STI) in five pilot cities in Asia. Ministry of Physical Planning and Works coordinates the project with the financial assistance of ADB. The main visions of the project are to improve the public transport operations and introduce pedestrian areas in the city centre of Kathmandu, and eventually improve the air quality of the city. Several government departments, Kathmandu Metropolitan City office, and Metropolitan Traffic Police were consulted and are involved in the project. The project has four components whose aims are to: a) improve public transportation, b) manage traffic in the city centre, c) improve pedestrian mobility in the city centre, and d) improve air quality respectively.  

The major highlights of component A – public transport can be outlined as follows:

a. Assignment of routes according to the size of the vehicles, for instance larger buses will be assigned routes on the peripheral terminals along wider roads, while smaller tempos will operate on tertiary routes in the city centre.
b. Reorganization of independent public vehicle operators into smaller groups/cooperatives with a responsibility of an entire route (as shown in Figure 7)
c. Construction of new bus stop for long-distance bus journeys, and remodeling of present old bus park for Valley transport services only; and improvement of bus interchanges for people without obstructing the flow of traffic in the city centre
d. Reintroduction of trolley buses in existing infrastructure, increase in the fleet of large-sized buses, and a corresponding decrease in the medium and small-sized vehicles.
e. Formulation of new rules and amendments on existing regulations for the improvements
f. Facilitation of technical support to make public transport efficient, acceptable, and affordable to all groups of the society. (KSUTP Final Report, 2010)

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Figure 7: KSUTP proposal for reorganization of public transport operators. (Source: KSUTP Final Report, 2010)

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The component B – traffic management relates to the aim of improving the circulation of motorized vehicles within the city centre of Kathmandu. The existing junctions in the city centre will be reconfigured with further construction to increase the capacity to handle greater traffic volume. Physical construction includes installment of eight sets of traffic signals, 21 pole mounted swivel CCTV cameras, and 21 radio headsets for traffic police. Congestion and delays in the movement of traffic will be decreased by the designation of urban clearways and prohibition of street parking. (KSUTP Final Report, 2010)

Another component of the project is the pedestrianisation of the city’s historic centre and improvement of accessibility and safety of the pedestrians. The roads and alleys within the city centre will be designated for pedestrians only, by restricting the entrance of motorized vehicles into the historic core. Many discovery routes will be selected and improved for the promotion and conservation of historic architecture and cultural heritage. The movement of public vehicles will be restricted within the centre while private vehicles will be regulated according to designated hours of the day/night. The construction an enforcement program will be undertaken by KMC. (KSUTP Final Report, 2010)

The last component of the project involves the improvement in the air quality in Kathmandu city in general. This is expected with the reintroduction and extension of trolley bus service. Air quality will be improved by the reduction of fuel-powered vehicles and introduction of zero emission vehicles. Regulations on emission and mechanical standards of existing and new vehicles will be enforced to ensure less emissive and standard vehicles in operation. The fuel quality will be standardized to Euro III standard, which will emit less green house gases, and overall improve the operation of the vehicles. In addition, public awareness campaigns will be held to inform the public about the risks associated with polluted air. (KSUTP Final Report, 2010)
3. Methodology

In this thesis two separate methods are applied to measure and analyze collected data from the surveys and fieldwork.

3.1 MEERCI

Measurement of Experience in Environment from Results of Core affect Investigation (MEERCI) is a method to measure people’s affective appraisals and experiences of the urban environment. The method uses questionnaire that asks people for their own experiences depending on various urban factors such as design, lights, walkways, traffic, and services. MEERCI outlines an analysis of the urban characters depicting in a picture of a selected area, and questions people of their assessment of the selected area. The questionnaire consists of both multiple choice and open-ended questions.

MEERCI was developed and validated by Lena Steffner in her doctoral thesis work in 2009. Urban character is basically urban morphology, space, structures, buildings and patterns, greenery and water, landscape and aesthetics, demographical orientation, and public services. Open-ended questions allow the respondents to put forward their comments; therefore, valuable information from people can be obtained from the survey. The survey is conducted in January 2012 at nine different locations within the city centre, each with different urban characters and appeals for the participants. The selected areas were: Sundhara, Kathmandu Durbar Square (Basantapur), Ason, Indrachowk, Bhotahity, Teku, Mahankal, NAC Station, and Jyatha. All of these sites are either in the city’s historic core or at the periphery of the centre. The selection of sites is rational, because each site embodies a specific urban landscape. Therefore, it is justifiable to include different locations with variety of characteristics, so as to get a heterogeneous response from respondents. The variation in locations also produces disparate conclusions on people’s varied relation and evaluation of their own personal state of mind. Different factors in different environments induce different feelings in different people. A total of 26 random people answered the questionnaire. The sample population aged from 21 to 35 years, and included local residents, tourists, and intellectuals.

The first section of the questionnaire displayed pictures of nine different sites within the city centre, and the participants were asked multiple-choice questions about their assessment of the given urban environments. The second section of the questionnaire had general open-ended questions about 27 urban characters, and the respondents were asked to evaluate their experiences of the characters. These 27 characters were validated by Steffner (2009) in her doctoral thesis in 2009. With these assessments, a general understanding of people’s satisfaction can be derived. Furthermore, the comments and information provided in open-ended questions correspond to people’s expectations and demands for their environment. In short, the questionnaire is intended to produce both people’s experience and suggestions for improvements. That is, the current situation is assessed according to their affective appraisals, and future improvements are suggested. This information is valuable for urban planners, who

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often tend to neglect people’s perspectives on a certain scenario, whilst imposing own expertise and knowledge to reify a given situation.

