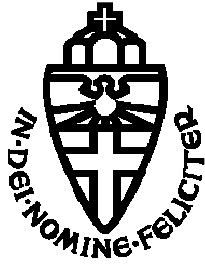


# Urban Mobility Systems in India

A research for the Enviu Tuktuk project



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Human Geography  
October, 2009



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## SUMMARY

The urban mobility in India is diverse with busses, (motor-)cycles, cars, barrows, pedestrians and (auto-)rickshaws moving next to one other on the roads. The motorized vehicles cause severe air-pollution, congestion and produce large amounts of CO<sub>2</sub>. A shift from public to private vehicles is ongoing, which results in more air-pollution and congestion. Auto-rickshaws are one of the transport modes which form a major share of the air- pollutants. The current urban mobility system in India is not sustainable, if congestion and air-pollution increase. Future scenarios help by giving insight in trends and developments, in order to cater for a sustainable mobility system in the future. The developments in combination with the current urban mobility system, are translated into strategies for the Tuktuk company. This company aims at implementing an affordable upgrade system for auto-rickshaws in India. With this system pollution can be decreased and savings on fuel costs can be accomplished for the rickshaw drivers.

The environmental scanning method, which is used in this research, makes it possible for a company to respond to a changing environment. The environment of the urban mobility system in India is changing rapidly, due to developments in the domains of demography, ecology, technology and economy. Urbanization and population growth increase pressure on urban land. Due to economical growth more people can afford a motorized vehicle, which leads to increased emissions and congestion. More environmental friendly vehicles are necessary for a sustainable future. The Indian government is changing its policies and is aiming at a reverse shift, to get people out of the private vehicle and into the public vehicle. A result of these changing policies is the positive trend in quality of public transport. The cities of Delhi and Chandigarh have already started introducing various improvements to the public transport sector. Delhi introduced a metro line and is currently expanding the line, while Chandigarh is finalizing plans to build a metro line in the near future. Furthermore, both cities are actively replacing public buses by more comfortable ones and Delhi has opened dedicated bus lanes to further improve the attractiveness of buses.

The gap between rich and poor is considerable in India. This influences the urban mobility system. Overall, the poor use public transport and non- motorized vehicles and the rich are able to afford private vehicles. Auto- rickshaws are mainly used by the middle class for door-to-door movements. Experts in the field of transportation believe the middle class will not grow in the coming years. However, literature shows that the middleclass has increased considerably in the last decade and will continue to grow until 2020. The assumption is that an increased attractiveness of public transport for the middle class will result in a relative decline in the use of the auto- rickshaw. The experts believe the auto- rickshaw might become very useful as a 'feeder' to mass transport systems, as metro lines and bus stations. The result of this change is shorter average trip distances for the auto rickshaw. The Tuktuk company needs to further assess the effects of the developments in India on the organization of the project, before actually introducing a sustainable auto rickshaw .

In order to anticipate on these developments, that affect the urban mobility, scenarios for the time period until 2020 can be used. Three strategies out of a total of six within the environmental

scanning method are suitable to be adopted by the Tuktuk company. Beneath these strategies are given, together with their consequences for the Tuktuk-project.

- The adaption strategy: The Tuktuk company should adapt its marketing plan to the new environmental conditions. It is recommendable to focus attention on vehicles which do not need oil for propulsion.
- The offensive strategy: The Tuktuk company should try to turn the new influences into an advantage, because quick response can give the company a competitive advantage. The auto-rickshaw will become more useful for shorter distances. A small electric battery is sufficient for these shorter distances
- The contingency strategy: The Tuktuk company should determine a broad range of possible reactions. Before the company is able to penetrate a large market share with its systems and/or vehicles, changes in the current infrastructure should be generated. Education for the auto-rickshaw drivers regarding sustainable ways of transport have to be given.

It can be stated that a combination of the above mentioned strategies is most suitable for the Tuktuk company to be adopted, in order to sustain in a profitable and sustainable future. It is recommendable that the Tuktuk company should focus its attention on auto- rickshaws which drive shorter distances in the future. Furthermore is it necessary to provide education for the rickshaw drivers, without the rickshaw drivers it is impossible to implement an affordable upgrade system. Subsequently is further development of the Indian infrastructure necessary in order to introduce new innovative forms of transport on the Indian roads.

## SAMENVATTING

De stedelijke mobiliteit in India is divers. Bussen (motor-) fietsen, auto's, karren, voetgangers en (auto-)rickshaws rijden naast elkaar op de wegen. De gemotoriseerde voertuigen veroorzaken grote hoeveelheden luchtvervuiling, opstoppen en produceren grote hoeveelheden CO<sub>2</sub>. Een verschuiving van publieke naar private voertuigen is zichtbaar, dit resulteert in meer lucht verontreiniging en congestie. Auto- rickshaws zijn een van de vervoersmiddelen die een groot deel van de lucht- verontreiniging veroorzaken. De huidige stedelijke mobiliteit in Indiase steden is niet duurzaam als congestie en luchtverontreiniging blijven stijgen. Scenario's voor de toekomst helpen om te voorzien in een duurzaam mobiliteit systeem. Scenario's geven inzicht in algehele trends en ontwikkelingen op het gebied van stedelijke mobiliteit. Toekomstige ontwikkelingen in combinatie met de huidige stedelijke mobiliteit kunnen worden vertaald in strategieën voor de Tuktuk company. Dit bedrijf heeft tot doel een betaalbare upgrade systeem voor auto- rickshaws in India te introduceren. Met dit systeem kan luchtvervuiling worden verminderd en kunnen er besparingen op de brandstofkosten voor de auto- rickshaw bestuurder gegenereerd worden.

De 'environmental scanning' methode, die gebruikt wordt in dit onderzoek, maakt het mogelijk voor een bedrijf om te reageren op een veranderende omgeving. De omgeving van de stedelijke mobiliteit in India is in een hoog tempo aan verandering onderhevig, als gevolg van ontwikkelingen op het gebied van demografie, ecologie, technologie en economie. Verstedelijking en bevolkingsgroei vergroot de druk op stedelijk land. Door de economische groei kunnen meer mensen zich een gemotoriseerd voertuig veroorloven, dit leidt tot meer uitlaatgassen en meer congestie. Er zijn meer milieuvriendelijke voertuigen nodig voor een duurzame toekomst. De indische regering is zijn prioriteit aan het verleggen, voor een duurzamere toekomst. Het richt de aandacht nu meer op een verschuiving van private naar publieke voertuigen. Het hoopt mensen uit het private voertuig te krijgen en in het publieke. Een gevolg van dit veranderende beleid is de positieve trend in de kwaliteit van het openbaar vervoer. De steden Delhi en Chandigarh zijn reeds begonnen met het invoeren van verschillende verbeteringen in het openbaar vervoer. Delhi introduceerde een metrolijn en is momenteel bezig met de uitbreiding van deze lijn. Chandigarh is plannen om een metrolijn te implementeren aan het afronden. Bovendien zijn beide steden actief bezig met de vervanging van openbare bussen, met als doel deze meer comfortabel te maken. Verder heeft Delhi speciale busbanen geopend om de aantrekkingskracht van het openbaar vervoer verder te vergroten.

De kloof tussen rijk en arm is groot in India. Dit beïnvloedt het stedelijke mobiliteits systeem. Over het algemeen gebruiken de armen het openbaar vervoer en niet- gomotoriseerde voertuigen. De rijkere mensen kunnen zich private voertuigen veroorloven. Auto- rickshaws worden hoofdzakelijk gebruikt door de middenklasse voor deur-tot-deur transport. Deskundigen op het gebied van transport zijn van mening dat de middenklasse niet zal groeien in de komende jaren. Echter, uit literatuur blijkt dat de middenklasse aanzienlijk is toegenomen in de afgelopen tien jaar en zal blijven groeien tot 2020. De veronderstelling is dat een verhoogde aantrekkelijkheid van het openbaar vervoer zal resulteren in een relatieve daling in het gebruik van de auto- rickshaw door de

middenklasse. De deskundigen geloven dat de auto- rickshaw zeer nuttig kan worden als een 'feeder' naar massale vervoersmiddelen, als metrolijnen en busstations. Het resultaat van deze wijziging in de manier van gebruik is dat de gemiddelde vervoersafstand met de auto- rickshaw korter zal worden. Voordat een duurzame auto- rickshaw geïmplementeerd kan worden, moet de Tuktuk company de verdere bijkomende effecten van de ontwikkelingen in India op het project bepalen.

Om te anticiperen op de ontwikkelingen die de stedelijke mobiliteit beïnvloeden, kunnen scenario's voor de periode tot 2020 gebruikt worden. Drie strategieën uit een totaal van ze binnen de environmental scanning methode zijn geschikt om te worden aangenomen door de Tuktuk company. Hieronder zijn deze strategieën samen met de gevolgen voor het Tuktuk project samengevat.

- De 'adaption' strategie: De Tuktuk company moet haar marketing plan aanpassen aan de nieuwe algehele omstandigheden in de omgeving. Het is aan te raden om de aandacht te richten op voertuigen die geen olie nodig hebben om in beweging te komen.
- De 'offensive' strategie: De Tuktuk company moet proberen om de nieuwe invloeden om te zetten in een voordeel, omdat snelle reactie het bedrijf een concurrentievoordeel kan opleveren. Een kleine elektrische batterij is voldoende om de auto-rickshaw voor kleine afstanden voort te laten bewegen.
- De 'contingency' strategie: De Tuktuk company dient een breed scala van mogelijke reacties vast te stellen. Voordat het bedrijf in staat is om een groot marktaandeel te genereren met haar systemen en/of voertuigen, moeten veranderingen in de huidige infrastructuur gerealiseerd worden. Onderwijs aan de bestuurders van de auto- rickshaw moet worden gegeven om hen duurzame manieren van vervoer te leren.

Het kan worden gesteld dat een combinatie van de hierboven genoemde strategieën het meest geschikt is om voor de Tuktuk company te worden aangenomen. Het is aan te bevelen dat de Tuktuk company de aandacht in de toekomst richt op het vervoer van auto- rickshaws welke korte afstanden rijden. Verder is het noodzakelijk te voorzien in onderwijs voor de bestuurder van de auto- rickshaw, want zonder auto- rickshaw bestuurders is het onmogelijk om een betaalbare upgrade systeem te implementeren. Vervolgens is verdere ontwikkeling van de Indiase infrastructuur nodig om nieuwe innovatieve vormen van vervoer in te voeren op de Indiase wegen.

## PREFACE

One year ago I started the master Human Geography at the Radboud University in Nijmegen. This report is the end product of this master. Within the Human Geography are internationalization and globalization main topics of my interest. I express these interest in my enthusiasm for travelling and my curiosity for different cultures. These are amongst reasons why I have chosen for the specialization 'Globalisation, Migration and Development' within the master of Human Geography. In line with these interests I searched for an interesting organization to conduct my thesis research for. A sustainable and international topic was what I was looking for; I found a match in the organization of ENVIU!

Naturally I would like to use this opportunity to give my gratitude to all people that contributed to my research. First, I would like to thank all members of ENVIU, especially Elmar Stroomer and Mathijs Huis in 't Veld. ENVIU gave me the opportunity to graduate and provided me with the chance to be part of a very special and interesting project. Project leaders Elmar and Mathijs helped me out concerning the content of the research. From the Radboud University, Jackie van de Walle guided me as a supervisor with the more theoretical part and with the design of the report. Thank you Jacky!

Furthermore I would like to thank all persons who were willing to share their knowledge on transportation with me. Without the respondents of the interviews and questionnaire it would not have been possible to gain insight in the future of urban mobility systems in India.

Before I will be graduated and have to start with a 'serious' life, of course I would like to thank my family and friends. My parents have always shown interest in my activities and have supported me, in all my years of study. And Alexander helped me with the so much needed critical reflection.

Thanks everybody. I hope auto- rickshaws in India will be improved in a sustainable way in the coming years. In 2020, I will go back to India and check it out. But for now, let's go on a holiday!

Janneke Nix

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# 1. Introduction

## 1.1 Background

Busses, (motor-)cycles, cars, barrows, pedestrians, taxis and (auto-)rickshaws move around next to one other through the cities of India. These movements often result in a noisy and congested urban environment. The urban mobility system in India is diverse. Motorized vehicles cause severe air-pollution and produce large amounts of CO<sub>2</sub>. The non- motorized vehicles share lanes with the motorized vehicles and are a cause of congestion. Due to bad, or lacking, public transport and increasing welfare, people in India shift from public to private transport modes. More private vehicles on the road result in more congestion and more air- pollution. The current urban mobility system is in most Indian cities not sustainable, if congestion and air- pollution increases.

The government is one of the causes of the Indian road problems. In the past, the government did not encourage the use of public transport. Currently, the national Indian government is changing its policies and is aiming at getting more people into the public transport. The population of India exceeds the one billion and changing policies is a complex process. Within the population is the divide between poor and rich substantial. The rich can afford private vehicles and the poor use non-motorized vehicles. The middle class is able to afford semi- public modes of transport.

Auto- rickshaws are semi- public and are numerous on Indian roads. These small three- wheelers (figure 1) provide door- to- door transport and are especially in urban areas popular for short distance movements. The disadvantage of auto- rickshaws is that this is one of the transport modes which form a major share of air-pollutants. The auto- rickshaw is on the Indian roads since the fifties. Overall, auto-rickshaws have not been



**Figure 1; auto- rickshaw in India**

changed since the fifties and old vehicles dominate within this mode of transport. The original auto-rickshaws are operating on diesel and petrol, which cause air- pollution. The newer auto-rickshaws which are being introduced in the last years have CNG (Compressed Natural Gas) or LPG (Liquefied Petroleum Gas) propulsion and are more environmental friendly. The changing models of auto-rickshaws are benefiting the environment as well as the rickshaw drivers. The drivers of the rickshaws constitute mainly to the poorer groups of society and are most vulnerable to air- pollution, since they are not protected against breathing in the polluted air.

The different developments in the Indian society create a changing environment for the diverse urban mobility systems. These mobility systems have to be adapted to the changes, here for is a correct planning and adequate insight in the developments is necessary. Auto- rickshaws are a semi-public mode of transport and are a common sight on the roads in India. This mode is a major air- and noise pollutant. The auto- rickshaw is a vehicle which can be improved considerably in the coming years, in order to make the environment in India more sustainable.

## 1.2 Enviu; the 'Tuktuk Project'

In order to make existing auto-rickshaws in Indian cities more efficient and more environmental friendly, Enviu introduced a project. Enviu is a Non- Governmental Organization, based in Rotterdam. This organization strives at contributing to a sustainable world where innovative entrepreneurship creates value for people and planet. An innovative project of Enviu is the Tuktuk project. This project aims at implementing an affordable upgrade system for auto- rickshaws in India. With this system the air pollution can be decreased and savings on fuel costs can be accomplished for the rickshaw drivers. This will contribute in a healthier and more positive social-economic environment. At this moment, the project is still in the starting- up phase. Its goal is to become a sustainable company, which looks after, and is responsible for, an upgrade system for auto- rickshaws. Although, the name of the company is in this stage not known yet, in this report it will be referred to as the 'Tuktuk Company'. To succeed it is important to include external factors and developments in the vision of the future. Globalization puts high strains on an emerging economy as India, and so, future developments are likely to be substantial. For the Tuktuk Company it is important to gain knowledge about these future developments and trends on urban mobility in India to start the project in such a way that the chance to succeed is highest.

## 1.3 Goal and research questions

### 1.3.1 Goal

The main concern of this research is future scenarios on urban mobility. By making future scenarios it is possible to show future trends, which can be translated into strategies for the Tuktuk Company. As a time frame the year 2020 is chosen, trends in 11 years from now will be outlined. Using this time frame, the scope of the research will be clearly marked out. The year 2020 is chosen due to the relatively short period from now. Developments till 2020 can be predicted with a great level of certainty. Though, the period of time is long enough for changes in the society and in mobility systems. Shorter periods of time would not show developments on a large scale, especially not in India where developments are likely to take a while before being visible. The time frame of 11 years is an intermediate period in which extreme changes are not likely to occur, but the more predictable changes can be revealed.

When looking at changes and developments in the future, it is important to include different disciplines of society. Developments in domains of demography, ecology, technology, economy, politics and socially have to be included for an all- embracing future scenario. Recommendations to the Tuktuk Company will be made based on these developments and on the future scenarios.

### 1.3.2 Research questions

In order to be able to give recommendations to the Tuktuk company, the following main question will be answered in this report:

'How can be anticipated on urban mobility scenarios in 2020 in India?'

It has to be understood that within this research the term 'urban mobility' refers to the whole system of public, semi- public and private transport modes which can be found in an urban area, or city. To answer the main-question, several sub- questions have been formulated.

First, it is necessary to obtain a clear view of the current urban mobility system in India, otherwise it is not possible to generate future scenarios. The current situation and past trends show how the system is developing and how the future might be constructed. On a macro level, the current situation in India will be outlined. To indicate future changes and developments on a micro level, two case studies are used; Delhi and Chandigarh. Delhi and Chandigarh will provide deeper insight in current mobility systems in different Indian cities. Three questions on the current urban mobility system have been formulated.

Current urban mobility system:

- How is the current urban mobility system in India composed?
- How is the urban mobility system in Delhi composed?
- How is the urban mobility system in Chandigarh composed?

Second, developments and trends in different domains have to be outlined in order to obtain an all-embracing view of society. Urban mobility systems and developments in different domains influence each other, and so is it necessary to gain insight in the different developments. By making scenarios for the future, these general developments should be included. Scenarios have to be based on certain directions of development to make them more plausible. DESTEP factors are used to identify the different domains of development. Amongst DESTEP domains are demography, environment, technology and economy. These developments distinguish from each other and thus sub- questions are formulated for every domain of development.

Demographical developments:

- What are prospects on urbanization in India, till 2020?
- Till what extent will the population in India grow till 2020?

Environmental developments:

- To what extent exist environmental problems due to urban mobility?

Technological developments:

- What are global technological developments in the transport sector?
- To what extent is it possible to implement the global technological developments in Indian cities?

Economical developments:

- What are developments in income on micro and macro levels till 2020?

Finally, the current urban mobility system and the different domains of development can be brought together by the creation of the scenarios. By answering the sub- questions on the sub- topic scenario, it will become clear what the role of the auto- rickshaw will be by 2020. Furthermore are the scenario's which are most likely to happen and which will have the biggest impact on the urban mobility system elaborated. By possessing a clear and complete view of the scenarios in 2020, recommendations for the Tuktuk company on how to anticipate on the specific scenarios can be given and the main question can be answered.