3.2 GMAA

The second phase of the study concerns with the proposition of the optimal strategy for the transport system in Kathmandu city centre. The city is undergoing rapid urbanization, and the status quo of the transport system is declining, hence affecting different sectors of the society. Ministry of Physical Planning and Works, in cooperation with Asian Development Bank (ADB) and many other respective national authorities, has initiated Kathmandu Sustainable Urban Transport Project (KSUTP) from early 2011. The KSUTP Final Report predicts tremendous improvements in transport system, and in general the well being of the people and living conditions in the city. However, these changes have their own pros and cons, and therefore, needs to be assessed instrumentally. The assessment is performed under three different criteria: environmental, socio-cultural, and economical. Two action alternatives were decided for the transport system in the city: Current System and KSUTP. Current System referred to no changes in the transport system. This meant allowing the current trend of events to follow over the years, and making no changes whatsoever in the system. On the other hand, KSUTP presented immediate changes in different sectors of the transport system, and development/improvements in the infrastructure, conservation policies, and traffic regulation and maintenance.

A qualitative survey was conducted in April 2012 to summarize people’s evaluation of different attributes within socio-cultural, environmental, and economical realms. The survey was intended to understand people’s perception on different sectors affected by current transport system, and their expectations from the changes brought by KSUTP. The questionnaire (Annex 8) had an introductory section asking for general information about the respondents, followed by three specific questions about their participation in local cultural events, level of trust, and utility of public space. A total of 187 people were asked randomly. The sample population consisted of local residents, local business owners, and tourists. The provided information is their evaluation of the attributes, as perceived by them. The responses are categorized in five levels from 1 to 5, where 1 corresponds to the lowest level, and chronologically increasing in order to 5 the highest level. Other facts and figures were collected from ministries, Kathmandu Metropolitan City Office, Traffic Police, non-governmental organizations, Department of Roads, Department of Transport Management, Nepal Tourism Board, and KSUTP Final Report. The hard facts and data from respective authorities were also collected to carry out an analysis of the action alternatives.

Depending on information from public evaluation and data from authorities, an analysis of the alternative strategies was carried out using Decision Support System (DSS) approach. DSS, a subset of computer-based information systems (CBIS), is a human interactive computer based decision-making system that facilitates decision makers (DM) in making decisions with multiple objectives. The analysis of strategies are based on two factors: first, likelihood of the possible consequences of each strategy, and second, the DM’s preferences on expected consequences. The secondary data, collected data, professional predictions, and preferences are used to quantify the range of consequences. In steps, the analysis can be divided into four steps: 1) structuring the problem, 2) identifying the action alternatives, 3) quantifying
preferences, and 4) evaluation of alternatives. A sensitivity analysis is carried out by simulating the results.\(^{23}\)

In this thesis, Generic Multi-Attribute Analysis (GMAA) system is used to evaluate the action alternatives. GMAA is an additive multi-attribute utility model that accounts for uncertainty about alternative consequences and considers incomplete information about DM’s preferences. The system allows decision makers (DM) to assign weights and utility functions to attributes according to their preferences. The overall utilities provide an insight into the classification of alternatives and their consequences, which helps DMs to deal with operational difficulties in a multi-criteria decision making process. The GMAA system provides different types of sensitivity analysis that helps to determine non-dominating and potentially optimal alternatives. This serves the DM to consider all possible alternatives, and accordingly rank them on the basis of their desired consequences. (Jiménez et. al. 2004, pp. 1081-1082) The data from second survey and from authorities were put into GMAA model (designed on GMAA workspace). The model is presented in Section 4 of the thesis.

### 3.3 Validity and Reliability

The results of the survey and analysis can be expected to be valid within the similar population of socio-demographic group, and as long as the urban characters remain the same as in the time of survey. The results from first survey concerning MEERCI are reliable because the survey was conducted among a random selection of local residents, tourists, and intellectuals who are the users of the urban environment of Kathmandu city. In addition, MEERCI method has been validated by Steffner (2009) in her doctoral thesis. Using a computer system as GMAA to evaluate the alternatives also signifies the reliability of the results.

### 3.4 Limitations

There were, however, few limitations experienced during the study. First, there was a severe lack of previous researches that required technical data and measurements such as the level of erosion of historical monuments. Therefore, the experts’ judgments were the only source of information. A general outlook from the sample population can raise problems in the validity of the data collected. Second, there were no official records by authorities in some cases such as commercial transaction records of a designated area.

4. Results and Findings

The results from the first survey taken in January 2012 showed that there is a general consensus between the general public about the worsening conditions of urban environment in Kathmandu city. Using MEERCI method, this general public discontent was portrayed in people’s emotional responses to their surroundings. Among all nine locations selected in the survey, only Kathmandu Durbar Square (Basantapur) had positive reviews (Figure 4), and other sites’ urban attributes were negatively responded by the participants (Figure 5). According to the public opinion, historical heritage, architecture, artistry and craftsmanship, and commercial services are the characters that should be preserved; and accessibility to services, pollution level, greenery and vegetation, street furniture, public transport and pedestrian walkways should be improved.