Scenarios in 2020:

- How important is the auto- rickshaw in urban mobility systems in India, Chandigarh and Delhi, now and in 2020?
- What are urban mobility scenarios in 2020?
- Which scenario is most likely to happen by 2020?
- Which scenario will have the biggest impact on the urban mobility system by 2020?

Table 1 is an overview of which sub- topics, with corresponding sub- questions, will be answered in which chapter and paragraph.

**Table 1;Overview of sub- topics and corresponding chapters**

Sub- topics	Chapter
Current urban mobility system	3.1, 3.2 & 3.3
Demographical developments	4.1
Environmental developments	4.2
Technological developments	4.3
Economical developments	4.4
Scenario's in 2020	5

## 1.4 Societal relevance

The Tuktuk project of ENVIU is of high societal relevance. As is already mentioned in paragraph 1.2 is the project aiming at a decrease in air- pollution and at an increase in income for the rickshaw- drivers. The advantages for the general society are considerable. If air pollution will decrease, the environment will become more sustainable, not only in India but in the whole world. And if rickshaw

drivers will accumulate more income, their individual life will improve. Looking at the amount of rickshaw drivers in India, a lot of lives will improve. This results in an increasing amount of children who have access to better education and the general Indian society will become more developed. The Tuktuk project is still in the starting- up phase and before it can become a success, research is necessary. The advantages of the project will for a major part be generated on the longer term, and so is insight in developments on the longer term necessary. Furthermore should the auto- rickshaw not be seen as unattached to other vehicles. This research is giving scenarios for the year 2020 and includes a broad context for implementing the affordable auto- rickshaw.

## 1.5 Scientific relevance

A trend analysis for the Tuktuk project is of high scientific relevance. A lot of research is carried out on current urban mobility systems and urban mobility in developing countries. Less is known about future trends in urban mobility, especially in an emerging economy as India this is of high importance for a correct planning nowadays. One have to look at the future before implementing certain developments at present. With looking at the future it is important to include different disciplines of society. Demography, ecology, technology, economy, political and social factors have to be include for an all- embracing scenario. Most literature on urban mobility is focusing on one of these factors, but not all. This research, on the contrary, is including several disciplines of society. Furthermore, most research is being carried out on macro level and less on micro levels. This research is using two case studies in order to look at developments on a micro level.

## 1.6 Structure of the report

In this first chapter an introduction to the research is given. The different methods of research are described in the second chapter. An insight in the current urban mobility system and the domains of development is given as a theoretical framework in the third chapter. Following on the current situation of urban mobility systems in India, expected trends and developments will be observed in chapter 4. These trends and developments are then translated into future scenarios in chapter 5. The main question can be answered in the conclusion. And if the main question is answered, recommendations for further research will be created in the final chapter. An overview of the report structure is given in table 2.

**Table 2; Overview of the report structure**

Theoretic Part			Data Collection & Analysis	Recommendations	
Chapter 2 Methodology	Chapter 3 Theoretical Framework	Chapter 4 Developments and trends till 2020	Chapter 5 Scenario's 2020	Chapter 6 Conclusion	Chapter 7 Recommendations for further research



## **2. Methodology**

The objective of the research is to develop future scenarios on the urban mobility system and to give recommendations to the Tuktuk Company on how to anticipate on these scenarios. In this chapter will the different methods on how to get to the objectives be described. Also will the motivation for using the different methods be given. Furthermore, is the way of conducting the different methods going to be outlined in this chapter.

### **2.1 Qualitative research**

This research is of explorative nature, it calls for a descriptive qualitative research method. The research requires a detailed understanding of reasons behind the emergence and the impact of certain developments. This research implies that scenarios for 2020 can be created as urban mobility systems emerge and evolve over time. Therefore, literature related to development factors of the auto- rickshaw is relatively weak. Several ways of acquiring information are essential. There are different ways of obtaining qualitative data; surveys, desk- research, case studies and in- depth interviews. In this research is chosen to apply a combination of these methods, since they all serve a different purpose. In order to acquire a complete image of the context in which developments occur, a combination of methods on a macro and micro scale are useful. Instead of face-to-face surveys, an online questionnaire is used. A survey and a questionnaire can be compared, since they both have the objective of acquiring general information in substantial amounts from respondents. In addition to the above mentioned methods, the environmental scanning is used as a guidance throughout the research.

### **2.2 The method- Environmental scanning**

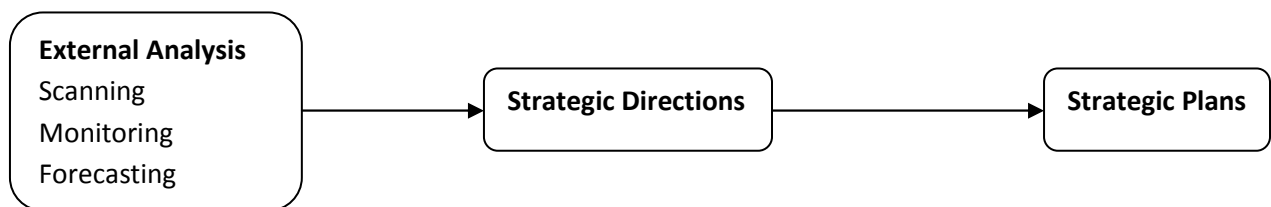
The method of environmental scanning will be used as a guidance for recommendations to the Tuktuk company. This theory is chosen because of its external character. This is important since multiple external factors play a role in the making of future scenarios. The different phases of the theory can be applied on the different phases of the research. This method enables the company to understand the external environment and the interconnections of its various sectors and translate this understanding into the institutions' planning and decision making processes. Brown and Weiner (1985) define environmental scanning as "a kind of radar to scan the world systematically and signal the new, the unexpected, the major and the minor". Coates (1985) identified the following objectives of an environmental scanning system:

- Detecting scientific, technical, economic, social, and political trends and events important to the institution.
- Defining the potential threats, opportunities, or changes for the company implied by those trends and events.
- Promoting a future orientation in the thinking staff of the company.

- Alerting staff to trends that are converging, diverging, speeding up, slowing down, or interacting.

Throughout the research the following steps will be taken (Figure 2):

- Scanning; scan the environment to identify changing trends and patterns. This will be done by a literature study.
- Monitoring; monitor specific trends. This will be done in chapter 3.
- Forecasting; forecast the future direction of these changes and patterns. In chapter 4 will the trends be forecasted and in chapter 5 future scenarios will be made.
- Assessing; assess the organizational impact of the changes. This last phase will be included in the final chapter of giving recommendations to the Tuktuk company.



**Figure 2; the role of external analysis in strategic planning and environmental scanning**

For a company, also for the Tuktuk company, there are six ways of responding to the changes in the assessing phase. According to Aguilar (1967), one (or more) of the following recommendations can be made to the company:

- Opposition strategy; try to influence the environmental forces do as to negate their impact, this is only successful where you have control over the environmental variable in question.
- Adaption strategy; adapt you marketing plan to the new environmental conditions
- Offensive strategy; try to turn the new influence into an advantage, quick response can give you a competitive advantage.
- Redeployment strategy; redeploy your assets into another industry
- Contingency strategies; determine a broad range of possible reactions, find substitutes.
- Passive strategy; no response, study the situation further.

The assessing phase occurs in the conclusion. Here, it will be discussed which strategy is most suitable for the Tuktuk company to apply. For a part, the strategies are intertwined and thus is it possible to recommend a combination of the six strategies of the environmental scanning method. Before strategies can be recommended in the conclusion, the environmental scanning theory has the purpose as a guidance throughout the research. This method can be applied on all sub- topics, with its sub- questions in the research (table 3). Every phase of the method corresponds with a different chapter, as is already mentioned before.

**Table 3; Indication of environmental scanning method and appliance on sub- topics.**

	Current urban mobility system	Demographical developments	Environmental developments	Technological developments	Economical developments	Scenarios in 2020
Environmental scanning	x	x	x	x	x	x

### 2.3 The method - Desk- research

Desk- research is used with intensity in this research. This type of research is applied on the current situation for urban mobility systems and on developments. Different kind of sources have been used; books, articles and internet websites. Literature showed developments and trends on a macro level and not, or in a lesser extent on a micro level. Articles provided a more detailed insight in problems which the urban mobility system is facing. The books provided a broader view on the theme and they were useful as a guidance throughout the resource. Specific figures about India's demography, technology, environment and economy are obtained by using official data from the Indian government and from international sources (e.g CIA). By looking at the acquired data it is important to keep in mind that data and figures can differ from reality, since sources in India can be incomplete due to the lack, or bad, administration organs. In table 4 can be seen that desk- research is applied on almost all sub- topics in the research, in order to answer the sub- questions.

**Table 4; Indication of desk- research and appliance on sub- topics**

	Current urban mobility system	Demographical developments	Environmental developments	Technological developments	Economical developments	Scenarios in 2020
Desk- research	x	x	x	x	x	

### 2.4 The method – In- depth interviews

In addition to desk- research, in- depth interviews are conducted. Literature showed trends on a macro level and not, or in lesser extent, on a micro level. By using in-depth interviews with stakeholders in the transport sector, a multi level sketch on the future can be obtained from different perspectives. The 'spider web' method (2.4.1), is used for the creation of scenarios from in-depth interviews. By conducting in-depth interviews, interviewees are more likely to respond with an open attitude, compared to surveys. Face-to-face meetings provided the opportunity to interpret the source in a correct way. The scenarios are based upon these meetings, and so it is important that the respondents have an open attitude towards future predictions. From a practical point of view are in-depth interviews one of the only possibilities to get in- depth contact with Indian people. Due to a lack of modern communication technologies and a cultural barrier, is it hard to reach the stakeholders otherwise, but face-to-face.

The in- depth interviews are applied on the sub- questions about the scenarios in 2020 (table 5). The scenarios form the link between the current urban mobility system and the different domains of development, and are of big importance for the research.

**Table 5; Indication of in- depth interviews and appliance on sub- topics**

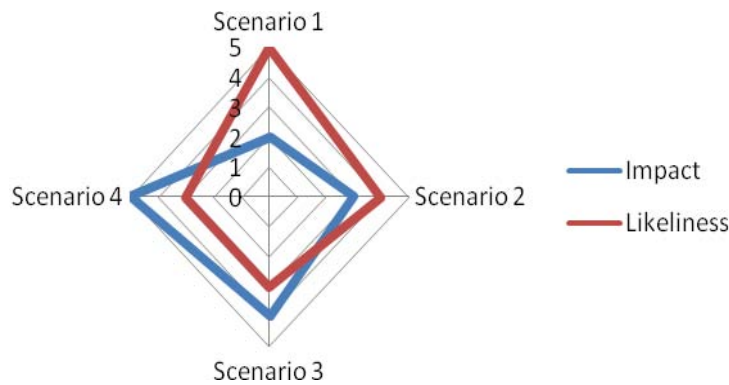
	Current urban mobility system	Demographical developments	Environmental developments	Technological developments	Economical developments	Scenarios in 2020
In- depth interviews						x

#### **2.4.1 Design of the in- depth interviews; Method- ‘Spider Web’**

The design of the in- depth interviews will be done according to the ‘Spider Web’ method. This method provides a visual image of the scenarios. A visual image offers the opportunity to see in a glance how scenarios are graded, compared to other scenarios. Moreover, multiple elements can be included in one spider web, this is useful for a comparison between elements and scenarios. The Spider Web method can be applied on the acquired qualitative information.

The British author Bernstein (1986) described in his book, ‘Bedrijfsidentiteit – Sprookje en werkelijkheid’, the spider web technique as a tool to enable the management of a company to come to consensus about the desired identity. The method starts with asking the different parties involved to define how they see the company. Next, individuals have to write down a list of distinctive company characteristics. From all these characteristics a top eight is been made. This is followed by a grading system. All persons involved have to grade the top eight individually on ‘factual’ and ‘desired’ situation. The average of all grades is outlined in the graphical reproduction of a spider web. Based on the spider web a discussion about the desired identity can be stimulated amongst the involved persons of the company.

The spider web method of Bernstein is used to identify characteristics of a company. Within this research on future scenarios, this method is adapted to enables one to see in a glance which future scenarios are likely to happen and whether the impact level on the urban mobility system is high or not. In this research, the axis are not characteristics of a company, but the different future scenarios. These are not graded on ‘factual’ and ‘desired’, but on ‘likeliness’ and ‘impact level’, as can be seen in the example of figure 3. The scenarios of which the likeliness and impact level are highest, are marked as scenarios in 2020. The scenario of which the likeliness is highest, will be closest to the future reality. And the one of which the impact is ranked highest, will have the most impact on the urban mobility system and so is it useful not to neglect this specific future scenario.



**Figure 3; example of a spider -web with rickshaw scenarios on likelihood and impact**

The first part of each interview will contain more or less similar questions to all stakeholders. In the second part, future scenarios are going to be given. In this part the respondents have to grade (1-5) four different scenarios on the future of urban mobility. They have to grade all scenarios on likelihood and impact. The average of all grades will be made visible in the spider web. A free- flow discussion during the interviews is made, which would not have been possible with a more structured format. Argumentations of respondents regarding the specific grading have to be paid attention at carefully.

## 2.5 The method – A questionnaire

In addition to the in- depth interviews in Delhi and Chandigarh is a questionnaire on the urban mobility in India made. The aim of this questionnaire is to get a broader range of respondents. The amount of people interviewed is limited and thus is a questionnaire useful for a more adequate view on the given answers. The questionnaire is used to answer the sub- questions regarding scenario's in 2020 (table 6). The questionnaire, with the questions for the respondents, can be found in appendix 2.

In order to stick to respondents who have affinity with transport, the website of 'Arrivesafe' ([www.arrivesafe.org](http://www.arrivesafe.org)) is used to publish the questionnaire. As the name of the website already indicates, this website provides information about safety on Indian roads and other transport related topics. The founder of this website, Harman Singh, is dedicated to improve Indian roads, since he was involved in a serious road accident himself.

**Table 6; Indication of the questionnaire and appliance on sub- topics**

	Current urban mobility system	Demographical developments	Environmental developments	Technological developments	Economical developments	Scenarios in 2020
Questionnaire						x

## 2.6 The method – Case studies

To indicate future changes and developments on a micro level, two case studies are used. Information about the cities of Delhi and Chandigarh is obtained. Both cities are located in the North of India (figure 4). Delhi is the capital of India and contains over 14 million inhabitants. Chandigarh is smaller with slightly under one million inhabitants. This latter is only one out of many Indian cities



**Figure 4; location of Chandigarh and Delhi on map India (CIA, 2008)**

with a population of around this size; more than 35 cities in India have 1 million, or more inhabitants (Badami, 2005). Delhi is a city which is expanding uncontrolled, and so does its roads system. Chandigarh, on the contrary, is a planned city with an extensive road network. Chandigarh is known for its Western character and Delhi for its chaotic old part of the city. The differences between these two cities are considerable. By zooming in on those cities it is possible to find out whether the urban mobility systems differs between two cities of different size and character, but in close proximity. Not only the difference between these cities will become clear, the two cities have also the purpose of being examples for comparable cities in India. Future scenarios can be applied on cities of equal size and character.

The case studies are used in order to obtain a clear view of the current urban mobility system in Chandigarh and Delhi. Sub- questions related to this topic can be answered by gathering information about these two Indian cities. The information about the current urban mobility system will be applied on the scenarios. Sub- questions regarding the scenarios in 2020 can be answered by looking closer into the cases of Chandigarh and Delhi. Table 7 shows the appliance of the case studies on the different sub- topics.

**Table 7; Indication of the two case studies and appliance on sub- topics**

	Current urban mobility system	Demographical developments	Environmental developments	Technological developments	Economical developments	Scenarios in 2020
Case studies	x					x

## 2.7 Conclusion

Due to the explorative nature of this research, the method of qualitative research is most suitable. Qualitative research is done by using the methods of environmental scanning, in- depth interviews, desk- research, a questionnaire and by using two case studies; Delhi and Chandigarh. A combination of methods is used for an all-embracing context to construct the future scenarios. All methods have

different characteristics and purposes (table 8); the environmental scanning theory to understand the external environment and the interconnections of its various sectors. It can translate this understanding into the planning and decision making processes of the TukTuk Company. Desk-research for the background of developments and for the current situation of urban mobility. In-depth interviews for a multi-level in-depth sketch on the future. The questionnaire for a broader range of respondents. And the two case studies for an indication of future changes and developments on a micro level, by showing the differences in urban mobility systems between cities.

**Table 8; Characteristics methods in the research**

Method	Characteristics
<b>Environmental Scanning</b>	<ul style="list-style-type: none"> <li>- Macro level</li> <li>- External character</li> <li>- Company orientated</li> </ul>
<b>Desk- research</b>	<ul style="list-style-type: none"> <li>- Macro level (books, national data)</li> <li>- Micro level (articles)</li> <li>- Provides predictable developments</li> </ul>
<b>In- depth interviews</b>	<ul style="list-style-type: none"> <li>- Micro level</li> <li>- Overcomes practical communication problems</li> <li>- Experts in transport field</li> <li>- Provides unpredictable developments</li> </ul>
<b>Questionnaire</b>	<ul style="list-style-type: none"> <li>- Micro level</li> <li>- Broad range respondents</li> </ul>
<b>Case studies</b>	<ul style="list-style-type: none"> <li>- Micro level</li> <li>- Marks out the scope of research</li> </ul>

### 3. Theoretical framework

In order to understand the changing urban mobility system in India, it is important to gain insight in the current urban mobility system. This insight can be used as a starting point for future scenarios. In addition to the current state of the mobility system, developments which influence the transport system have to be taken into account when looking at the future. In this chapter a theoretical framework will be given on the current urban mobility system and the different domains of development that are significant for the mobility system. In paragraph 3.3 will the current urban mobility systems and the domains of development be linked in a theoretical discussion. Here, it will be discussed whether the various factors of development might be an explanation for the different urban mobility systems in Delhi and Chandigarh.

#### 3.1 The current urban mobility system in India

The urban mobility system is split up between public, private and semi-public modes of transport. The differentiation of public, private and semi- public modes of transport is the usual division within literature. Public transportation is accessible for all Indians, since it is owned by the government. As a result, fares are kept low in order to serve a broad public. This form of transport serves limited destinations from limited departure areas, since it is operating on a fixed track. Private transport, on the contrary, serves many destinations from many departure areas. This form of transport is privately owned, and so the operating track is not fixed. Private and semi- public modes of transport share the characteristic of flexibility; they both serve many destinations. Semi- public modes of transport are privately owned, but are accessible for everybody. The flexibility of the track is reflected in the transportation costs. Private and semi- public transportation are more expensive than public transportation, though semi- public is on its turn cheaper than private owned transport. In order to show the characteristics in a glance, differences between the three transport modes can be found in table 9.