4.1 Survey Results

The second survey was intended to measure three different qualities of the city centre, as assessed by the public. A total of 187 individuals were questioned, of which 136 used public transport and 51 used private vehicles for daily mobility need. The age group ranged from 17-74 years old. When asked about their participation in local events, level of trust among fellow citizens, utility level of public spaces, the population answered evenly on all levels from highest to lowest, as shown in Figure 8.

Figure 8: Results from the second survey showing people’s level of participation, trust and utility of public spaces.

The information on level of erosion of historical buildings and monuments due to air pollution and noise disturbances (vibrations) were gathered from the Department of Archeology, Government of Nepal. Due to lack of previous studies on the issue, there were no concrete figures on the erosion level. However, the personnel at the department confirmed damaging effects pollution has on the monuments, but it was also argued that there is an element of natural erosion as well, unless the sites are scientifically maintained. Therefore, there was no clear attribution to pollution for eroding statues and buildings. A general outlook suggested that there is a natural
course of erosion, and air pollution and disturbances from regular heavy traffic expedite the level of erosion.

The assessment for the level of commercial activities was quantified on the basis of information from Nepal Chamber of Commerce (NCC), Kathmandu. According to NCC, the level of commercial activities in the city centre is not recorded because of the difficulties of informal street vendors and false revenue figures asserted by the business owners. Therefore, there was neither a clear statement nor registered figures from NCC. However, the authority suggested that there might not be a reciprocal change in trading and daily business in terms of revenues.

4.2 GMAA Assessment

Using GMAA interface, a model was created to evaluate the optimal alternative among current system and KSUTP as shown in Figure 9. The evaluation was based on three main criteria – socio-cultural, environmental, and economical – and the results from MEERCI. The fourth criterion, that is the results from MEERCI, was labeled as personal mood in the model. After creating the hierarchy of objectives and sub-objectives with different attributes, attribute weights and utility functions were assigned to individual attributes. The assignment of weights and utility functions were derived from the two surveys and the collected data from various authorities. The minimum and maximum ranges for the attributes were acquired from survey data. The units of measurement were decided before the surveys. Once the preferences were quantified and valued entered for each attribute, component utilities were assessed.
Figure 9: A GMAA model for the assessment of optimal strategy for urban transport system in Kathmandu.

Figure 10: Alternative classification showing overall utilities and ranks.

Figure 10 illustrates that KSUTP has an overall average utility of 0.5346 compared to current system’s 0.3427. Consequently, KSUTP ranks as the optimal strategy for transport system of Kathmandu city centre. The deviation from the average utility to both ends (minimum and maximum utility) shows that there is an overlapping of utilities as shown in Figure 10, however, it is not clear what attributes have caused such an overlapping. Individual assessment of the attributes explains the causal factors associated with the extension in the utilities. Figure 11 presents how each attribute has impacts on the overall utility of the alternatives. This differentiation in attributes is clearly visible in Figure 12 and Figure 13.
Figure 11: A stacked bar ranking of two alternatives, showing utilities of different attributes.

Figure 12: Graph showing utilities for each attribute for current system alternative.

Figure 13: Graph showing utilities for each attribute for KSUTP alternative.
From Figure 12 and Figure 13, it can be concluded that there are significant differences in the following attributes. These differences are explained with utility function graphs in the proceeding sub-section 4.3.

- Access to Services
- Traffic Volume
- Resettlement of Affected People
- Restoration of Old Roads
- Access to Transport

4.3 Utility Function Graphs

The accessibility to public services is measured in terms of the time duration it takes from the point of origin to reach the intended public service. The standard time of measurement is 30 minutes. However, the current situation in the city centre with its poorly managed transportation and road network, the time to access services vary from 15 to 45 minutes. With the implementation of KSUTP, road networks will be routed for maximum efficiency, and vehicular transport will be managed so as to yield optimal utility for overall transport system; it is expected to reduce the time duration from 15-45 minutes to 5-15 minutes. This is a significant increase in the utility of time and public services. The following figure (Figure 14) shows the utilities at different time scale. The attribute has a linearly decreasing function, with maximum utility of 1 for 0 minutes to public services to minimum utility of 0 for 45 minutes to public services.

![Utility Function Graph](image)

Figure 14: Component utility showing utilities as different time scale for access to public services.

Another significant difference was seen in traffic volume per day in the city centre of Kathmandu. Under current system, there is movement of an average of 461,927 motorized vehicles per day on the roads within the city centre. KSUTP proposes to reduce vehicular traffic to a moderate number, so as to suffice the basic needs of mobility, not damaging the surrounding environment. With restrictions on motorized vehicular movement within the historic core, and regulating the movement of private and public vehicles, KSUTP expects to reduce the number of vehicles to less than half, yet maintaining near maximum utility and satisfaction in the public experience. Figure 15 demonstrates maximum utility at 0 vehicles, however, having no vehicles for mobility does not maximize city’s productivity. A sufficient number of vehicles, but not excess, is necessary for the city. Therefore, an excess number of 461,927
vehicles in a day means minimum utility of 0, while around 200,000 vehicular movement in a day is permitted for maximum utility (as shown in Figure 15).