**Table 9; Characteristics of public, private and semi- public transport modes.**

<b>Public</b>	Government owned	Accessible for everyone	Serves limited destinations from limited departure areas	Cheap form of transportation
<b>Private</b>	Privately owned	Accessible for the private owner only	Serves many destinations from many departure areas	Expensive form of transportation
<b>Semi- public</b>	Privately owned	Accessible for everyone	Serves many destinations from many departure areas	More expensive than public, but cheaper than private form of transportation.



In the next paragraphs will the public, private and semi- public transport systems in India, and in specific Delhi and Chandigarh, be outlined. Auto-rickshaws fit in the third group of semi- public transport, a more elaborated situation of these will be given. Only motorized forms of transport will be outlined, since these form the majority of the total transportation system in Indian cities. Furthermore have motorized vehicles the most influence on the environment and infrastructure. (Pucher ea, 2005).

### **3.1.1 Public urban mobility system in India**

The public share of urban mobility systems in India is composed out of public busses, metro's and trains. A definition of public transport is; "services provided for the carriage of passengers and their incidental baggage over long or short distances, within or between urban areas, usually on a farepaying basis" (Mijn Woordenboek, 2008). This definition includes public transport between urban areas, but the focus in this research is transport within urban areas and not between urban areas.

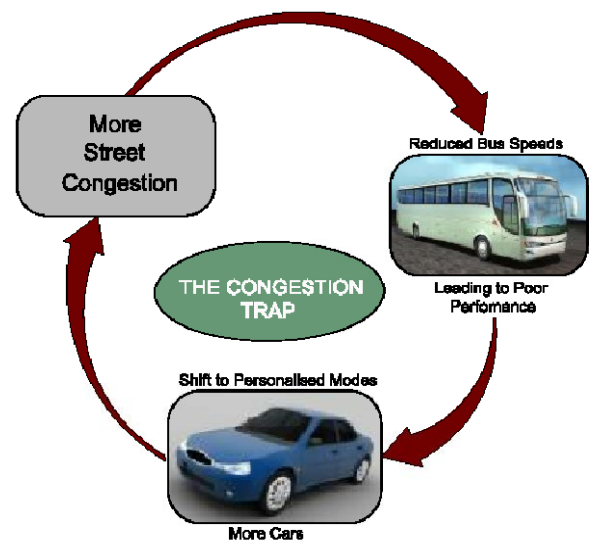
The level of public transport is not equal throughout India. Major cities as Gangtok, Bikaner, Raipur, Amritsar, Agra, Patna, Varanasi and Surat do not have public transport services. Here, people are forced to use semi-public or private modes of transport. In cities with public transport, buses take care of over 90 percent of all public transport in Indian cities. This is caused by the fact that most cities have no intra-urban rail transport and rely mainly on buses for their public transport. The average distance to a bus stop in India varies from 400 to 1500 meter (Ministry of Urban Development, 2005).

In general, larger cities have a better accessibility to public transport. An explanation can be the availability of different modes of transport. Though, the biggest cities do not have the highest quality of public transport services due to congestion. According to the Indian Ministry of Urban Development (2005) medium sized cities score better on quality of public bus services. One of the reasons for this better score can be that the average trip distance in medium sized cities is shorter, so busses are less crowded. Furthermore is the average speed of the buses in medium sized cities higher, because of less congestion. This makes the trips faster and the service more reliable and thus lead to a higher score on the quality of the bus services.

As Indian cities have grown in population, they have also spread outwards. This is resulting in uncontrolled sprawled development extending rapidly in all directions, due to lack of effective planning and land-use controls. Sprawled cities have greatly increased the number and length of trips for most Indians, forcing increasing reliance on motorized transport. Longer trip distances make walking and cycling less feasible, while increasing motor vehicles makes walking and cycling also more dangerous (Pucher ea, 2005). This is one of the reasons that fares for public transport in India are kept low, because the travel modes of walking and cycling are mostly used by the poor, who have no other opportunities to meet their travel needs. Fares have been kept low as a measure of social equity. This has resulted in public transport systems being unable to finance even its operating costs. Public transport services became sustainable only by compromises on the quality of the service they render (Ministry of Urban Development, 2005). It does not encourage the more affluent people to use this form of transport. Bus services have deteriorated and passengers have turned to private

modes and semi-public modes, adding to traffic congestion and air- pollution, which has had its impact on bus operations.

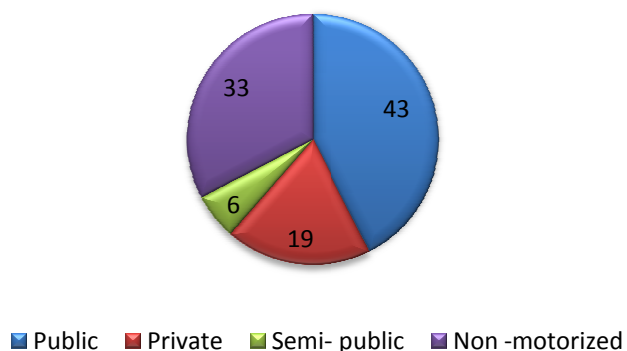
Most of the current public transport in Indian cities is deteriorated, with low transport costs and low quality. This is resulting for considerable amounts of people in a shift to private or semi-public modes of transport. In turn, traffic congestion increases and air pollution is becoming a major issue. In figure 5 is the congestion trap visualized. This trap shows the impact of increasing car amounts on the environment. If congestion increases bus speeds reduce which leads to poor performances and a shift to private vehicles. Without interfering, the cycle is ongoing.



**Figure 5; the congestion trap (Ministry of Urban Development, 2005)**

### Public urban mobility system in Delhi

As a major Indian city, Delhi contains multiple forms of public transport modes. Intra city trains, a metro system and elaborated public bus services. To cope with these modes of transport, different corporations exist in Delhi. The Delhi Metro Rail Corporation (DMRC) is responsible for the metro in Delhi. Currently the metro is covering a distance of 25.1 km, more kilometer is under construction. The line connects East- Northeast- North and Northwest Delhi and was first opened in December 2002. Although Delhi has got a metro line, this is only a minor part of the public transport in this city, since 25.1 km is relatively few compared to the amount of inhabitants and compared to the city size. Bus services are the majority of public transport modes in Delhi. Bus trips count for 41 percent of total trips within Delhi, out of a total of 43 percent on public transport trips (figure 6) (Ministry of Urban Development, 2008).



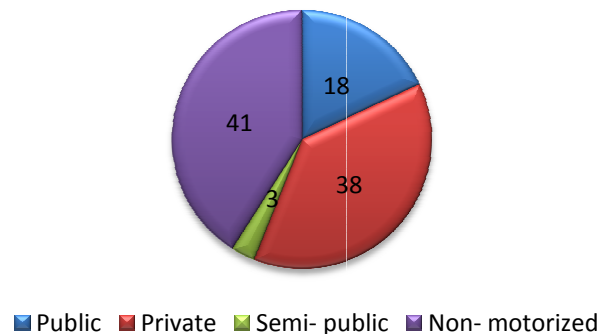
**Figure 6; Share of transport modes in Delhi, in percentage (Ministry of Urban Development, 2008).**

The Delhi Transport Corporation (DTC) provides the public busses in Delhi. DTC is the first transport corporation in India to have inducted Compressed Natural Gas (CNG) for its busses (DTC, 2009). This

shows that this corporation is involved in making the air less polluted in Delhi. Air-pollution is due to excessive use of motorized transport a major problem in big cities as Delhi with an inhabitant amount of over 14 million. In the inner-city of Delhi the public transport system is not functioning optimal, due to congestion. Public busses get often stuck in the traffic and delay, which de-motivates people to use this mode of transport, resulting in more private transport. One result of the congestion in Delhi is that only 38 percent of working trips are accessible within 30 minutes. People need motorized transport for daily transportation which adds to congestion on the roads (Ministry of Urban Development, 2008).

### Public urban mobility system in Chandigarh

The public transport system in Chandigarh differs compared to the transport system in Delhi. The only public transport available are public- run buses. The share of public buses of all transport modes is 18 percent (figure 7), compared to 43 percent in Delhi (Ministry of Urban Development, 2008). Due to this fact, inhabitants of Chandigarh are forced in a position to take distinctive forms of transport, like private cars, motorcycles or auto-rickshaws.



**Figure 7; Share of transport modes in Chandigarh, in percentage (Ministry of Urban Development, 2008).**

Chandigarh is a planned city which offers broad and well- maintained roads. Congestion is here less common than in other Indian cities, thus public busses are less likely to get stuck in traffic jams. From this perspective is Chandigarh the perfect city for an extended public transport system. In paragraph 3.1 is stated that poor people of society tend to take increasingly public transport vehicles when non-motorized transport is becoming risky. Chandigarh hosts the best pedestrian facilities of Indian cities, and so this can be an explanation for the limited use of public transport; pedestrians are to a lesser extent in danger. By public transport almost 100 percent of work trips are accessible within 30 minutes (Ministry of Urban Development, 2008). Thus, it appears that the public transport system in Chandigarh is proficient for daily commuters by means of on time transport, although the share of public buses is only 18 percent of all transport modes. The extended road network and the limited amount of congestion is one of the underlying reasons for this.

### 3.1.2 Private urban mobility system India

The private urban mobility system in India is becoming increasingly important. Private transport is, as opposed to public transport, transport in one's own vehicle. A definition is: "Any transport service that is restricted to certain people and is therefore not open to the public at large" (Babylon, 2009) Included in private transport are private cars and motor cycles. These vehicles do not have a fixed

track and are very flexible. This flexibility is an advantage above the fixed tracks of public transport and is one of the reason for people to shift from public to private transport. This shift contributes to a higher amount of air- pollution and traffic congestion. Besides the disadvantages of the public transport, private transport has several advantages to make a public-private shift a rational decision. As already mentioned, is private transport flexible and comfortable. In addition is this form of transport a certain status symbol in India. The car as a status symbol is a global feature, though in India this is more visible, since the differences between poor and rich are bigger, compared to the developed world. Affluent Indian people have often the need to show off to the outside world. According to the Indian Ministry of Urban Transport (2008) was the mean percentage of private transport (motor bicycles and cars) approximately 34 percent of total transport modes in major cities in 2007.

### Private urban mobility in Delhi

Compared to public transport, private transport in Delhi is limited. Of total transport trips, a percentage of 19 percent is made by private transport in 1999. Of this percentage are trips made by car 14 percent and 5 percent are trips which are made by motor- cycle (Ministry of Urban Development, 2008). The increase of private vehicles in Delhi is compared to other Indian cities low. As can be seen in figure 8 are the amount of roads multiple, and small alleys are in the part of old-Delhi a common feature. Congestion and the probability of car damage can be reasons for the inhabitants of Delhi to keep them from buying a car. As is already mentioned in 3.1.1 is the public bus service in Delhi not functioning optimal. Thus, private and public vehicles are both no optimal transport modes to move within the city of Delhi. Here for, inhabitants have to look for the most suitable way for transportation within the city. The affluent people often live in the less congested suburbs of the city. The poor often live in the older part of the city, which is congested and crowded. The affluent are able to afford a car and so they buy a car, since the neighborhoods where they live are not congested yet. Although the roads of inner Delhi are congested, they make the choice of a private vehicle and the choice to increase trip durations, by increasing congestion further.

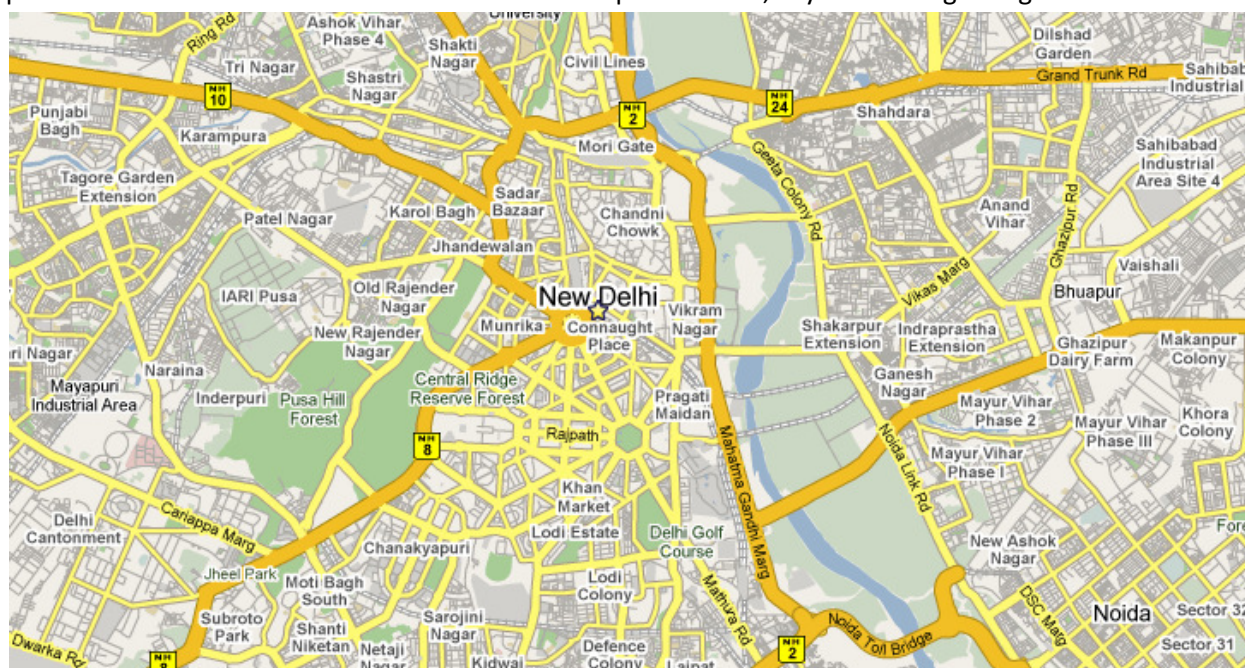


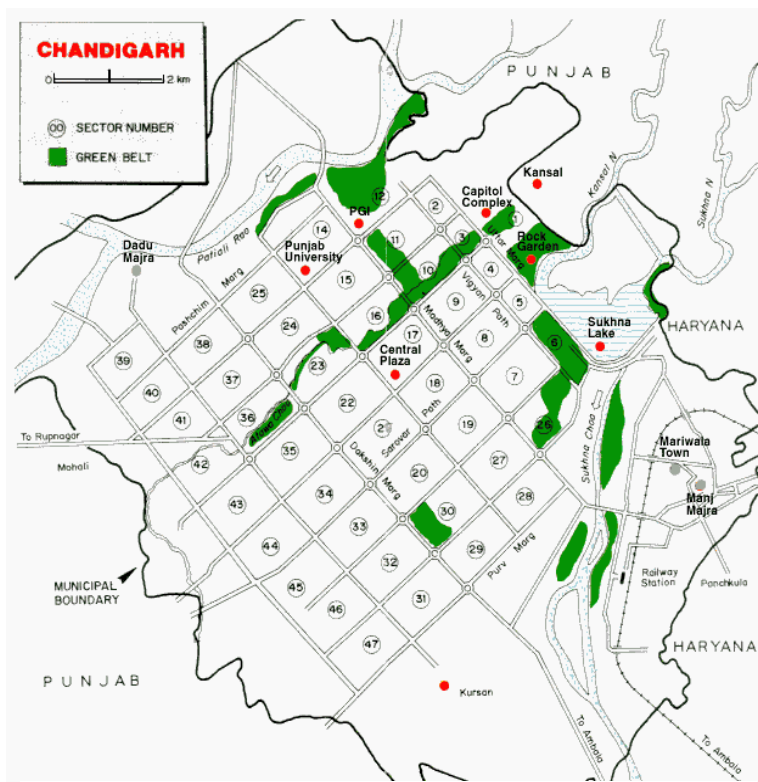
Figure 8; Map of Delhi (Google Maps, 2009)



According to a survey on 30 Indian cities by the Ministry of Urban Development (2008), Delhi has got the highest congestion index. Probably, this is a result of the interference of slow moving- and fast moving traffic within the city on the same lanes. It can be considered that safety, environment and economic developments are degraded by roadway congestion. If this process is ongoing, it will keep Delhi from developing itself. Eventually, the increase of private vehicles is dampened by this process.

### Private urban mobility in Chandigarh

Private urban transport is considerable in Chandigarh, as opposed to the public transport. The grid system of Chandigarh's road network, planned by Le Corbusier, is extensive (figure 9). This network consists out of broad lanes with multiple roundabouts and separate lanes for slow moving vehicles, as pedestrians, cycles and barrows. Small alleys hardly exist and congestion in Chandigarh is non, or, hardly existing. Out of 30 Indian cities, Chandigarh contains the lowest congestion index. This reflects the good road network and stimulates the use of private transport. Compare to other Indian cities, the use of cars out of all transport modes is in Chandigarh high with 28 percent (Ministry of Urban Development, 2008).



**Figure 9; Map of Chandigarh with its grid system (Global Security, 2005)**

The differences between rich and poor are less obvious in Chandigarh. Chandigarh is a relatively new city which exists since 1952. The city is located on the borders of two Indian states; Punjab and Haryana. Chandigarh is the capital of these two states and is the regional hub for services (e.g. hospitals), education (e.g. universities) and politics (e.g. local government). These are amongst reasons for educated people to move to Chandigarh. Within India, Chandigarh is known as a Western city, this attracts even more affluent people. The city ranks number 1 in India on the Human Development Index and has been rated as the wealthiest town in India. In the year 2004-2005 the GDP of Chandigarh has risen with 16.1 percent, compared to the Indian average of 8.2 percent

(Chandigarh Administration, 2009). These features of Chandigarh, show that the city is relatively affluent within India. The affluent inhabitants are able to afford private vehicles and are less likely to make use of public transport. The economic character of Chandigarh creates for a major part the urban mobility system in this city.

### 3.1.3 Semi- public urban mobility in India

Semi- public, or para-transit, transport in India refers to auto-rickshaw's and to taxi's. Semi- public modes of transport are intermediary facilities falling in between public- and private transport. It is also referred to as Intermediary Public Transport (IPT) emphasizing that it is more of a public transport than not. All Indians can make use of this form of transport, nevertheless have the vehicles private owners. In more developed countries, this form of transport is less common. Here, more people are able to afford private vehicles and due to a better developed infrastructure and a smaller population density, congestion is less. Auto- rickshaws are non, or hardly, existing in the developed world. Taxi's are an example of semi- public vehicles which do operate in a bigger extent in developed countries.

The majority of Indian auto- rickshaw drivers loan the vehicle and pay daily fees to the owner. All national Indian banks offer loans to buy an auto- rickshaw under self- employed schemes. Major auto- rickshaw manufacturers in India include Bajaj and Tata. The vehicle is shaped in a triangular form, this makes it easy for the vehicle to maneuver. The front single wheel negotiates the available gap and the rear two wheels forcing a larger space. This feature gives the auto- rickshaw in cities an advantage above four- wheeled vehicles. Indian cities are crowded and with congestion on the roads can every small available gap in the traffic be advantageous for further movements.

In India the semi- public transport is a substantial source of employment. The average number of semi- public vehicles per 10.000 inhabitants in Indian cities is 62.5 (Figure 11) (Ministry of Urban Development, 2008). Although most cities have these semi- public transport modes, some have not. Hilly cities in the North of India, like Shimla and Gangtok, do not have accessibility to auto-rickshaws. Here, mountains and hills prevent vehicles with a low propulsion power to operate. The propulsion power of auto- rickshaws is too small to drive upwards on the steeper hills. Other vehicles, as semi- public taxi's and public buses, are more suitable in these kind of hilly cities. In cities which do have semi- public transport, the shift from public to semi- public transport is made when public transport fails in adequate on time transport, or when destinations cannot be reached otherwise. The main advantage of semi- public transport is its flexibility. Small and medium sized cities have often no adequate and extensive public transport system. In these small and medium sized Indian cities, intermediate public transport modes play a significant role in meeting the transport demand. Table 10 clearly shows this situation. The auto- rickshaw can in this table be categorized under 'intermediate public transport fast'. In the category 'intermediate public transport slow' can cycle-rickshaw be placed.

Thus, it can be stated that the bigger cities have more extensive mass transport systems and therefore people use the intermediate public transport modes in a lesser extent. Table 10 shows percentages in 1994, though it can be assumed that the overall relation between the different sized cities are still existing.

**Table 10; Existing modal split in Indian cities in 1994 (in %) (Ministry of Urban Development, 2008)**

City population (in millions)	Walk	Mass transport	Intermediate public transport		Car	Two-wheeler	Bicycle
			Fast	Slow			
<b>0.10 - 0.25</b>	37.1	16.4	<b>10.4</b>	20.1	3.3	24.1	25.7
<b>0.25 - 0.50</b>	37.8	20.6	<b>8.9</b>	17.2	2.6	29.8	20.9
<b>0.50 - 1.0</b>	30.7	25.4	<b>8.2</b>	12.0	9.5	29.1	15.9
<b>1.0 - 2.0</b>	29.6	30.6	<b>6.4</b>	8.1	3.3	39.6	12.1
<b>2.0 - 5.0</b>	28.7	42.3	<b>4.9</b>	3.0	5.0	28.9	15.9
<b>5.0 &gt;</b>	28.4	62.8	<b>3.3</b>	3.7	6.1	14.8	9.4

The main disadvantage of the semi-public modes of transport are its pollution concerns. Typically, auto-rickshaws carry one to four persons and have until recently been powered by highly polluting two-stroke engines. Tests, in the early 1990s, showed that these vehicles produced higher levels of carbon monoxide and hydrocarbon, and a quarter of particulate emission per kilometer relative to buses, despite buses having much larger, more powerful engines and carrying over 40 people (Shah and Nagpal, 1997). Due to factors as poor maintenance and fuel adulteration, many auto- rickshaws pollute heavily, despite tightening of vehicle emission standards since the 1990s. Local governments throughout India are changing policies in order to make the air less polluted. More environmental friendly fuels are being introduced and health concerns are more taken into account. Besides disadvantage of high air- pollution noise pollution is also a major concern of the auto-rickshaws. The older vehicles with two- stroke engines produce large amounts of noise, which reduces the quality of living conditions in urban areas further. The recently implemented new vehicles are less noisy. A reason for this improvement is the four- stroke engines in the new vehicles, which produce less emission and less noise. Amongst major cities in India which are in introducing auto- rickshaws with four- stroke engines are Delhi and Chandigarh.

### **Semi- public urban mobility in Delhi**

Of Delhi's total land area, 21 percent is devoted to roads, compared to only 11 percent in Mumbai. Mumbai has a more restricted geography due to its location on a peninsula. This peninsula channels travel and land use development in only a few directions. In Mumbai, this encourages suburban rail use. Delhi, on the contrary, has no geographical restrictions and sprawls out into all directions. (Pucher et al., 2005). Thus, Delhi relies primarily on auto-rickshaws, taxis, motorcycles and private cars to serve the multi- destination, less- focused travel patterns of its residents. In figure 7 can be seen what the average time in minutes is in relation to the distance in kilometer by different modes of transport. The semi- public transport falls into the 'M2W' category, as do motorcycles. It is clear that the 'M2W' is much faster than buses, and only slightly slower than cars. Buses are used only when it is unavoidable, and cars are beyond the reach of most (Badami, 2005).

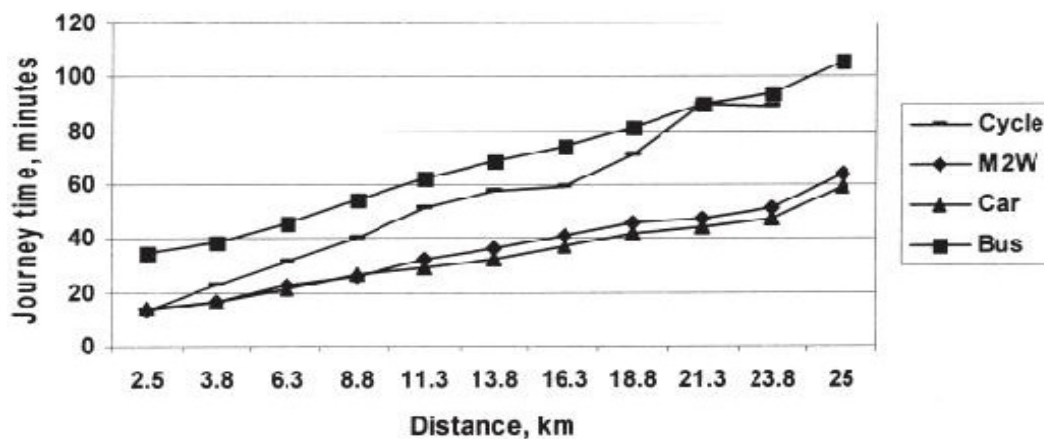


Figure 10; door- to- door journey time by different modes of transport in Delhi (Badami, 2005)

Although the speed of auto- rickshaws is higher than that of buses, the share of rickshaws of total transport is only 6 percent in Delhi, compared to 43 percent of public transport (Ministry of Urban Development, 2008). Though, the average number of semi- public vehicles per 10,000 residents is with 76 higher than the Indian average of 62.5 (figure 11).

As is already said in the previous paragraph, are auto- rickshaws major air pollutants. Air- pollution in Delhi was extremely high, not only due to the auto- rickshaws, but due to a combination of air- polluting vehicles which used petrol or diesel for propulsion. Smog was a common sight in the city of Delhi. In July 1998, ordered the Supreme Court of India the Delhi government to implement CNG (Compressed Natural Gas) fuel in order to improve the air- quality. Currently, all cars, auto- rickshaws and the entire bus fleet in and around the city are converted. The air- quality has improved gradually with the switch from petrol and diesel to CNG.

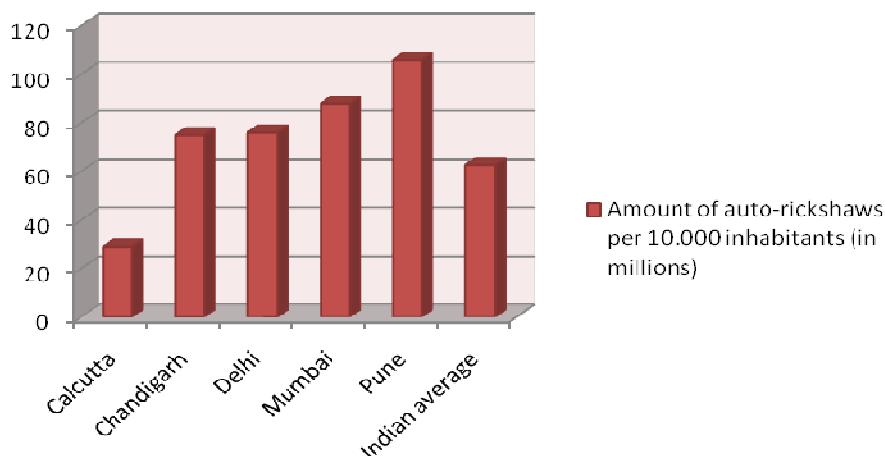


Figure 11; Amount of auto-rickshaws per 10.000 inhabitants in selected Indian cities (Ministry of Urban Development, 2008)



### **Semi- public urban mobility in Chandigarh**

As is noted before, the road network of Chandigarh is extensive and planned and the share of public transport is not as big as in Delhi. In 3.2.2 is stated that considerable amounts of residents in Chandigarh use private transport vehicles. On the contrary, semi- public transport is not as frequently used. The auto-rickshaw share is only 3 percent of all transport modes. Of 30 major cities in India having auto- rickshaws, this percentage is lowest. An explanation can be the extended road network. In Chandigarh is it relatively easy to use private transport, since congestion is non- existing. The amount of auto-rickshaws per 10,000 residents is 75 (Ministry of Urban Development, 2008). Thus, the amount of auto-rickshaws is almost identical between Chandigarh and Delhi. Though, the total share in Chandigarh is with 3 percent of all transport modes, lower. This indicates that the total motorized urban mobility in Chandigarh is more extended, in comparison with Delhi. And although the percentage of auto- rickshaws as compared to all transport modes is low, the local government is aiming at an improvement of these vehicles. The Chandigarh Administration is developing a plan to implement a radio auto- rickshaw service in the near future (2009-2010). This service makes is possible to have a door-step transport facility for Chandigarh's residents. It will become a 24/7 radio auto service, as comparable to that of regular taxi's. The vehicles of the service will run on LPG and CNG and will be equipped with a Global Positioning System (GPS) (Indian News, 2009). The fact that the auto-rickshaws will run on LPG is forthcoming out the fact that all rickshaws have to be converted into the more environmental friendly fuel. In comparison with Delhi, Chandigarh lacks behind with this introduction. Here, only recently auto- rickshaws are being converted in LPG. Chandigarh is not located near a CNG pipe line and thus is chosen to convert vehicles into LPG.

### **3.2 Domains of Development**

In addition to the current urban mobility systems general developments exist, which influence the mobility system substantially. In the previous paragraphs multiple developments that characterize the urban mobility system in India, Delhi and Chandigarh have been described. In order to identify these developments, DESTEP factors will be used in the research. The DESTEP factors together form a tool which can be applied for mapping external surroundings. This mapping step will function as the monitoring phase of the environmental scanning method.

By using the DESTEP factors in a scenario analysis, the scenarios contain a consistent wide perspective. This broad perspective is necessary since multiple factors play a role in the making of future scenarios. The scenarios are going to be constructed by looking at the current situation and the expected future situation. The description of the expected future situation (based on the DESTEP factors ) is the forecasting step of the external analysis within the environmental scanning method.

Below the six DESTEP factors are explained. The elaboration of these factors for the case of India takes place in the next chapter.

DESTEP stands for six domains;

1. Demographical; migration, urbanization, obsolescence, age structure.
2. Ecological; environmental effects, climate, natural resources, accessibility to natural resources.
3. Social; values and beliefs, culture, religion, societal stimulants.
4. Technological; knowledge, innovative possibilities,
5. Economical; competitiveness, market forces, financing.
6. Political; political climate, policies, maintaining law, level of government interference.

(Schouten, 1997)

It is not possible to do research on all the above mentioned domains due to the time frame of the research and due to lack of data. This is the reason that in this research trends in the most influential domains regarding Indian urban mobility will be outlined. The demographical, ecological, technological and economical domains are most influential. Although social developments in India are major, due to globalization, it is not expected that in a time frame of 11 years (till 2020), this will change dramatically in a way which could influence the mobility system. The political developments are also left out of consideration. The reason for not looking at these developments is due to the complexity of the political system in India. Although a national government exists, state governments often overrule, change or make their own policies. With 28 states and 7 union territories it is hard to look at developments, trends, the political climate and the government interference.

Below the four most influential domains of development are explained. In the explanation the importance of the specific domain of development on the urban mobility system is given.

### **Demographical factors**

The demographical factors show if a population pressure on cities exist and what the consequences of urbanization on urban mobility are. As in most developing countries and emerging economies, Indian cities are booming. The Indian urban population was 109 million in 1971. Thirty years later, in 2001, this amount exceeded the 285 million. The rapid growth of India's cities has generated a correspondingly rapid growth in travel demand, overwhelming the limited infrastructure (Pucher et al., 2005). The current mobility system is not sustainable if population increases and urbanization is ongoing. So, in order to make future scenarios, it is important to include demographical developments.

### **Ecological factors**

The urban mobility system puts high pressure on the environment. Emissions and pollution in Indian cities is considerable due to the amount, and type, of vehicles. The shift from public to private or semi- public modes of transport increases the pollution. Important are the availability of different

fuels and types of vehicles. These factors are important, because if ongoing environmental damage exists, it is necessary to interfere.

### **Technological factors**

Technological developments show future possibilities. This domain is very important for the making of future scenarios. Global developments in transport modes and availability of Indian infrastructure are important. The Indian government and institutes, like the Indian Urban Transport Institute, strive to implement mass transport systems. Metro's, electric trolley buses and light rail systems are new forms of public transport. These new technological developments will have a great impact on the mobility system (Ministry of Urban Development, 2005).

### **Economical factors**

Economical factors are important when looking at the shift of modes of transport. The increasing levels of motor vehicle ownership and use, have resulted in alarming levels of congestion, air pollution, noise and traffic danger. For some segments of the population, mobility and accessibility have declined. India's poor have been especially disadvantaged. They have such low incomes that they cannot afford public transport fares and must walk or cycle long distances (Pucher et al., 2005). The economy of India is emerging and due to liberalization, more FDI's are located in Indian cities, this resulting in the rise of GDP (CIA, 2009). If more persons in India are affluent, more persons are able to afford private vehicles.

## **3.3 Theoretical discussion**

In paragraph 3.1 the situation of current urban mobility systems in India is outlined. Here, a distinction is made between urban mobility systems in India in general, Delhi and Chandigarh. In addition, in paragraph 3.2 domains of development, which might influence the urban mobility systems, are discussed. It is interesting to look whether the differences between the urban mobility systems of Delhi and Chandigarh in first instance can be explained by the different factors of development. If it appears these developments do not influence the differences between the mobility systems, it is not useful to generate scenarios for the future according to these domains of development. Such scenarios would not show clear differences between Delhi and Chandigarh.

### **Chandigarh**

The main characteristic of the mobility system in Chandigarh is the amount of private vehicles on the roads. This can be explained by economic factors. The GDP of Chandigarh is relatively high compared to other Indian cities, and the city ranks number 1 in the HDI (Human Development Index) of India. This shows that the city is affluent, with inhabitants who can afford cars. In addition to economical factors can demographical factors be used for the explanation of the cities welfare. Chandigarh is a relatively new city and exists officially since 1958. Due to its planned character, sprawled developments did not take place, until recently. People did initially only migrate to Chandigarh for working purposes and the Western character of the city. It can be assumed that networks amongst the poorer people of society were hardly existing and slum areas could not be found in and around the city. This assumption makes it plausible for the public transport system not to be extensive, since

this form of transport is mainly used by the poorer people of society. Currently, Chandigarh has attracted many poorer people from surrounding areas. Designated green areas at the cities borders, have changed into slum areas. These poorer people serve the affluent inhabitants and need their own transportation modes. Public transport and non- motorized transport are becoming more visible on the roads of Chandigarh. Non- motorized transport mixed with the faster modes of transport, are a result of congestion. So far, congestion is low in Chandigarh but in the future this situation might change. And although public transport in Chandigarh was sufficient in previous years, due to a low amount of poorer people. Currently, public transport is more frequent used and this sector needs to be further assessed to make it more efficient.

Ecological factors can be used to explain the relative low level of environmental friendly implementations in the transport sector. Chandigarh is a widespread city with relatively low levels of pollution. Buses drive on petrol or diesel and a shift to LPG in auto-rickshaws is only recently being made, and most vehicles are not shifted yet. Chandigarh is not located near a CNG pipeline and thus can CNG not being introduced and is chosen to shift to LPG. The relative low level of air pollution, results in small amount of changes to make transport more environmental friendly. In addition result the broad roads in Chandigarh and the low use of public transport in a low degree of necessity of implementation of advanced technological developments, so far.

## Delhi

Delhi is compared to Chandigarh an old city. Throughout the years, Delhi expanded in an uncontrolled way. Migration from surrounding villages is a reason for this uncontrolled growth. High urbanization rates in recent years can have considerable effects on the mobility system. Delhi expanded rapidly and trip distances have grown. Motorized transport can be used to travel these longer distances, with as result insufficient infrastructure, congestion and air pollution.

Public transport in Delhi is used with much higher frequency, compared to Chandigarh. This can be explained by the amount of poorer people in the city, which is relatively high in comparison with the newer Chandigarh. Thus, economic factors might play a distinctive role in the emergence of public transport systems. The feature of high bus amounts, can be the reason for high levels of pollution in Delhi. The high population density of the older part of Delhi result in environmental degradation. This might make it necessary to implement environmental friendly transport modes and mass transport systems. Technologies and technological developments can play in important role in the implementation of these new modes of transport.

Based on the different DESTEP factors of development, differences between Delhi and Chandigarh are visible. These differences might explain the differentiation in mobility between the cities. In the next chapter will first be explored in what direction the DESTEP factors are going to be developed. Subsequently can these factors be applied as basis for the scenarios of the specific cities. In order to outline the differences in mobility between Delhi and Chandigarh is local knowledge of experts in the field of mobility and development going to be used. The reason for outlining the developments first in a general way, is that this forms the basis for statements towards the experts. Specific data for both cities in the literature is insufficient for doing elaborated research on the most influential factors.

### 3.4 Conclusion

It can be stated that differences between public, private and semi- public mobility in Indian cities are considerable. Public transport is not as flexible as private- and semi- public transport, but overall it is a cheaper form of transport. Furthermore is public transport accessible for everybody, as opposed to private transport. Auto- rickshaws fit in the category of semi- public transport and are privately owned, but accessible for everybody.