![Figure 15: Component utility showing a linearly decreasing function for traffic volume per day.](image)

Under the present scenario, informal street vendors and squatters are not to be relocated/resettled. At present, there are 1068 squatter households occupying the riverbanks of Bishnumati (flowing aside the city centre), and numerous informal street vendors within the city centre. However, within KSUTP, there is a provision for resettlement program for the affected people that amounts to USD 2.15 million. This cost of resettling the affected people implies that economically, KSUTP has minimum utility because a linearly decreasing utility function is assigned to the attribute. In other words, the utility of the attribute is maximum when the resettlement cost is minimum. Figure 16 shows the utility function for resettlement cost.

![Figure 16: Component utility showing utility graph for expenditure on resettlement of affected people.](image)

Similarly, restoration of old roads is a cost featured in KSUTP whilst not a component in the current system. The attribute is assigned a linearly decreasing utility function with an assumption that the attribute will have highest utility when there are no costs for restoring the old roads. Consequently, current system has higher utility value compared to KSUTP with restoration cost of USD 8.75 million. The restoration cost includes capacity building of traffic police and involved personnel, public awareness campaigns, training and consultancy, devices and technical equipments, regulations and enforcement, and renovation and construction of roads. Figure 17 shows utility function graph for restoration cost.
Another important component that differed greatly while comparing two alternatives is the access to transport facilities. The current transport system is poorly managed as portrayed by the surveys and facts. The time to access transport facilities is generally between 15-30 minutes. This is primarily because of poor management of vehicles and routes, irregular time schedule, multi-modular transport system, and private vested interest on maximizing profit rather than meeting public service demands. As a part of KSUTP implementation plans, different routes will be individually assigned to an allocated number of vehicles, and a committee formed of individual vehicle operators will given the responsibility of certain route/s for operation to serve public mobility demand. This improvement is expected to reduce the time to access transport service to about 5-15 minutes depending on geographical distances. As a result, maximum utility is obtained at lesser times while minimum utility when more time is needed to access vehicles. This is illustrated in Figure 18 below.

Apart from the five major differences, road accidents, air pollution, and maintenance of the roads are other components that differ to significant extent. These three components are expected to decrease over time after the improvements made in the transport system with the application of KSUTP. According to the Metropolitan Traffic Police, over the last 10 years, the number of road accidents has increased from 2180 (2003) to 3998 (2011) per year. The number of deaths related to road accidents, however, has remained consistent in those years. Annex 2 demonstrates the increase of road accidents in Kathmandu city. The implementation of KSUTP will decrease the number of private vehicle and encourage public transport, which will result in the decrease of traffic volume and congestion. There will be separate lanes for pedestrians.
and motorized vehicles. There is no estimation of the reduced number of accidents, but it is generally accepted fact that improvements in transport safety measures prevent unnecessary accidents.

Similarly, the current PM10 concentration in ambient air in the city varies from 200 µg m⁻³ to 624 µg m⁻³. The majority of pollutants come from vehicles on the roads. Higher number of vehicles represents higher levels of pollution. As a result of decrease in number of vehicles, the level of PM10 will decrease accordingly. As regards to maintenance of old roads, Kathmandu Metropolitan City Office has an allocation of USD 4.19 million for the year 2011/12. It is evident that poor maintenance of roads will add more depreciation cost in the later years, and there will be an exponential escalation of cost for maintaining the roads in their current conditions. While in comparison, KSUTP will restore the old roads and hence, the total maintenance cost will decrease. However, KSUTP has designated USD 253,570.00 for repair and maintenance. The basic assumption is that minimum the cost of maintenance; the higher is the utility value of the attribute. In the case of two alternatives, KSUTP (with minimum maintenance cost) has higher utility value than current system (with higher maintenance cost). The utility function graphs for all the components are attached in the annex section (Annex 5).

4.4 Monte Carlo Simulations and Statistics

Once all the necessary data were entered into the GMAA model, component utilities assessed, and alternative consequences quantified, the alternatives are then evaluated based on their utility functions and consequences. A sensitivity analysis was performed using simulation techniques. The simulation technique used Monte Carlo simulation to enable statistical analysis, which provide in depth understanding of multi-criteria model. Random weights are generated for the attributes, and a total of 10,000 simulations are run to generate a boxplot diagram showing statistical significance for each alternative, as shown in Figure 19 and Figure 20.

![Figure 19: Simulation techniques for sensitivity analysis of the alternatives.](image)

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25 KSUTP Final Report, the Economical Assessment. Ministry of Physical Planning and Works/ ADB.
In Figure 19, the alternatives are represented along the x-axis, and the positions in alternative rankings are shown in y-axis. The blue lines show the maximum and minimum, and the yellow mark signifies the ranking of the alternative. From Figure 19, it is evident that current system as an alternative can be removed because its best performance is at the lowest. These statistics show co-relation with alternative classification in Figure 10. Since there are only two alternatives, it is confidently assertive to conclude KSUTP as the optimal alternative. However, to assess the dominance of one alternative over another, dominance and potential optimality is checked. As shown in Figure 21, KSUTP has a slight dominance value of -0.9475, which is less than/nearly equals to zero. This means KSUTP is marginally dominating over current system.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Min.</th>
<th>25th percentile</th>
<th>50th percentile</th>
<th>75th percentile</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Policy</td>
<td>2</td>
<td>1</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>2</td>
<td>1.963</td>
</tr>
<tr>
<td>KSUTP</td>
<td>1</td>
<td>1</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>2</td>
<td>1.037</td>
</tr>
</tbody>
</table>

Figure 20: Statistical presentation of alternatives.