A shift exists from public to private transport, due to congestion, rising living standards, longer trips distances and deteriorating public transport. The share of public transport in Delhi is high, compared to the semi-public and private transport. In Chandigarh, on the contrary, is the share of private transport larger. An explanation is the extensive, planned, road network of Chandigarh and the relatively high amount of affluent people in the city. Four domains of the DESTEP factors will be applied to map the external surroundings. Demographical, ecological, technological and economical factors are chosen to be applied on the research, since these are most influential. Based on these DESTEP factors of development are differences between Delhi and Chandigarh visible. These differences might explain the differentiation in mobility between the cities. The future direction of development will be given in the next chapter.

## 4. Developments and trends till 2020

In chapter 3 is the current urban mobility system in India, Delhi and Chandigarh outlined. Now, in this chapter, developments and trends which influence the urban mobility system will be discussed. According to the environmental scanning theory, this chapter functions as the forecasting phase. It will forecast future directions of changes and patterns. DESTEP factors, which are discussed in the theoretical framework will be used in this chapter to map developments till 2020. Demographical, ecological, technological and economical factors will be outlined in respectively paragraph 4.1, 4.2, 4.3 and 4.4. Factors which are unforeseen should not be overlooked, in paragraph 4.5 these factors will be briefly mentioned. The direction of development of the various factors will be discussed in this chapter. Subsequently can these factors be applied as basis for the scenarios of the specific cities in chapter 5.

### 4.1 Demographical developments

The demographical factors show whether land pressure on cities exist and what the consequences of urbanization on urban mobility are. As in most developing countries and emerging economies, Indian cities are booming. The rapid growth of India's cities has generated a correspondingly rapid growth in travel demand, overwhelming the limited infrastructure (Pucher et al., 2005). The current mobility system is not sustainable if population increases and urbanization is ongoing. In order to make future scenarios, it is important to include demographical developments.

#### 4.1.1 Population growth

The world population is growing and India is participating in this growth. A growing population puts pressure on the economical and ecological systems. India occupies 2.4 percent of the world's land area and supports over 17.5 percent of world's population. Currently, in 2009, the total Indian population exceeds the 1 billion and it is the second country in the world which reaches one billion inhabitants (after China). The population is still growing, though, the population growth rate is not amongst the highest worldwide. With an annual growth rate of 1.5 percent (est. 2009), is India ranked number 84 out of 235 countries worldwide (CIA, 2009). The Planning Commission Government of India (2002) estimates that the amount of inhabitants in 2020 will be 1331 million (figure 12).

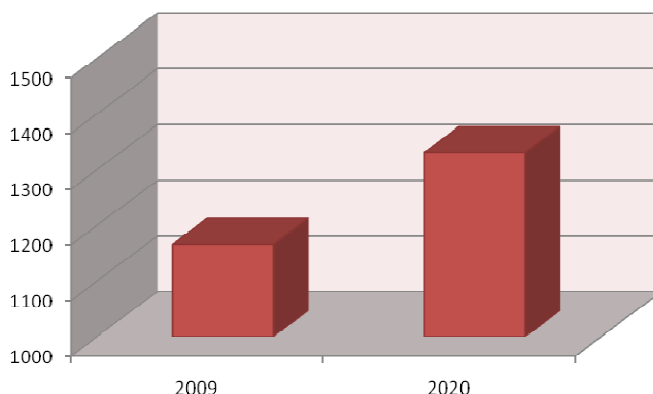


Figure 12; Indian population, 2009-2020 (CIA, 2009)

This scenario is made upon the assumption that the current growth rate is proceeding, but with a substantial decline in birth rate. Urbanization, rising educational attainment and increasing employment among women are factors of a lower birth rate. As a result, the decline in global population growth is steeper than in earlier periods. The rate of decline in population growth is likely to be further accelerated during the next decade.

The age structure in India is important considering when looking at the population pressure. India consists of a very large proportion of children and persons in the reproductive age. Due to the large reproductive group, the population will continue to grow, even when the replacement level of fertility is reached. It is necessary to generate enough employment opportunities for this work force and utilize the human capital to accelerate economic growth (Indian Planning Commission, 2008).

#### 4.1.2 Urbanization

Globally, the number of cities with 10 million, or more, inhabitants is increasing rapidly. Most of these new 'megacities' are in developing regions. In 1960, only New York and Tokyo had more than 10 million inhabitants. It is projected that there will be 28 megacities by 2015 of which five in India; Bangalore, Calcutta, Chennai, Delhi and Mumbai (Indian Planning Commission, 2008).

In India, the labor force occupation in agriculture is high, with almost 60 percent (CIA, 2009). Indian life, therefore revolves mostly around agriculture and allied activities in small villages. Of total Indian population, 29 percent is urban. This percentage is annually growing with 2.4 percent point (estimated till 2010). In figure 13 is estimated that by 2020 the least developed regions in the world will overdraw India in urbanization rate (UNFPA, 1999). The least and less developed world are urbanizing relatively rapid, in comparison with more developed regions. The urban Indian population will be approximately 38 percent of total population, in 2020 (see figure 12). That is an increase of ten per cent point, compared to the current level of urbanization. The relatively low level of urbanization in India is partly due to a stringent definition of 'urban' in India. It excludes for instance peri-urban areas (UNFPA, 2009).

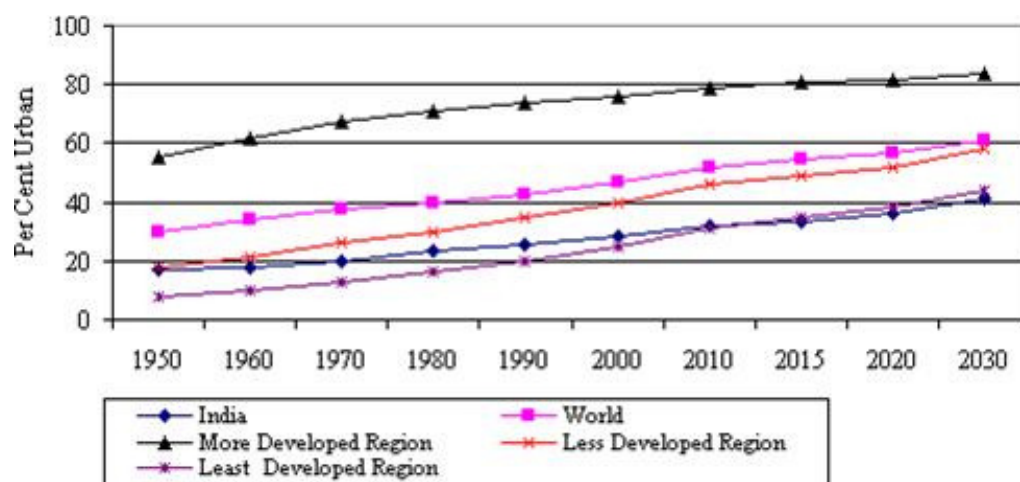


Figure 13; World urbanization trends, 1950-2030 (UNFPA, 2009)

Cities and towns are the engines of social change and economic development. Urbanization is associated with improved access to education, employment and health care. As people are moving towards and into cities, cities sprawl outside and urban slums expand. More urban people, results in an increase in automobiles, air pollution and congestions. Therefore, cities have to provide an adequate transportation network. The more people, the bigger the challenge to provide a sustainable, good working transportation network of infrastructure and transport modes.

Planners and policy makers in developing countries like India have to take the ongoing demographic changes into account, so that available human resources are optimally utilized to achieve improvements in quality of life. In order to retard urban growth, Indian policymakers have implemented the National Rural Employment Scheme in 2005. Through this scheme, the government provides a legal guarantee for 100 days of employment in every year for every rural household with an adult member willing to do unskilled manual work. It remains to be seen what impact this will have on rural-urban migration (Government of India, 2008). If this project is going to be a success, the future estimates on urbanization might change and transportation issues in cities might not as stringent as is predicted.

## 4.2 Ecological developments

It is not beneficial for the ecology if the shift from public to private, or to semi-public, modes of transport will continue and if urban areas are expanding. The demographical developments are influential on the ecological developments.

### 4.2.1 Pollution by motor vehicles

Air pollution due to emission from motor vehicles is causing serious health and welfare effects, and has been the focus of considerable public concern and policy attention in Indian cities (Badami, 2005). In figure 14 is the air pollution in Delhi by sources shown. It can be seen that between 1970 and 2001 the percentage of vehicular pollution is increased by 49 percent point (Singh, 2005). This indicates the emergence for cleaner vehicles. The World Health Organization (WHO) set up limits for air pollution. In many cities in India, these guidelines are being exceeded almost daily. Sometimes with peak levels as high as 6-10 times the WHO limit at many sites. Ozone has been a major problem, especially in winter (CPCB, 2004).

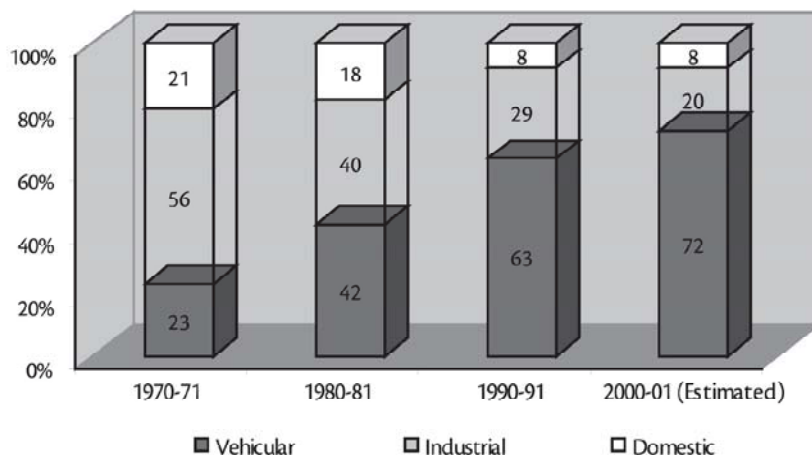


Figure 14; Air pollution in Delhi by sources (Singh, 2005)



The rapid increase in motor- vehicle activity in India is important, not only because of the many adverse local impacts that it causes, but also for the more global impacts, as climate change, energy security and acidification (Badami, 2005). Motor- vehicle activity, energy consumption and related carbon dioxide emissions from global transport have grown by about a third every decade over the last three decades (IEA, 2004).

The vast majority of motor- bicycles and auto- rickshaws in India have been powered by two- stroke engines, which are highly polluting. These vehicles produce higher levels of carbon monoxide and hydrocarbon per kilometer relative to buses. Several studies worldwide have shown that maintenance is a significant factor in vehicular performance. Emissions can increase between ten- to twentyfold in poorly maintained diesel and two stroke auto- rickshaws and motor- bicycles (Faiz ea, 1996). Maintenance levels in India are poor despite low labor and high fuel costs. Besides the auto- rickshaws and motor- bicycles, also buses which are operated by the state, are poorly maintained (Tiwari, 2002). These poor maintenance by vehicle users is due to several institutional factors. Good quality spare parts are expensive in India, in part because of high sales taxes. Inadequate spares have therefore been commonly used. Badami (2001) argues that monitoring and enforcement in the Indian context have been ineffective. Till 2020, this is not likely to change. It is a political issue, vehicle emission inspection regimes are technically flawed, open to corruption, and inconvenient for users, who get round or change the testing process (Badami, 2001). Fuel and lubricating oil adulteration has also been an important contributory factor to high pollution intensities. The attitude of auto- rickshaw drivers are a cause of this issue. The auto- rickshaw need major amounts of fuel and this fuel is relatively expensive. A result is that auto- rickshaw drivers are changing the composition of fuel and lubricating oil. This adulteration makes the fuel cheaper, but contributes to higher pollution intensities.

#### **4.2.2 Future of environmental effects**

The gap between local oil production and demand has been rising rapidly in India, the needs have to be met through imports. Oil imports account for almost a fifth of all Indian imports, and in 2006 three quarters of India's oil requirement were imported. The future is worrisome, given the projected trends in motor-vehicle activities (see chapter 3) and India's vulnerability to world oil prices due to the large amount of imports (Badami, 2005).

In order to diminish, or to slow down, the negative environmental effects of the increasing use of motor vehicles, India signed a declaration with the International Energy Agency (IEA) in 1998. As a result of this IEA-India cooperation, India released its first National Action Plan on Climate Change in 2008. This plan outlines eight national missions running up to 2017, to promote energy efficiency. One of these missions is the 'National Mission on Sustainable Habitat'. This plan seeks to promote energy efficiency as an essential component of urban planning. In the transport sector is calls for stronger enforcement of automotive fuel economy standards, using pricing measures to encourage the purchase of efficient vehicles, and providing incentives for the use of public transportation (IEA, 2009). The rickshaw drivers are a major target group in the enforcement of automotive fuel economy standards. They have to shift from petrol or diesel to LPG or CNG, in order to decline the air pollution in cities. The poor often suffer the highest exposures in the case of air pollution. Many of them live and work near roads, where air pollution levels are typically higher than further away. Incentives to promote energy efficiency are often hard to meet for the poor, they search for the cheapest way to

move. Most of the energy-efficiency measures require huge investments in the creation of new infrastructure. Efforts by the government to reduce CO<sub>2</sub> emissions by the way of introducing mass-rapid transit systems (e.g metro) would involve diverting resources from other priority claims on financial resources (Government of India, 2008). In the following paragraph on technological developments are several sustainable technological developments going to be discussed. These developments in the transport sector might give India the opportunity to prevent the environment from further deterioration.

### **4.3 Technological developments**

Technological developments show future possibilities for vehicles and their source of energy. Global technological developments in the transport sector are of importance for the future of the urban mobility system in India. The environment plays an important role with the implementation of new vehicles; the lesser the emission the better. The Indian government and institutes strive to implement mass transport systems in the bigger cities, in order to diminish emissions and road congestions. Focus on sustainable personal transport is also important. Hybrid vehicles are becoming more common on the roads. These vehicles and other global developments in the transport sector will be outlined in this paragraph.

#### **4.3.1 Hybrid and electric vehicles**

A hybrid vehicle is a vehicle that combines two or more power sources to move the vehicle. Commonly the term 'hybrid' refers to vehicles with traditional gasoline combined with an electric motor. These kind of hybrid vehicles can use either one or both energy sources for propulsion. Instead of an gasoline or electric motor, hybrid vehicles may include hydrogen, compressed natural gas (CNG), propane and solar energy as power sources. Though, nowadays is the hybrid- electric vehicle (HEV) mostly used (Driesen et al., 2007). The hybrid vehicles are an improvement for the environment, compared to the traditional vehicles with only gasoline. But, hybrid- electric vehicles generate more emissions in comparison with total electric, plug- in hybrid or solar- energy vehicles. The current infrastructure for these latter kinds of transport is not yet sufficient and negative points can be mentioned.

In table 11 are the advantages and disadvantages of hybrid, electric, plug- in hybrid and solar vehicles outlined. It can be seen that all these vehicles with different sources of energy can be used for different purposes. Currently, electric- and solar- run vehicles are useful for short distance movements. Hybrids and plug- in hybrids can be used for longer distances, since these have multiple sources of energy within the vehicle. By 2020, disadvantages and advantages might have changed. Electric vehicles, for example, might have a bigger capacity, and will be able to drive longer distances.

**Table 11; Vehicles with sustainable sources of energy and corresponding advantages and disadvantages**

Source of energy	Advantages	Disadvantages
<b>Hybrid</b>	<ul style="list-style-type: none"> <li>- Already on the market</li> <li>- Possibility for multiple energy sources</li> <li>- No need for extra infrastructure</li> <li>- Able to drive long distances</li> <li>- Less emission, compared to traditional vehicle</li> </ul>	<ul style="list-style-type: none"> <li>- Needs traditional gasoline</li> <li>- More emission compared to electric, plug- in, solar and hydrogen vehicles.</li> </ul>
<b>Electric</b>	<ul style="list-style-type: none"> <li>- No emission</li> <li>- No noise</li> <li>- Starting phase of introduction</li> </ul>	<ul style="list-style-type: none"> <li>- Needs recharging</li> <li>- Needs additional infrastructure</li> <li>- Short distances</li> </ul>
<b>Plug- in hybrid</b>	<ul style="list-style-type: none"> <li>- Less emission compared to hybrid, but more than electric vehicles</li> <li>- Drives longer distances compared to electric</li> </ul>	<ul style="list-style-type: none"> <li>- Needs recharging</li> <li>- Needs additional infrastructure, but less than for electric vehicles</li> </ul>
<b>Solar</b>	<ul style="list-style-type: none"> <li>- No emission</li> <li>- No noise</li> <li>- Starting phase of introduction</li> <li>- No need for additional recharge stations</li> </ul>	<ul style="list-style-type: none"> <li>- Needs sunshine</li> <li>- Solar panels are expensive</li> <li>- Short distances</li> </ul>

### Electric vehicles

Vehicles which do not use an internal combustion engine, but only electricity are called battery-electric vehicles (BEV). These vehicles are only useful for short distances, since they can run out of electricity. It is necessary to charge the battery occasionally. Although this form of sustainable transport is environmental friendly with no (direct) noise- and air pollution, the negative part is considerable. It is necessary to expand the electricity infrastructure in order to cater for battery run cars (e.g recharge stations). Market penetration on a large scale is not yet possible, several vehicles are found on the road nowadays. It is expected that this amount will be increased by 2020.

### Plug- in hybrid vehicles

An alternative to hybrid- electric and battery- electric vehicles is a combination. The plug- in hybrid vehicle increases the battery capacity in a HEV, and thus can be used as a BEV which generates less emission. The internal combustion engine is only used for longer distances (Driesen ea, 2007). The plug-in hybrid is more eco- friendly than the HEV but needs to be recharged occasionally, due to intensive use of batteries.

### Solar- run vehicles

As already mentioned above, hybrid vehicles can include solar energy. A combination of electric and solar vehicles seems a sustainable solution for transport systems in India; recharging is not necessary and sunshine is widely available. In October 2008 an environmental friendly cycle- rickshaw was introduced in Delhi. This green rickshaw runs on solar batteries and is called the "Soleckshaw". The

Soleckshaw is developed by India's Central Mechanical Engineering Research Institute (CMERI). It can be pedaled like a normal rickshaw or powered by a battery for approximately 65 kilometer before requiring recharge. This cycle- rickshaw is, like the traditional one, environmental friendly but generates also a physical boost for the drivers. The solar- powered rickshaw is currently, in 2009, still a pilot project in Delhi's Chandni Chowk area. More advanced versions of the Soleckshaw are expected to be ready during the Commonwealth Games in 2010. The more advanced versions will have better aesthetics, ergonomics and speed (Ministry of Science and Technology, 2008). It is not possible to adapt the current vehicles, replacement is necessary. Compared to the cycle- rickshaw, auto-rickshaws drive bigger distances and are thus harder to convert into electric or solar propulsion.

#### **4.3.2 Tata Nano car**

This year, in March 2009, the Nano car is introduced into India's roads. This small car is world's cheapest and is originally designed for the Indian market. It is a four passenger city car built by Tata Motors. According rating agency CRISIL (2008) is the Nano car expected to boost the Indian car market by 65 percent. The chairman of Tata Motors, Ratan Tata, described the car as an eco- friendly 'people's car'. The Nano is cheap and amongst it sources of energy is compressed natural gas (CNG), which is more eco- friendly than petrol or diesel. An electric version is also being developed, called the E-Nano. This version is not on the market yet, according to Ratan Tata is this E-Nano going be launched in September 2009.

Due to the rising economy of India, many Indians have been able to become more affluent and have shifted to India's growing middle class. Robinson states in his book 'Bankruptcy of our nation (2009)' that India's middle class is expected to increase tenfold by 2025, according to some estimates. The target group of the Tata Nano is this rising middle class. And if the middle class is going to grow and more automobiles are going to hit India's roads, more oil will be needed. Currently India is importing 70 percent of daily oil requirements. It can be expected that oil demands are going to grow exponentially (Robinson, 2009). The Tata Nano has the potential to increase total car sales by 20 percent in its first year, so this car is a major cause of the increasing oil demand (Uddin, 2009) The E-Nano, or other environmental friendly cars, would be a solution for the pollution, but would not relieve congestion on Indian roads. Public transport is a solution to relieve congestion.

#### **4.3.3. Public transport**

One of the objectives of India's National Urban Transport Policy (2005) is: "Investing in transport systems that encourage greater use of public transport and non- motorized modes instead of personal motor vehicles". Due to high emissions and road congestions, the Indian government started to encourage the use of public transport. Currently, in most Indian cities the public transport not well maintained. By introducing new forms and improving the older ones, the government is aiming at a shift from private to public transport.

In the previous sub- paragraph 4.3.2 is seen that technological developments in the transport sector can improve the quality of public transport. Developments as electric and solar driving are not yet available on a large scale and infrastructure is insufficient. Several available public transport technologies can be introduced on a large scale now and in the coming years till 2020, in India. In chapter 5 will developments in public transport in Chandigarh and Delhi be outlined, but the national government of India considers to introduce a wider range of technologies which can be seen in table

12. The public transport systems in table 12 are already operating in specific cities around the world. Advantages and disadvantages can be outlined for each system. Currently a metroline is in operation in Delhi and in Goa are plans to introduce a Sky bus. These developments show that the Indian government is expanding its public transport system. It can be expected that by 2020 more transport systems will be introduced in more cities around India. The technologies in table 12 show which technology is useful for a city with specific characteristics.

**Table 12; Characteristics of available public transport systems (revision of NUTP, 2005)**

Transport system	Advantages	Disadvantages	Cities where operating	Useful for
<b>Underground heavy rail system</b>	<ul style="list-style-type: none"> <li>- High carrying capacity</li> <li>- High speed</li> <li>- Very low pollution</li> <li>- Needs little urban space</li> </ul>	<ul style="list-style-type: none"> <li>- High capital costs</li> <li>- Inflexible</li> <li>- Needs extensive feeder network</li> </ul>	<ul style="list-style-type: none"> <li>- Several cities in Europe (London, Paris) and USA (New York) and Asia (Singapore, Tokyo, Hong Kong)</li> </ul>	<ul style="list-style-type: none"> <li>- High density corridors where road space is limited</li> </ul>
<b>Light rail system</b>	<ul style="list-style-type: none"> <li>- Capital costs are less than for heavy rail</li> <li>- Low pollution</li> <li>- Need less space than bus systems</li> </ul>	<ul style="list-style-type: none"> <li>- Capital costs higher than for bus systems</li> <li>- Inflexible</li> <li>- Carrying capacity is lower than heavy rail</li> <li>- Needs extensive feeder network</li> </ul>	<ul style="list-style-type: none"> <li>- Several cities in USA and Europe</li> </ul>	<ul style="list-style-type: none"> <li>- Medium density corridors where space is available for elevated structures</li> </ul>
<b>High capacity bus system on dedicated lanes</b>	<ul style="list-style-type: none"> <li>- Capital costs lower than for rail systems</li> <li>- Higher capacity than normal bus system</li> <li>- less extensive feeder network than rail systems.</li> </ul>	<ul style="list-style-type: none"> <li>- More polluting than rail based systems</li> <li>- Needs imported fuel</li> <li>- Needs urban space for dedicated corridor</li> </ul>	<ul style="list-style-type: none"> <li>- Several countries in Latin America (Brazil, Colombia)</li> </ul>	<ul style="list-style-type: none"> <li>- Medium density corridors where space is available for bus lane</li> </ul>
<b>Sky bus system</b>	<ul style="list-style-type: none"> <li>- No pollution</li> <li>- No noise</li> <li>- Needs limited urban space</li> </ul>	<ul style="list-style-type: none"> <li>- Inflexible</li> </ul>	<ul style="list-style-type: none"> <li>- Not yet anywhere. Only a test track in Goa (India)</li> </ul>	<ul style="list-style-type: none"> <li>- medium density corridors where space is limited</li> </ul>
<b>Electric Trolley bus system</b>	<ul style="list-style-type: none"> <li>- No pollution</li> <li>- Low operating costs</li> </ul>	<ul style="list-style-type: none"> <li>- Low capacity</li> <li>- Low speeds</li> <li>- Inflexible compared to normal bus</li> </ul>	<ul style="list-style-type: none"> <li>- In USA (San Francisco)</li> </ul>	<ul style="list-style-type: none"> <li>- All routes suitable for buses but where pollution has to be low</li> </ul>
<b>'Normal' bus system</b>	<ul style="list-style-type: none"> <li>- Very low capital costs</li> <li>- Low operating costs</li> <li>- Do not need feeder systems</li> <li>- Highly flexible</li> </ul>	<ul style="list-style-type: none"> <li>- Low capacity</li> <li>- High pollution</li> <li>- Low speeds</li> <li>- Poor social image</li> </ul>	<ul style="list-style-type: none"> <li>- Most cities around the world</li> </ul>	<ul style="list-style-type: none"> <li>- Low density corridors where local pollution is not a critical issue. And is feeder to higher capacity systems.</li> </ul>

## 4.4 Economical factors

Economical factors are important when looking at the future of urban mobility. Due to rising incomes and prosperity a shift in modes of transport is visible in India. The annual GDP growth is with 6.6 percent (2008) high in India, compared to other countries. According to the CIA World Factbook (2008) on GDP growth, India ranked 41 out of 217 countries worldwide, in 2008. The percentage of 6.6 percent shows that India is developing itself economically. Though, the annual growing percentages of 2006 and 2007 were higher with respectively 9.6 and 9 percent (CIA, 2008).

The above mentioned growth percentages show India's development on a macro scale. GDP only indicates a part of the economic development. Besides the GDP, it is also important to look at the Human Development Index (HDI). This index looks beyond GDP to a broader definition of well-being. The HDI provides a composite measure of three dimensions of human development: living a long and healthy life, being educated and having a decent standard of living. It provides a broadened view for viewing human progress and the complex relationship between income and well-being (UNDP, 2008). The HDI does not show, for example, income inequalities. Income inequalities in India are considerable and GDP nor HDI shows these inequalities in their statistics, though the HDI highlights the very large gaps in well-being and life chances that divide the increasingly interconnected world.

The HDI for India is 0.619, which gives the country a rank of 128<sup>th</sup> out of 177 countries with data (in 2005). When looking at the trend in the past, India is increasing their HDI score progressively. As can be seen in figure 15, India bypassed the average of countries in South Asia and is increasing their HDI more rapidly than, for example, Europe. Although the HDI score is increasing and standards of living are becoming better, the gap between the affluent and the poor is continuing to exist. In 2007 lived 25 percent of the population in India below the poverty line of one US dollar as day (CIA, 2008). In the future, this gap can become smaller due to India's economical potential. Or this gap between rich and poor can widen due to unfair wealth distribution.

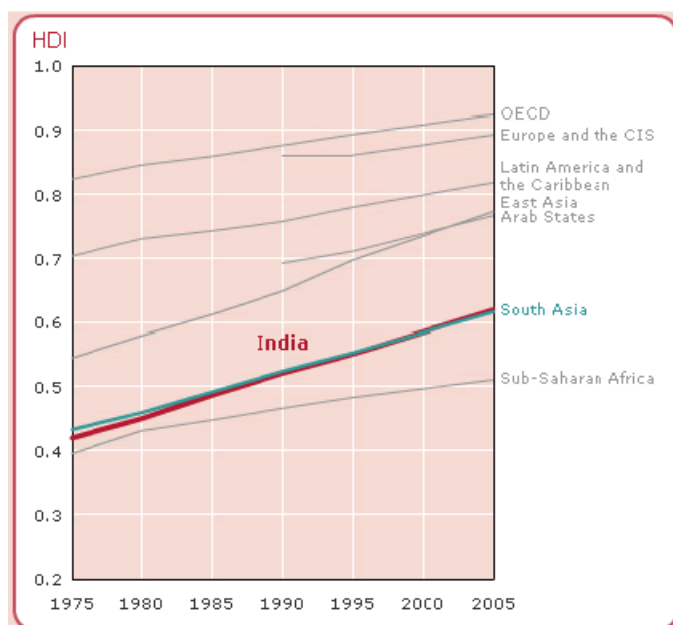


Figure 15; Trend HDI India, 1975-2005 (UNDP, 2008)

In connection with the urban mobility is the economy important. The increasing levels of motor vehicle ownership and use, have resulted in alarming levels of congestion, air pollution, noise and traffic danger. With 17.4 percent of the world's population, India account for 4.6 percent of global emissions. These emission levels are below the average of South Asia. Compared, high income countries account for 15 percent of the world's population but account for almost half of all emissions (UNDP, 2008). With a growing economy, the future of India's emissions are questionable.

The British author and historian, Paul Johnson, compared in the article 'Look to India (2005)' the future economy of China and India. He is positive about India's future and emissions, as compared to China. Johnson argues that by 2050, India will have the largest population in the world, with 1.6 billion inhabitants versus China's 1.4 billion, with India's population being much younger. As for the economic potential of India, this young population is an advantage. China tended to concentrate on old industries, with the goal of gaining quick returns through cheap exports. Johnson states that China is not investing enough in high technology, with the exception of the military, and is thus making the same mistakes the Soviet Union made. The economical and political situation of China seems fragile to Johnson. He argues that India has got more economic potential. The major educated part of India's population is fluent in English. The economy of India is leapfrogging over the industrial epoch into the advanced communications era. Johnson (2005) predicts that India will soon have more English- speaking computer operators than the rest of the world put together, and this will be linked to all the advanced economies. Due to the political freedom that prevails in India, inventions and new processes can be produced. The economy benefits from this political climate. Mobility systems, on their turn, react on this future situation.

#### **4.5 Unforeseen developments**

Besides the predictable DESTEP developments and trends, are also unforeseen developments important to be included in the future scenarios. Natural disasters (e.g. earthquakes, tsunamis), major diseases, extreme political interference (e.g. closure of borders, one- child policy), technological developments or discoveries and war are developments which are hard to predict, but which do have a major impact on Indian society and thus also on the future of auto- rickshaws.

#### **4.6 Conclusion**

Demographical, ecological, technological and economical factors influence transport systems. These factors are all intertwined and influence one other. Urbanization and population growth increase pressure on urban land. Due to (economical) growth more people can afford a motorized vehicle and emissions and congestion increase. Environmental friendly vehicles are necessary for a sustainable future. Currently, the Indian government is aiming at getting people out of the private vehicle and into the public vehicle. The National Urban Transport Policy shows this point of view in its objectives. It can be expected that due to technological developments and a green agenda, public transport systems will have improved substantially, by 2020. The DESTEP trends are predictions for the future, unforeseen developments cannot be predicted and can change systems abrupt. In this chapter were the demographical, ecological, technological and economical development outlined on a macro level.

In the next chapter are developments on a lower level going to be discussed. In this chapter 5 are scenarios for the year 2020 made and are trends for the mobility systems in Chandigarh and Delhi forecasted. Developments on a macro level influence events on a micro level, and so functions this chapter 4 as a guideline for the more in- depth chapter 5. The demographical, ecological, economical and technological factors can be applied as basis for the scenarios of the specific cities . The scenarios for the year 2020 will help to give recommendations to the Tuktuk Company on how to react on these scenarios and developments.



## 5. Scenario's 2020

In this chapter are four different future scenarios for the year 2020 generated. These scenarios are opposites of each other and are shown in their most extreme forms. Experts in the field of transportation in Delhi and Chandigarh have graded each scenario on likeliness and on impact of the urban mobility system. These results can be found in the second paragraph of this chapter. The scenario which is most likely to happen, and the one which will have the biggest impact on the urban mobility system are further elaborated in the third paragraph. In addition with chapter 4, this chapter functions as the forecasting phase within the environmental scanning theory. It forecasts the future directions of the changes and developments. According to the environmental scanning method, will only the final assessing phase follow on this phase. The assessing phase assesses the organizational impact of the changes and developments for the Tuktuk company. This final phase will be outlined in the next chapter of conclusion.

### 5.1 Explanation scenario's

In order to get a clear view of the future are four scenarios generated. The scenarios are made according to two elements which have a major impact on urban mobility systems; quality of public transport and extent of the middle class. These two elements are extracted from interviews; respondents mentioned these as elements which have major influence on the future. In the beginning, three respondents were interviewed and complex scenarios were shown. It appeared that these scenarios were too complicated for the respondents to grade and to understand. The initial four scenarios included too many variables, this made it inconvenient and hard to understand for the respondents. Those four scenarios were created based on random literature and did not have consistency. As a result four different scenarios were made, constructed with the two elements which are mentioned below (figure 16). These elements are chosen because those were mentioned by the first three respondents as important for the future. A second visit to the first three respondents showed that the new scenarios were more easy to understand. As a result, the four scenarios are shown to all respondents in Chandigarh and Delhi.

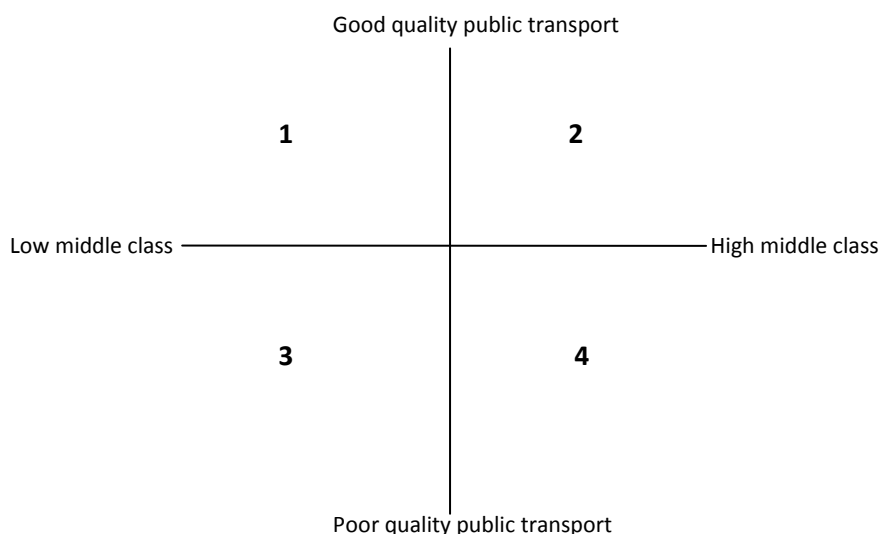


Figure 16; Four scenarios in relation to elements

As can be seen in figure 16, the elements are set against one other on the axes. The four scenarios are withdrawn from the four extremes.

An explanation of the four scenarios will be given below;

**Scenario 1:** Quality of public transport is good. Innovative new transport forms are being introduced and buses are more comfortable than 10 years ago. A low middle class is being observed. A divide between poor and rich persist.

**Scenario 2:** Quality of public transport is good. Innovative new transport forms are being introduced and buses are more comfortable than 10 years ago. A high group of middle class incomes exists. A divide between rich and poor is not being observed.

**Scenario 3:** Poor quality of public transport. And new innovative forms of transport are not (yet) being introduced. A low middle class is being observed. A divide between rich and poor persist.

**Scenario 4:** Poor quality of public transport. And new innovative forms of transport are not (yet) being introduced. A high group of middle incomes exists. A divide between rich and poor is not being observed.

## 5.2 Results interviews

Seven experts in the transport sector are interviewed in Chandigarh. In Delhi there were five respondents. Overall, each interview took between half an hour and 1.5 hour. A scheme with grades of the respondents can be found in appendix 1. The specific experts are chosen, in order to obtain a variability of expertise. Experts are employed in different working fields and have different point of views regarding mobility and transportation. Respondents who are associated with colleges and universities look at urban mobility from a macro level. Due to their working field, as for example a professor, they have knowledge from different angles and answered in a broad way. People within the working field, on the contrary, answered in a way as they experience it within their job. Often, the professors provided general answers. The answers of respondents, from for example the State Transport Authority, were more one-sided and specific.

Respondents are people with expertise in the field of transport and were selected via various ways. By searching on the internet, stakeholders in Chandigarh and Delhi were detected, though these people did not always gave a positive response. To stick to the time frame available in India, people who were willing to share their knowledge were interviewed. Some respondents provided names of other experts, this made it possible to interview more respondents. It can be stated that the respondents are not representative. Due to the time frame it was not possible to obtain a correct random sample of the Indian population. In order to acquire a consistence research, only experts in the field of transportation are chosen.

The respondents commonly agreed on the quality of the public transport. Within their opinion the quality of the public transport will definitely be improved by 2020. Currently, improvements are already being made. In this paragraph will the visions of the respondents in Chandigarh and Delhi be outlined.

In addition to the interviews in Delhi and Chandigarh, a questionnaire on urban mobility in India is answered by 36 respondents. The questionnaire (appendix 2) was placed on the website of [arrivesafe.org](http://arrivesafe.org) and visitors of this site, mainly inhabitants of Chandigarh and surrounding cities, answered the questions of the questionnaire on this website. This questionnaire is used in order to get a total and adequate view on the future. The respondents of the questionnaire function as sources of additional information, since the amount of respondents from the interviews is limited.

### **5.2.1 Chandigarh**

Chandigarh is the only planned city in India (see Chandigarh map in figure 6), and so developments within this city may not give a representative picture of other Indian cities. The reason for Chandigarh to be interesting is that developments and changes are most likely to be introduced in this city first, due to its planned character, compared to other Indian cities.