Figure 21: Dominance and Potential Optimality boxplot showing dominance of one alternative over another.
5. Discussions

With only two alternatives, it is fairly easier to select the best strategy for transport system in Kathmandu city. Having the results from MEERCI as a background for people’s appraisal of their urban environment, it can be concluded that people, in general, are not satisfied from their immediate urban structure and its characters. There is a general consensus over the positive and negative characters of the city. Most of the negative concerns arose from transport facilities in the city, and especially the city centre that suffers the most from poor management of transport. The current transport system has significant impacts on all the fourteen attributes divided under socio-cultural, environmental and economical criteria. Henceforth, a new project by Ministry of Physical Planning and Asian Development Bank was initiated in early 2011 with an objective to upgrade the transport system of Kathmandu city centre. KSUTP Final Report summarizes the key framework of actions to be undertaken during the period of the project implementation.

With this study, the intention was to analyze both alternatives, current system and KSUTP, and propose the optimal alternative. With the help of GMAA model, KSUTP is classified as the optimal alternative for transport upgrade in the city centre. There was a varying degree to which each of the assigned attributes differed in relation to two alternatives. However, some of the prominent differences were among access to transport and services, and traffic volume. The level of participation, level of trust, and utility of public places were evenly spread, and showed consistency even after the changes in the transport system. It can be derived from the component utility graphs (Annex 5); these attributes are assigned linearly increasing utility function. The results from the survey indicate that people are willing to participate in local events to certain extent after which participation level is almost constant. For example, those people who more often participate will participate regardless of the change in the transport facilities. However, most of the participants are opinionated to a view that better transport facilities will probably increase the participation level and the number of attendees. Similarly, similar opinions resounded for level of trust and utility level of public places. To a certain maximum level, people trust fellow citizens, and maintain the social cohesion, after which the level of trust usually remains constant. In case of utility of parks and courtyards, people who already use the public spaces will continue to use those places irrespective of the changes, and therefore, an increase in number of users may be expected, but cannot be asserted affirmatively. The personnel at Nepal Chamber of Commerce held identical views that there might not be a significant increase in the level of commercial activities, but rather facilitation in the commercial services.

Tourism sector seemed to be affected to a greater extent with the improvements in pedestrian walkways and better facilities for mobility. A graph showing the average spending per person per day is shown in the annex section (Annex 3). Over the last decade, tourist spending has fluctuated from USD 79.10 (2003) to USD 39.90 (2011). There is a decline in the spending despite the increase in the number of tourist arrivals from 338,132 (2003) to 735,965 (2011). To analyze the co-relation between these two variables is not within the scope of the study, however, it can be concluded that poorly managed transport, safety concerns during travel, displeasure from the environment, pollution and crowded places, and loss of cultural heritage and architecture are some of the reasons for tourists staying less in the city. With an improvements in these
sectors of the city landscape, it can be expected that there will be more willingness among the tourists wanting to staying longer for leisure, hence, contributing to the local economy and cultural exchange.

Economically, it is apparent that current system is dominant over KSUTP, for reasons that there are lower costs for restoring old roads and resettlement of affected people. From a short-term perspective, minimization of restoration cost may seem as the best choice at present. However, it must be noted that KMC Office already has an allocated budget of USD 4.19 million (for year 2011/12) for maintenance of road infrastructures in comparison to USD 253,570.00 of KSUTP. However, records from previous year 2010/11 show that the actual expenditure on maintenance by KMC was only USD 485,493.40 while the estimated budget for the same year was USD 2.36 million. This implies that less than four times is invested in maintenance than necessary. It is not within the scope of the study to investigate on the decrement of maintenance cost by KMC. The discounted investment now on maintenance will internalize the actual costs over a long period of time to a greater cost of reconstructing the whole network of roads again. The cost of this consequence will be much higher than the combined restoration and maintenance cost occurring now. In summary, in a short-term perspective, economically current system may seem as the optimal strategy, however, in a long run, current system has negative consequences for transport infrastructures. This is an important aspect that decision makers should consider when assessing utility function for different components. A long-term vision is an important element in urban planning.

The resettlement cost of affected people is another aspect that hints toward social criteria, if not only economical. As of now, the number of squatter households is rapidly increasing along the banks of Bishnumati river and Bagmati river in the city. The main reason is internal migration from neighboring districts and rural areas of the country, especially in search of work, facilities and health services. However, the resulting damage on the urban environment is unparalleled. Problems such as waste management, socio-economic disparity, health issues, strain on natural and economic resources, and so forth will escalate geometrically. These issues are not immediate and extensively detrimental now (as of year 2012), but have potentials of being so in near future. For this very reason, the government is not, in particular, concerned of the problem as such. Another important aspect affected by informal vendors and illegal squatters is the aesthetics of the city. Under the KSUTP plan, there is a program with USD 2.15 million for resettling the affected groups. Therefore, economically, KSUTP has lower utility compared to current system. However, if we consider the holistic picture of socio-environmental and the economical imbalances the increasing number of informal vendors and illegal squatters will have in the city, it is wise to look at the long-term effects and make decisions accordingly. Reflecting upon MEERCI results, it can be concluded that, generally, people will be pleased and happier with the improvements in their urban environment, making it more habitable, accessible, and sustainable. Consequently, the numbers of people who are happy and content are expected to increase; and the number of sad and distressed people to decrease. Without another survey after the completion of KSUTP, it is rather difficult to cement a numerical figure on the number of people on any category of emotions.