#### **Metro line**

The Chandigarh Transport Authority is aiming at implementing a metro line within the next ten years. Though, according to the respondent Navdeep, do several researches show that a metro line will not benefit Chandigarh and its roads. Distances within Chandigarh are relatively small, and people need transit to the metro station and from the metro station. This is time consuming, and so people will continue to use private vehicles to move around, according to his opinion. Thus, the question remains whether the metro line will indeed be introduced in Chandigarh in the next 20 years. The consequences of a metro line for auto-rickshaws is that the trip lengths will be shortened. People can use the fast metro line for bigger distances. For transit to and from the metro station auto-rickshaws will be used. In the overview of different available public transport systems in table 10 could be seen that metro lines are already operating in several cities around the world. Due to Chandigarh's western character it has the possibility to learn from these other western cities which already have a metro line.

#### **Quality public transport**

Although it remains questionable whether the metro line will be introduced, the quality of public transport will definitely be improved by 2020. Public buses are becoming more comfortable. Ms. Disodia of the State transport Authority mentioned that air conditioned buses are already introduced, and more will come in the near future. She argues that it is possible that also the more affluent people will use public transport in the future. Currently only the poorer people of society use this form of transport. Within the next six months a new bus fleet will be introduced on Chandigarh roads. In order to decrease road accidents and air pollution current city buses are being sealed, this makes it impossible to drive faster than 50 km an hour. Although, buses cannot drive faster than 50 kilometer per hour, the new busses will still drive on diesel.

It can be stated that the State Transport Authority is aiming at an improvement of public transport in Chandigarh. Professors Mr. Sharma and Ms. Sharma argue that good public transport is lacking currently, but by 2020 the quality would be improved. The current lack in good public transport is giving rise to an increasing amount of private vehicles, including the Tata Nano. This lack of good public transport can be given as an explanation of the popularity of the auto-rickshaw. By the end of August 2009, it is compulsory for all auto-rickshaws to be converted to LPG. Though, the trajectory of

converting a rickshaw vehicle is a long one, and it still has to be seen whether all rickshaws will be converted. In case all auto-rickshaws will drive on LPG, a decline in air- and noise- pollution can probably be noticed by 2020.

### **Auto-rickshaws**

Unlike the public buses, auto-rickshaws are being converted to LPG in Chandigarh. From the 31st of August 2009 onwards, auto-rickshaws driven on petrol or diesel are not allowed into the city centre anymore. Disodia points out that the underlying reason for this contradiction between buses and auto-rickshaws is that auto-rickshaws are more polluting.

Currently, 60 percent of population travels by auto- rickshaw in Chandigarh. This percentage is likely to drop by 2020 if buses become more comfortable and if more people shift to this mode of transport. Though, as all respondents in Chandigarh argue, the auto-rickshaw will still be the second frequent used mode of transport by 2020. Private transport rates number one in the list of most frequent used forms of transport. Auto-rickshaws are second and public transport rates number three. Due to the extended network of roads in Chandigarh, it is expected that these rates will continue to exist in the next ten years. New improved forms of auto- rickshaws can easily be implemented on the extended road network of Chandigarh. And although public transport is improving, the auto- rickshaw will still be used in Chandigarh frequently, though the trip length may be shortened. In Chandigarh can be anticipated on this auto-rickshaw scenario by introducing new sustainable innovative forms of rickshaws. When the metro line is implemented, trip lengths will be shorter and electric vehicles are easier to implement. The relatively high educated population of this city will look at the electric vehicles as an improvement for their city and will support the initiative for a sustainable future.

### **Private vehicles**

It is easy and comfortable for the generally affluent population of Chandigarh to purchase a private vehicle. Congestion is not as bad compared to other Indian cities, for example in Delhi. Here for people are not tempted to use public transport more frequently. In addition, Mr. Sharma argues, that buses are not running on time and are even absent in some areas. The Tata Nano will especially in Chandigarh be used frequently, due to its broad network of roads and lacking or bad public transport. The professor of Highway engineering, Mr. Sharma, argues that the Nano car can become very popular, but it will never replace the auto- rickshaw. Currently there are approximately 6000 auto- rickshaws in Chandigarh and this amount is still rising. The price of the Nano and the auto-rickshaw may be around equal, but the auto-rickshaw is already for decades on Indian roads and these will not disappear soon.

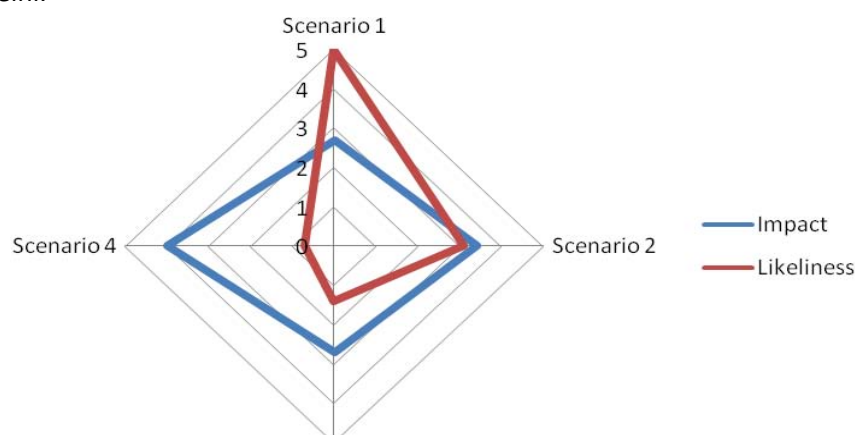
It can be stated that a mutual relation exists between the use of public, private and semi- public modes of transport. If public transport becomes more comfortable, the use of private and semi-public modes of transport might decline. And if the environmental conditions are positive for the use of private vehicles, public vehicles might not be used frequently. In table 13 are the characteristics of public, private and semi- public transport in Chandigarh shown. A distinction is made between the characteristics which are found in the literature and the characteristics which are found in the in-depth interviews with the experts.

**Table 13; Characteristics of public, private and semi- public transport in Chandigarh**

	Characteristics in literature	Characteristics in interviews
<b>Public transport</b>	<ul style="list-style-type: none"> <li>- Only buses</li> <li>- 18 percent of total transport</li> <li>- Hardly congestion</li> </ul>	<ul style="list-style-type: none"> <li>- Public buses more comfortable in future (e.g. AC buses)</li> <li>- Plans for metro-line</li> <li>- Petrol or diesel buses</li> <li>- Sealing buses to prevent speeding</li> </ul>
<b>Private transport</b>	<ul style="list-style-type: none"> <li>- Cars and motorcycles</li> <li>- 28 percent cars of total transport</li> <li>- High GDP &amp; No 1 HDI in India</li> <li>- Broad and extensive road network</li> </ul>	<ul style="list-style-type: none"> <li>- Nano car can become popular</li> <li>- Easy to purchase private vehicle</li> </ul>
<b>Semi- public</b>	<ul style="list-style-type: none"> <li>- Auto- rickshaws and taxi's</li> <li>- 3 percent auto-rickshaws of total transport</li> <li>- Lowest percentage auto-rickshaws of 30 major Indian cities</li> <li>- Recently shifting to LPG</li> </ul>	<ul style="list-style-type: none"> <li>- Auto-rickshaws more polluting than public buses</li> <li>- 60 percent of population travels by auto- rickshaw</li> <li>- Amount of trips will decline if public transport increases</li> <li>- By 2020 auto- rickshaws will still be 2<sup>nd</sup> used mode of transport</li> </ul>

### Scenario's

The four scenarios, mentioned in paragraph 5.1, are graded by the respondents in Chandigarh on likeliness and impact (figure 17). It is clear that scenario 1 is most likely to happen in Chandigarh. This scenario argues that the quality of public transport will improve, and that the middle class is not likely to rise, by 2020. The scenario which will have the biggest impact on the urban mobility system, as compared to the current urban mobility system, is scenario 4. Although scenario 4 is graded highest (4.0), scenarios 1, 2 and 3 are with the respective grades 2.7, 3.4 and 2.7 close after scenario 4, compared to the mutual differences of the grades on likeliness. The fourth scenario argues that the quality of the public transport will not improve and that the middle class is likely to rise, by 2020. Scenario 1, which is most likely to happen, and scenario 4, which will have to greatest impact on the urban mobility system will be elaborated in the next paragraph, merged with the grades given in Delhi.



**Figure 17; Scenario's on likeliness and impact situated in 'spider- web', in Chandigarh**

### 5.2.2 Delhi

Delhi has with its 13 million inhabitants an extended public transport system. Within the city can major differences be observed. Overall, the city of Old Delhi is crowded, congested, polluted and roads are narrow. In this part are especially the poorer people of Delhi located. Cycle- and auto-rickshaws are moving alongside buses, (motor-) cycles and non-motorized modes of transport. The newer, more modern, part of Delhi can be described as cleaner and the roads are broader. Here, most of the middle class is located, and private vehicles dominate the roads.

#### Quality public transport

According to Ms. Roychowdhury of the Centre of Science and Environment (CSE) in Delhi, was the percentage of total movements done by public transport around 60 percent, five years ago. In 2008, this percentage had dropped to 41 percent. The government of Delhi never improved the public transport in the past. It never looked at long term problems and investments, this is the reason why public transport is facing problems nowadays. The implementation of the metro line shows that the government is started to improve its public transport (figure 18). The metro line is introduced in 2005 and is still expanding. It is expected that by 2010 the whole of Delhi will be covered by metro. Only long distance commuters are likely to shift to metro. Professor Ramachandran argues that the main shift is going from bus to metro and not from private vehicles to metro, and so it is unlikely that the metro is relieving congestion.



Figure 18; Metro line Delhi

One other creation in public transport in Delhi, are bus lanes. To improve public transport, are besides the metro line, bus lanes introduced. Bus lanes are not designed in order to relieve congestion, but to cater the amount of buses on the roads in Delhi. Before, buses got stuck in traffic jams and people were not triggered to take the bus. Now, buses go faster than regular traffic. Currently a debate is ongoing about these designated lanes. If a bus lane is introduced, there is one lane less for other vehicles and congestion increases. Normally, the more affluent people are car owners and are stuck in the traffic. These people are most influential and complain most about the bus lanes, as compared to the poorer people in the buses. Popli from Delhi Transport Corporation argues that on average 80 people move in one bus, and so they need priority on the roads. Besides

this priority bus lane, the quality of all buses is being improved. Delhi hosts the Commonwealth Games in 2010 and all older buses should be replaced by that time.

### **Private vehicles**

More affluent people do not use the metro, they will continue to move by private vehicle. In order to accomplish a shift to public transport, Sarkar, Ramachandran and Roychowdhury all argue that the government should not only improve the public transport, but should also discourage private transport. By raising higher taxes, parking prices and increasing interest rates for loans, the government can discourage car ownership in Delhi. According to Roychowdhury is the Tata Nano an example of how the government encourage private car ownership. This car is made artificial cheap due to low, or non existing taxes, the government is asking Tata for their factories. One other element which Ramachandran outlines in order to encourage car ownership, is that interest rates for loans at banks to buy a private vehicle are very low.

### **Quality of environment**

In order to reduce air pollution, all public transport is driving on CNG in Delhi since 2004. Delhi is located near a CNG pipeline and so the introduction of CNG in public transport was not as hard, as for example the introduction of LPG in Chandigarh will be. In the near future more cities in India will shift to CNG, since India found new gas. Ms. Roychowdhury mentions that the availability of gas will be doubled by 2012. CNG did improve the quality of air gradually, though the increasing amount of vehicles in the city might worsen the air quality in the near future.

### **Auto- rickshaws**

Every day 1000 new motorized vehicles are added to Delhi's urban mobility system, according to Roychowdhury. This amount is excluded auto- rickshaws. Since 1998 is the amount of auto- rickshaws frozen. In this way are the auto-rickshaws improved all the time, while older models are phasing out. Due to its frozen status, it is possible to adjust the current vehicles, but new ones cannot be introduced, unless the older vehicles disappear. This frozen status is under discussion. The need for auto- rickshaws is bigger than auto-rickshaws are available. In the future, by 2020, the status will probably be abolished. Professor Sarkar argues that the auto-rickshaw will have the purpose as a feeder in the future. This kind of transport will move people from house to the station and back.

Like in Chandigarh, exists in Delhi a mutual relation between public, private and semi-public transport. The government is giving public transport more attention and if the metro line in Delhi is going to be extended, it is likely that more people shift to this mode of transport. Though, it is possible that a shift between public modes of transport is going to occur. All modes of transport are related to one other. In table 14 are the characteristics of public, private and semi- public transport in Delhi shown. A distinction is made between information from literature and from interviews.

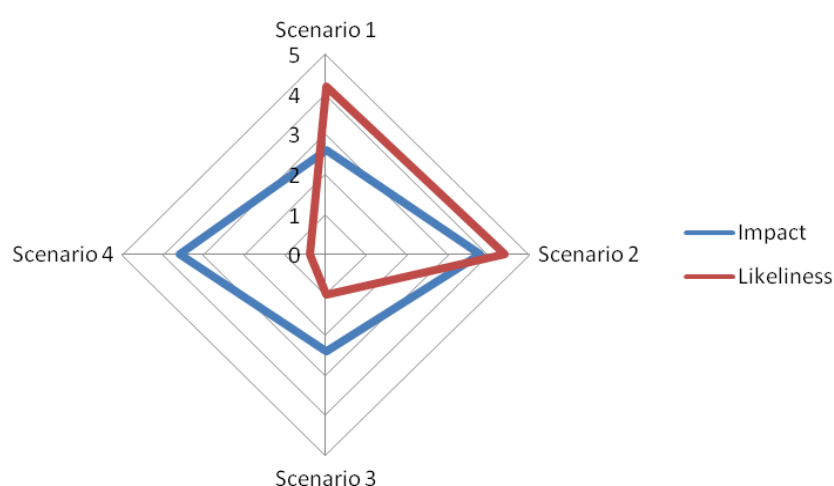


**Table 14; Characteristics of public, private and semi- public transport in Delhi.**

	Characteristics in literature	Characteristics in interviews
<b>Public transport</b>	<ul style="list-style-type: none"> <li>- Buses, metro &amp; intra- city trains</li> <li>- 43 percent of total transport (41% is bus)</li> <li>- Buses drive on CNG</li> <li>- Not functioning optimal</li> </ul>	<ul style="list-style-type: none"> <li>- Metro line is expanding</li> <li>- Main shift is bus to metro</li> <li>- Bus lanes are introduced</li> <li>- Government is shifting its attention to public transport</li> </ul>
<b>Private transport</b>	<ul style="list-style-type: none"> <li>- Cars and motorcycles</li> <li>- 14 percent cars of total transport</li> <li>- Highest congestion index of 30 major Indian cities</li> <li>- In New- Delhi relatively a lot of car owners, compared to old- Delhi</li> </ul>	<ul style="list-style-type: none"> <li>- Government should discourage private transport</li> <li>- Easy to purchase private vehicle</li> </ul>
<b>Semi- public transport</b>	<ul style="list-style-type: none"> <li>- Auto- rickshaws and taxi's</li> <li>- 6 percent auto- rickshaws of total transport</li> <li>- Auto- rickshaws drive on CNG</li> </ul>	<ul style="list-style-type: none"> <li>- Amount of auto- rickshaws is frozen</li> <li>- Auto-rickshaw will have purpose as a feeder in future</li> </ul>

### Scenario's

The four scenarios, mentioned in paragraph 5.1, are graded by the respondents in Delhi on likeliness and impact. As can be seen (figure 19), is scenario 2 most likely to happen in Delhi. This scenario argues that the quality of public transport will improve, and that the middle class is likely to rise, by 2020. This second scenario has got the highest grade with 4.4 out of 5. The difference with scenario 1 is only small with 0.2 points. The scenario which will have the biggest impact on the urban mobility system, compared to the current urban mobility system is scenario 2. Although scenario 2 is graded highest (3.8), scenarios 1,3 and 4 are with the respective grades 2.6, 2.4 and 3.6 close after scenario 2. It can be stated that in Delhi scenario 2 is most likely to happen and will have the biggest impact on the urban mobility system, by 2020.



**Figure 19; Scenario's on likeliness and impact situated in 'spider- web', in Delhi**



### 5.2.3 Questionnaire

The website of Arrivesafe attracts mainly visitors who are interested in road problems, and in specific road safety problems. Nevertheless, this website caters to a broad public and persons who are interested in mobility issues. It can be assumed that the 36 respondents completed the questionnaire voluntarily and with interest, only several respondents did not answer some questions and so these remained open. Auto-rickshaws and the future of these vehicles are for the greater part important in this research on urban mobility, as in comparison to other modes of transport. This is the reason that in this sub- paragraph mainly answers on questions regarding auto- rickshaws will be outlined.

#### General information of the respondents

The average age of the respondents is 33 and almost half of them (17) uses the motorcycle for daily use to go to work or school. The car is being used by 13 respondents and four persons use non-motorized forms of transport. Remarkable is that only one respondent uses public transport to go to work or school. This shows that the respondents of the questionnaire are mostly affluent people, this should be kept in mind when interpreting the answers. The overall opinion on public transport is that it is mainly a cheap way of transport and especially for the poorer people of society. The fact that buses are less polluting than cars is in the opinion of the respondents not an important issue.

#### Auto- rickshaws

Questions about the auto-rickshaw were answered in an almost unanimous way. The majority of respondents (62%) believe that the auto- rickshaw is used by most people because of its flexibility and its possibility for door- to- door transport. The issue of money is least important when looking at the results of the questionnaire. Only four respondents answered the option that taking an auto-rickshaw cheaper is than using a private car. Although pollution did not play a major issue when looking at the public transport, it does when questions on the future of the auto- rickshaw were answered. The future on the auto-rickshaw is positive. In ten years will the auto-rickshaw still be present, but in a less polluting way. Rickshaw vehicles are going to be improved and will become, for example, hybrid, electric or battery run. This is the opinion of 68 percent of the respondents. A small group (18%) shares the opinion that the majority of the auto-rickshaws will disappear in the next ten years, since public transport is going to be improved and a shift will be visible from auto-rickshaw to bus. A minor group of 15 percent believes that the scenario on the auto-rickshaw in the next ten years is not going to differ from the current situation.

#### Scenario's

The four scenarios (paragraph 5.1) which were asked to the respondents of the interviews in Chandigarh and Delhi were also asked in the questionnaire. Though, the respondents of the questionnaire could not grade the scenarios. They have only mentioned the scenarios which are, according to them, most likely and which will have the biggest impact on urban mobility system in 2002. Here fore, it is not possible to make a spider web from the results like in Chandigarh and Delhi with the interviews. A scheme is made (table 15) in order to make the results visible in a glance. It can be seen in the scheme below that scenario two is most likely to happen. This scenario will also have the biggest impact on the urban mobility system in 2020. It can be stated that almost all respondents share the opinion that public transport will be improved by 2020. Only two respondents

believe that public transport will not improve in the coming years. It is remarkable that the same amount of respondents choose for scenario one and scenario two when answering the question which scenario will have the biggest impact on the urban mobility system in 2020. The underlying reason for this can be that the question about the biggest impact was hard to imagine for the respondents, and hard to answer. It can be seen that two respondents did not answer this question at all, although they gave answer on the question about likeliness.