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The above discussion can be graphically summarized in Figure 22. When KSUTP is compared with current system in terms of overall utility values and consequences, it is evident that KSUTP produces better results with significant differences in some attributes such as access to transport and services, and traffic volume. Except for resettlement and restoration costs, KSUTP dominates current system in almost all criteria. Henceforth, conclusively KSUTP is the best action alternative for transport system in Kathmandu city centre.

![Figure 22: Comparison of alternatives in terms of utility values](image)
6. Conclusions

The current transport system of Kathmandu city is regarded as unsustainable and environmentally damaging in many ways. The consequences of such system in operation are visible in the form of environmental degradation, heritage loss, social disintegration, economical disparities, and alike. An improvement to make the transport sector more environmentally compatible, socially acceptable, and economically viable is essential, if the city is to retain its cultural identity, mobility, resilience, and sustainability. A holistic approach including socio-cultural, environmental, economical, political, and public feedback is necessary to streamline feasible developments in the system. Primarily, the study intended to find the optimal action alternative for transport in Kathmandu city centre.

With two phases of surveys, the study assessed people’s appraisal and experience of the urban environment and various characters of the landscape. The results of this assessment was further supported by the second survey and facts from the authorities that the current transport system of Kathmandu needs serious renovations and improvements. The study categorized two action alternatives as current system and KSUTP. With the help of a multi-attribute analysis method, GMAA, the data from the surveys were entered to assess the alternatives. The assessment and analysis demonstrated that Kathmandu Sustainable Urban Transport Project (KSUTP) was the best alternative based on different attributes.

The analysis was further supported by sensitivity analysis using simulation techniques of Monte Carlo. The simulations also yielded KSUTP as the optimal strategy to undertake in order to improve transport system in Kathmandu city centre. The implementation of KSUTP is expected to generate benefits for the general public, the local environment, and the local economy. As in the case of Kathmandu city centre, improving transport system results in lesser number of private and public vehicle movements. This in turn results in less congestion, lesser pollution, and less damage to historical architecture and buildings. Managed transport system with regulations and designated responsibilities, there will be less conflicts and road accidents. This improves the safety of pedestrians, which is further refined with constructing separate lanes for pedestrians and bicycles. This overall enriches the urban experience for the residents and tourists. Better and easier access to public transport and services enlivens the living standards of the locals in general. When there is cohesion among the members of the society benefitting from the social welfare, the social capital has tendencies to increase, thus, further enhancing the quality of life one can experience in an urban landscape like Kathmandu city centre. Hence, it can be concluded that these factors are complementary to each other and all of them are interlinked with each other in a network that underlies a sustainable society.

The expected benefits from KSUTP should be measured again through another survey and data collection. Therefore, another study confirming the dissipation of benefits from KSUTP needs to be undertaken to measure the consequences. In future research, more emphasis can be given on the collection of scientific data from previous researches, though it may be more time consuming and extensive.
Bibliography


Annexes

Annex 1

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Annex 1: A tabular representation of people’s affective appraisal and experiences in nine different locations in Kathmandu city using MEERCI measurement method. The numbers are percentage of the total sample population.

Annex 2

Annex 2: A graph showing the increase in total number of road accidents from year 2001 through 2011. The number of deaths and serious injuries, however, has remained constant over the decade. Figures on x-axis represent the years, and y-axis represents the number of accidents.
Annex 3: A graph showing tourist spending per person per day in US dollars. Y-axis represents the amount of dollars spent by a tourist in a day in Kathmandu.

Annex 4 illustrates people’s affective appraisal and experience of nine different locations in the city centre. The graphical presentations show the percentage of respondents who responded to different emotions as per induced by the surrounding environment.

Place 1: Sundhara
Place 2: Ason

Place 3: Kathmandu Durbar Square
Place 4: Teku

Place 5: Jyatha
Place 6: NAC Station

Place 7: Mahankal
Place 8: Bhotahity

Place 9: Indrachowk
Annex 5 shows utility functions for different components. The graphs are assigned linearly increasing or decreasing function. In case of linear decreasing function, the maximum utility is at zero (0) and minimum utility is at maximum attribute value.

Graph 1: Level of participation in local events

Graph 2: Level of trust

Graph 3: Access time to public services
Graph 4: Number of road accidents

Graph 5: Level of Erosion

Graph 6: Amount of PM10

Graph 7: Utility level of public spaces
Graph 8: Traffic volume per day

Graph 9: Level of commercial activities

Graph 10: Tourist spending per person per day

Graph 11: Expenditure on maintenance per year
Graph 12: Expenditure on resettling affected people

Graph 13: Expenditure on restoring old roads

Graph 14: Access time to public transport

Graph 15: Percentage of happy people
Graph 16: Percentage of content people

Graph 17: Percentage of sad people

Graph 18: Percentage of distressed people
Annex 6 shows weigh distribution among various sub-objectives and attributes, and the maximum and minimum consequences for each attribute.
Annex 7 shows the uncertainty of weight distribution in all the attributes.

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Annex 8: Questionnaire for second survey in April 2012.

The aim of this questionnaire is to find out people’s utility of public transport, services, and level of trust. The selection of choice is divided into 5 categories as follows:

1 = never
2 = rarely
3 = sometimes
4 = more often
5 = very much

1. Age ______________

2. Gender:
   ___ Male
   ___ Female

3. Means of transport
   ___ Private
   ___ Public

4. How often do you participate in local events such as cultural events, religious ceremonies, festivals, social occasions, and alike?
   ___ never
   ___ rarely
   ___ sometimes
   ___ more often
   ___ very much

5. How often do you trust your fellow citizens in Kathmandu city?
   ___ never
   ___ rarely
   ___ sometimes
   ___ more often
   ___ very much

6. How often do you use the public spaces such as parks, courtyards, street furniture, and alike?
   ___ never
   ___ rarely
   ___ sometimes
   ___ more often
   ___ very much

Thank you for your participation. Your input is highly appreciated.

Annex 9: Questionnaire for the first survey in January 2012.
WELCOME!

This questionnaire is about how you personally experience the areas on map 1 (Kathmandu City centre) and the 9 places shown on map 2.

The results will be used in a student thesis work by a student from Nepal in the program for sustainable planning at Uppsala University and the Swedish University for Agricultural Sciences in Uppsala, Sweden.

We hope you will enjoy answering the questions about how you feel in this part of Kathmandu. Thank you in advance for your participation!

Age ___________________________ Sex ____________________________

How well do you personally know the area and the places?

☐ Very well  ☐ Quite well  ☐ A little
Place number 1 – Sundhara (aside Kathmandu Post Office)
Underline the feelings you have experienced at place number 1? (one or several)

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Explain some of the reasons to your feelings:

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________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Place number 2 - Ason
**Underline the feelings you have experienced at place number 2? (one or several)**

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<td>Bored</td>
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**Explain some of the reasons to your feelings:**

- 
- 
- 
- 
- 
- 
- 
-
Place number 3 – Kathmandu Durbar Square
Underline the feelings you have experienced at place number 3? (one or several)

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Explain some of the reasons to your feelings:

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________
Place number 4 - Teku
Underline the feelings you have experienced at place number 4? (one or several)

- Interested
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- Restful
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- Irritated
- Uncomfortable
- Upset
- Distressed
- Tense
- Scared

Explain some of the reasons to your feelings:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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________________________________________________________________________

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Place number 5 - Jyatha
Underline the feelings you have experienced at place number 5? (one or several)

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<td>Tense</td>
<td>Scared</td>
</tr>
<tr>
<td></td>
<td>Harmonious</td>
<td>Restful</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explain some of the reasons to your feelings:

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________________________________________________________________________
Place number 6 – NAC (near entrance to New Road)
### Underline the feelings you have experienced at place number 6? (one or several)

<table>
<thead>
<tr>
<th>Interested</th>
<th>Excited</th>
<th>Happy</th>
<th>Pleasant</th>
<th>Peaceful</th>
<th>Harmonious</th>
<th>Safe</th>
<th>Calm</th>
<th>Restful</th>
<th>Uninterested</th>
<th>Dull</th>
<th>Irritated</th>
<th>Uncomfortable</th>
<th>Distressed</th>
<th>Tense</th>
<th>Scared</th>
</tr>
</thead>
</table>

### Explain some of the reasons to your feelings:

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Place number 7 – Mahankal (near entrance to New Road)
Underline the feelings you have experienced at place number 7? (one or several)

<table>
<thead>
<tr>
<th>Interested</th>
<th>Excited</th>
<th>Happy</th>
<th>Pleasant</th>
<th>Peaceful</th>
<th>Safe</th>
<th>Calm</th>
<th>Uninterested</th>
<th>Irritated</th>
<th>Uncomfortable</th>
<th>Disstressed</th>
<th>Dull</th>
<th>Bored</th>
<th>Upset</th>
<th>Tense</th>
<th>Scared</th>
</tr>
</thead>
</table>

Explain some of the reasons to your feelings:

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Place number 8 – Indrachowk
Underline the feelings you have experienced at place number 8? (one or several)

<table>
<thead>
<tr>
<th>Interested</th>
<th>Excited</th>
<th>Happy</th>
<th>Pleasant</th>
<th>Peaceful</th>
<th>Safe</th>
<th>Calm</th>
<th>Uninterested</th>
<th>Dull</th>
<th>Irritated</th>
<th>Uncomfortable</th>
<th>Distressed</th>
<th>Tense</th>
<th>Scared</th>
</tr>
</thead>
</table>

Explain some of the reasons to your feelings:

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_________________________________________________________________________
Place number 9 - Bhotahity
Underline the feelings you have experienced at place number 9? (one or several)

<table>
<thead>
<tr>
<th>Interested</th>
<th>Pleasant</th>
<th>Safe</th>
<th>Uninterested</th>
<th>Irritated</th>
<th>Disstressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excited</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tense</td>
</tr>
<tr>
<td>Happy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Scared</td>
</tr>
</tbody>
</table>

Explain some of the reasons to your feelings:

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________________________________________________________________________
Fill in how you experience the following factors summarized for the whole area on map 1
Comment if you like.

• PEDESTRIAN WALKWAYS; possibilities to move by feet
  □ Positiv  □ Neutral  □ Negativ

Comment: ...........................................................................................................

• BICYCLE PATHS; possibilities to bike
  □ Positiv  □ Neutral  □ Negativ

Comment: ...........................................................................................................

• PUBLIC TRANSPORT; possibilities to go by bus
  □ Positiv  □ Neutral  □ Negativ

Comment: ...........................................................................................................

• CONSTRUCTION SITES; order and information
  □ Positiv  □ Neutral  □ Negativ

Comment: ...........................................................................................................
• TRAFIC; cars, motorbikes, trucks and buses
  
  □ Positiv  □ Neutral  □ Negativ

Comment: ……………………………………………………………………………………………

• PARKING; cars, motorbikes and bicycles
  
  □ Positiv  □ Neutral  □ Negativ

Comment: ……………………………………………………………………………………………

• HISTORY; the historic heritage in buildings and places
  
  □ Positiv  □ Neutral  □ Negativ

Comment: ……………………………………………………………………………………………

• MAINTENANCE; of buildings
  
  □ Positiv  □ Neutral  □ Negativ

Comment: ……………………………………………………………………………………………
- MAINTENANCE; of public space (streets and squares)
  - Positiv
  - Neutral
  - Negativ
  
  Comment: .................................................................

- PATTERN OF CITY; organization of streets and blocks
  - Positiv
  - Neutral
  - Negativ
  
  Comment: .................................................................

- MIX USE; variety of uses such as housing, commercial, institutional, business etc
  - Positiv
  - Neutral
  - Negativ
  
  Comment: .................................................................

- CONTEXT; adaption between new and old
  - Positiv
  - Neutral
  - Negativ
  
  Comment: .................................................................
• ENVIRONMENTAL DISTURBANCES; noise, air and water pollution
  □ Positiv  □ Neutral  □ Negativ

• ACCESSIBILITY; for public use and disabled
  □ Positiv  □ Neutral  □ Negativ

Comment: ………………………………………………………………………………………

• BOUNDRIES; between public, half public and private places
  □ Positiv  □ Neutral  □ Negativ

Comment: ………………………………………………………………………………………

• STREETFURNITURE; sofas and places to sit, waste paper bins and other facilities in public places
  □ Positiv  □ Neutral  □ Negativ

Comment: ………………………………………………………………………………………

• LIGHTING; streetlighting and daylighting
  □ Positiv  □ Neutral  □ Negativ

Comment: ………………………………………………………………………………………
• COMMERCIAL SERVICE; shops and stores
  □ Positivt □ Neutral □ Negativt

• PUBLIC SERVICE; schools, libraries, healthcare and other
  □ Positiv □ Neutral □ Negativ

Comment: ………………………………………………………………………………………………………

• WORKPLACES; offices and crafts
  □ Positiv □ Neutral □ Negativ

Comment: ………………………………………………………………………………………………………

• ACTIVITIES; opportunities to be part of activities (for example cultural events)
  □ Positivt □ Neutral □ Negativt

Comment: ………………………………………………………………………………………………………

• ARCHITECTURE; craftsmanship in buildings
  □ Positiv □ Neutral □ Negativ

Comment: ………………………………………………………………………………………………………

Meerci™ www.qualityarchitects.se
• ART; sculptures, installations

☐ Positiv ☐ Neutral ☐ Negativ

Comment: …………………………………………………………………………….

• ADVERTISMENT; signs

☐ Positiv ☐ Neutral ☐ Negativ

Comment: …………………………………………………………………………….

• VARIATION; contrast in the environment

☐ Positiv ☐ Neutral ☐ Negativ

Comment: …………………………………………………………………………….

• SCALE; size and proportion of buildings and places

☐ Positiv ☐ Neutral ☐ Negativ

Comment: …………………………………………………………………………….

• MATERIAL; of building facades and on the ground

☐ Positiv ☐ Neutral ☐ Negativ

Comment: …………………………………………………………………………….

• VIEW; outlook and scenery

Meerci™ www.qualityarchitects.se
Comment: …………………………………………………………………………….

• SPACE; spatial sensitivity

Comment: …………………………………………………………………………….

• COLOUR; harmonies and contrasts

Comment: …………………………………………………………………………….

• VEGETATION; greenery, trees bushes, flowers

Comment: …………………………………………………………………………….

• WATER; natural or in fountains

Comment: …………………………………………………………………………….
• ANIMALS; for example birds

☐ Positive ☐ Neutral ☐ Negative

Comment: .................................................................

• SEASONS; fit of design to winter, spring, summer and autumn

☐ Positive ☐ Neutral ☐ Negative

Comment: .................................................................

• MICROCLIMATE; local weather such as sun, shade, wind, rain protection etc.

☐ Positive ☐ Neutral ☐ Negative

Comment: .................................................................

**Final question:**

What would you wish most to be improved in this area of Kathmandu?

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