**Table 15; Results of scenario's on likeliness and impact generated from the questionnaire**

	Most likely	Biggest impact
<b>Scenario 1</b>	14	14
<b>Scenario 2</b>	19	19
<b>Scenario 3</b>	2	0
<b>Scenario 4</b>	0	0

### Comparison

In comparison with the respondents of the interviews, the respondents of the questionnaire are more in the assumption that the middle class will rise and that the gap between poor and rich will decline in the future. The majority of all respondents share the opinion that public transport will be improved by 2020. The opinions regarding the likeliness of the scenarios are more equal amongst all respondents, compared to the answers on scenarios with the biggest impact. The respondents of the questionnaire look at scenario one and two with the biggest impact on the urban mobility system. In contrast with the respondents of the questionnaire, the persons who are interviewed believe on average that scenario four will have the biggest impact. Although scenario two was also graded high, just behind scenario four. The difference between the two groups of respondents can be explained by the level of expertise in the field of urban mobility. The respondents of the interviews are chosen because of their knowledge of mobility. The respondents of the questionnaire are random persons, of which can be assumed that not all will have knowledge of mobility on a higher level.

Presumably would the answers of the mobility questionnaire be different if the group of respondents would have been less affluent. In that matter would it be more likely that the money issue would be more significant and the importance of public transport would have risen.

### 5.3 Scenarios elaborated

The scenario which is most likely to happen and the scenario which will have the biggest impact on the urban mobility system, will be elaborated in this paragraph. In order to obtain a clear view of the scenarios in 2020, averages of grades in Delhi and Chandigarh will be used. By merging the grades of both cities, the range of respondents is bigger and a more complete view of the scenarios can be obtained. The respondents of the questionnaire have not graded the scenarios, and so these results

are not used in this paragraph. Though, in order to look at the scenarios in a broader way, their overall responses will be used as comparison with the responses of the interviewees.

### 5.3.1 Most likely scenario

Grades of Chandigarh and Delhi are merged in the table below. When looking at this table 16 it is clear that scenario 1 is most likely to happen in 2020. In the previous paragraph grades of Chandigarh and Delhi were separated. It was clear that scenario 1 was most likely to happen in Chandigarh. In Delhi on the other hand, was the difference between scenario 1 and 2 small, with only 0.2 point. Overall, scenario 1 scored highest and scenario 3 and 4 are not likely to happen according to respondents in both cities.

**Table 16; Scenario averages of Delhi and Chandigarh on likeliness**

	Averages
Scenario 1	4.6
Scenario 2	3.8
Scenario 3	1.2
Scenario 4	0.6

In the overview of all scenarios, which was shown to the respondents (paragraph 5.1) , is scenario 1 described as; ‘Quality of public transport is good. Innovative new transport forms are being introduced and buses are more comfortable than 10 years ago. A low middle class is being observed. A divide between poor and rich persist’.

### Quality public transport

As all four of the scenarios, scenario 1 consists out of two elements; the quality of public transport and the extent of the middle class. The respondents commonly agreed that the quality of public transport will improve in the next years. Currently, this stage has already started with the introduction of a metro line in Delhi and with air- conditioned buses in Chandigarh. In the future more improvements are going to be made, as is mentioned in the previous paragraph. It is likely that the composition of the urban transport system will change, if more improvements on the public transport are going to be realized. These improvements of the public transport could generate a shift from private to public transport. This shift is important to relieve congestion and emissions. Besides these aspects of the public transport improvements, is the accessibility to public transport also important.

### Poorer people of society

As is mentioned in chapter 3.1, the poorer people of Indian society have often no other means but to travel by cheap public transport or by non-motorized forms of transport (e.g bicycle, walking). Previously, fares have been kept low as a measure of social equity. This resulted in public transport systems which were unable to finance even their operating costs. Now, and in the future, the danger

of the improvements in the public transport is that poorer people might not be able to afford this kind of transport and will be forced to walk or cycle long distances. This danger can be overcome by implementing special discounts for people with an income below a certain level. If major amounts of people shift from one transport vehicle to another, certain transport modes might become less useful.

### **Middle class**

In general are Indian people in the assumption that public transport will be improved, though it will be hard to get people out of their cars and into the public transport in reality. Currently, a discussion is going on around the Tata Nano and that this car will influence the amount of cars on the Indian roads. As is stated in 4.3.2, the Nano is expected to boost the Indian car market by 65 percent. If the Indian middle class will rise, the amount of personal vehicles will rise too, the Tata Nano is one of the causes. The experts in the transport field gave scenario 1 on average a higher grade on likeliness than scenario 2. In scenario 1 is the gap between the poor and rich population big and scenario 2 shows a growing middle class. So, the opinion of the expert is in contradiction with developments for the future which are shown in chapter 4. In case the Indian middle class is not going to rise fast (like the experts argue) within the next 10 years, the Nano might not become a success at the end, but other vehicles might flourish on Indian roads.

### **Auto- rickshaw**

If scenario 1 is going to become reality in 2020, it can be expected that the auto- rickshaw will still be seen on Indian roads, but in fewer amounts. People use the auto- rickshaw primarily for short distances and from door-to-door movements. Due to improved public transport with an extended transport network, door-to-door movements will become more possible by public transport. With shorter waiting times and more comfort, people will take more easily a bus, or other public vehicle, instead of an auto-rickshaw. The money issue is also important, since especially the lower middle class make use of the auto-rickshaw. Travelling by auto-rickshaw is more expensive, compared to the public transport. And although the majority of the respondents in Chandigarh and Delhi share the opinion that a low middle class will be observed by 2020, the respondents of the questionnaire argue that the gap between rich and poor will decline. If this latter is going to happen, the auto-rickshaw will still be used less frequently. The middle class is able to afford motorcycles and Nano cars; the need for auto-rickshaws will lessen. This is an assumption whereby the urbanization grade is not taken into account. It is possible that auto-rickshaws are still needed by 2020 as much as they are today. Due to urbanization the amount of citizens in the city will grow. Mostly poor rural people will move into the city, who cannot afford the auto-rickshaw. But when those people enter the city, other people will benefit from their entry. These people become more affluent and can use either auto-rickshaws or private vehicles.

Overall, it can be stated that it is likely that the auto-rickshaw will be used less frequently by 2020. This mode of transport, together with cycle-rickshaws, will be very useful as a feeder to mass transport systems. If scenario one is going to become reality, the public transport will improve. More people will shift from private and semi-public vehicles to public transport systems. The Tuktuk company can anticipate on this scenario by improving the remaining auto- rickshaws and by providing education to the rickshaw drivers. The drivers should learn that sustainable ways of transport are necessary on the longer term and that they will gain from the new forms of transport,

since it will be healthier and less fuel will be necessary. Partly, rickshaw drivers will become unemployed due to a smaller demand in transportation by rickshaw. These drivers can become the sustainability teachers of the future and can help with the construction of the new vehicles.

### 5.3.2 Biggest impact scenario

Grades of Chandigarh and Delhi are merged in table 17. The element of ‘biggest impact’ was hard for the respondents to grade. The grades reflect this difficulty, the mutual differences of grades are relatively small. An explanation for this difficulty can be that Indian people live from day-to-day; it is hard for them to compare a virtual future to the present. In table 17 is shown that the respondents argue that scenario 4 will have the biggest impact on the urban mobility system, compared to the current urban mobility system. Scenario 2 is graded behind scenario 4, with 0.2 point less.

**Table 17; Averages of scenarios in Delhi and Chandigarh on impact**

	Averages
Scenario 1	2.7
Scenario 2	3.6
Scenario 3	2.6
Scenario 4	3.8

In the overview of all scenarios, which was shown to the respondents (paragraph 5.1), is scenario 4 described as; ‘Poor quality of public transport. New innovative forms of transport are not (yet) being introduced. A high group of middle incomes exists. A divide between rich and poor is not being observed.’ This scenario is the opposite of scenario 1, which is elaborated in sub-paragraph 5.3.1. Scenario 4 argues that public transport will not be improved, and that the middle class will be risen by 2020. Scenario 2, which is graded only 0.2 point behind scenario 4, has the element of the ‘rising middle class’ in common with the fourth scenario. And so, it can be concluded that if the middle class will rise in the coming years, the impact on the urban mobility system will be considerable, according to the average grades of the experts in the field of transport in Delhi and Chandigarh.

### Middle class and quality of public transport

It will have a big impact on the urban mobility system if the gap between rich and poor in Indian society will diminish, or disappear, according to the experts in the field of transportation. In the year 2020 the society will have changed considerable regarding the gap between rich and poor, as compared to the current situation. By 2020 the middle class will have risen and not only the GDP will grow, but also the HDI will have reached western standards. Indian population on a lower level have increased their incomes and have profited of Indian participation in the global economy. Due to the rising middle class have cars amounts increased on Indian roads. As is stated in sub- paragraphs 5.2.3

and 5.3.1 are the respondents of the questionnaire in the assumption that this amount of cars will increase and that the middle class will rise.

Scenario 4 will have the biggest impact on the urban mobility system, according to the respondents in Delhi and Chandigarh. If this scenario will become reality in 2020, public transport will not be improved. The risen middle class, in combination with poor public transport will make the shift from public to private transport ongoing. People have few alternatives but to purchase a private vehicle. Since the middle class will rise, the auto- rickshaw might increase its popularity. Due to lacking improved public transport, people need other modes of transport to move from door-to-door. And now (2020), people who could not afford transport by auto- rickshaw before, are able to afford it since their income has increased.

The respondents of the questionnaire are in the assumption that scenario 2 will have the biggest impact on the current mobility system. This scenario was graded by the experts just behind the fourth scenario. If scenario 2 will become reality in 2020, public transport will be improved and the middle class will have risen. A lot of aspects of the mobility system and society will change. The more affluent (auto-)rickshaw drivers might charge higher fares for transportation. The middle class is able to buy motorcycles and (Nano) cars. And due to the improved public vehicles will more people make use of this kind of transport and less of the (auto-)rickshaws. Compared to the current Indian society and mobility system, scenario 2 will change more than scenario 4. Though, scenario 4 will have a bigger impact on the urban mobility system according to the experts. Scenario 4 makes the area of innovative auto-rickshaws very rewarding. Due to a greater demand will the amount of auto-rickshaws rise and can new models be introduced instantly. With a rise of vehicles are increasing amounts of drivers necessary. The Tuktuk company can anticipate on this by giving education to all future drivers. A possible idea would be a 'green' certificate. If the driver gets this specific 'green' certificate and starts driving in a 'green' vehicle, the rickshaw- driver might get a reward (subsidy) from the government. First the government should acknowledge to need of such a system.

## 5.4 Conclusion

Experts in the field of transportation are more pessimistic towards the future, compared to respondents of the questionnaire. Overall, the respondents of the questionnaire believe that the middle class will rise in the coming years. The experts, on the contrary, are in the assumption that the gap between rich and poor will have increased by 2020. Though, both groups are optimistic about the improvements of public transport. It is likely that public transport will be improved by 2020. Improvements are already visible in Chandigarh and Delhi, air- conditioned buses in Chandigarh and a metro-line and bus lanes are in operation and will be expanded in the future. Currently a shift from public to private vehicles is going on. It can be expected that due to the public transport improvements an opposite shift might become reality; more people will shift from private and semi-public vehicles to public transport. The auto-rickshaw is a semi-public vehicle and will be used less frequently by 2020. Whether the middle class will rise or not, this mode of transport will be (partly) replaced by other vehicles (Nano car, public transport, motorcycles). The auto-rickshaw might be very useful as a 'feeder' to mass transport systems as metro lines and bus stations. The Tuktuk company can anticipate in different ways on the situation. In the next assessing phase of the research, strategies of how to anticipate will be outlined.

## 6. Conclusion

India can be described as a developing country in transition. Due to its open boundaries and young educated workforce is the participation in the global economy considerable. As a consequence are GDP and HDI increasing, and are urban mobility systems changing. Different methods of qualitative research are used in this research in order to obtain a clear and complete view of urban mobility systems in India. Each method is used for different purposes and all different aspects are combined to generate an answer on the main question: 'How can be anticipated on urban mobility scenarios in 2020 in India?'. The developments and trends showed that by 2020 the Indian population has grown and that population pressure on cities will have increased. As a result, the Indian government is focusing on improvements on the roads. The shift from public to private vehicles has to stop and an opposite shift has to take place in the near future. If this latter shift is not going to become reality, pollution will increase and roads will become more congested. Both will affect the Indian economy, which might put a damper on further growth.

The environmental scanning method provided six ways to respond to changes in the urban mobility system. By using these strategies, the Tuktuk company can anticipate on developments in the urban mobility system in 2020 in India. Out of the six strategies, three are most suitable to be adopted by the Tuktuk company in order to create an advantageous situation in the year 2020. These three strategies are the 'adaption strategy', the 'offensive strategy' and the 'contingency strategy'. A combination of these strategies show how the Tuktuk company can anticipate on the urban mobility system in 2020. These three strategies include the context of a changing environment and recommend to respond to this changing environment in an active way, without losing the aim of the project. By finding substitutes, adapting the marketing plan and by turning new influences into an advantage, a competitive advantage can be created. By adopting these strategies, the aim of implementing an environmental friendly auto rickshaw, will still be feasible.

Other strategies for a company to respond to environmental changes, according to the environmental scanning method, are the 'opposition strategy', the 'redeployment strategy' and the 'passive strategy'. These strategies are not recommendable to the Tuktuk company. The opposition strategy is aiming at influencing environmental forces. This is only successful when the company can control the environmental variable, it is not likely that the Tuktuk company can influence the environment and thus is this strategy not recommendable. Within the redeployment strategy the company needs to redeploy its assets into another industry. If the Tuktuk company is going to realize this, its aim of creating an environmental friendly auto-rickshaw is going to disappear and the company has to change and will not function as a company for auto-rickshaws anymore. As a third strategy is the passive strategy not recommended to the Tuktuk company. This strategy aims at giving no response to the environmental conditions. When the environmental conditions are not taken into account with a marketing plan for the future, the context of different environmental forces is lost and it will be hard to sustain for a company.

The three most suitable strategies are elaborated for the Tuktuk company below.



### **The adaption strategy**

Within this strategy the Tuktuk company should adapt its marketing plan to the new environmental conditions. Currently the Tuktuk company is still in the starting up phase, and so it is likely that within its present marketing plan future developments, from 2009-2020, are taken into account. As is stated in the report, India is importing the majority of its oil. The import of oil in combination with a rising population and a growing amount of private car owners, makes it plausible to focus the attention on vehicles which do not need oil for propulsion. Innovations and developments in the field of sustainable transport are gaining importance in the coming years. It can be expected that by 2020 new innovative transport models are designed, for example electric vehicles with longer endurance.

### **Offensive strategy**

The offensive strategy argues that the company should try to turn the new influences into an advantage, because quick response can give the company a competitive advantage. Within Indian cities it is already visible that the government is shifting its attention to public transport. In major Indian cities rapid mass transport systems will be introduced in the coming years. As is seen in chapter 5 scenario 1 is most likely to occur and will public transport be improved. More people will use public transport. Resulting in a decline of the current auto- rickshaw transportation position. Due to the mass transport systems (e.g metro lines), travel distances by auto- rickshaw will become shorter and will be used less frequently. These new influences of the public transport will change the status of the auto-rickshaw. Instead of being used for movements which cannot be done by public transport, now movements as a feeder to this improved public transport will become frequent. The auto- rickshaw will become more useful for shorter distances and the vehicles do not need big engines anymore. If improvements for better electric batteries are not yet implemented by 2020, a smaller electric battery might be sufficient for these shorter distances. If the Tuktuk company already starts to focus on for example electric vehicles, it will have an advantage above the older LPG/CNG vehicles which are currently being introduced.

### **Contingency strategy**

This strategy argues that the company should determine a broad range of possible reactions. This strategy is correct in saying that one should have substitutes in case mobility systems might change drastically by 2020. This might be the case with unforeseen developments. The Tuktuk company should stick to the sustainable improvements of auto-rickshaws, but before it is able to penetrate a large market share with its systems and/or vehicles, changes in the current infrastructure should be generated. The current auto-rickshaws are already on the Indian roads for a long time and will not change overnight. Education has to be given to the auto-rickshaw drivers regarding sustainable ways of transport. It can be expected that the drivers might only be interested in their own financial situation and so should it be clear that they can profit on the longer term, if they buy a conversion kit or if they rebuild their rickshaw in a sustainable way. Education is especially important if scenario 4 will become reality. The transportation experts argue that this scenario will have the biggest impact on the urban mobility system. Scenario 4 forecasts that public transport is not going to be improved



and that the middle class will rise. In this case, the auto- rickshaw will be used more frequently and more rickshaw drivers have to be educated, as is stated in sub- paragraph 5.3.2.

The above mentioned strategies are most suitable for the Tuktuk company to be adopted, in order to sustain in a profitable and sustainable future. The total context of environmental conditions and developments in multiple domains needs to be taken into account for the future of the company. It is recommendable that the Tuktuk company should focus its attention on auto- rickshaws which drive shorter distances in the future, mainly due to quality improvements of public transport. Furthermore it is necessary to provide education for the rickshaw drivers, in order to gain manpower behind the idea of sustainable auto- rickshaws. Without the rickshaw drivers it is impossible to implement an affordable upgrade system. Subsequently is further development of the Indian infrastructure necessary in order to introduce new innovative forms of transport on the Indian roads.

## 7. Recommendations for further research

Recommendations for further research can be made. This can be done, since not all aspects of urban mobility systems are taken into account within this research. Without information of all aspects of the context, important information which might influence the Tuktuk company, can be overlooked. Four recommendations for further research can be found below.

- In this research are the scenarios made with only two elements; quality of public transport and the rise of the middle class. It can be recommended that in further research on scenarios, different elements need to be included in order to reach more in- depth knowledge.
- Culture plays in India an important part of daily life. Within this research this aspect is not taken into account; on a macro level culture does not play a major role. Though, the role of culture in mobility systems on a micro level is an important issue. Female passengers are often harassed in (auto-) rickshaws and public transport, this can be one of the reason to purchase a private vehicle. The Nano car might become popular partly due to this situation. The influence of culture on mobility systems needs to be elaborated in further research.
- Within this research were Chandigarh and Delhi two case studies. India is a very big country and in every city is the situation regarding transport different. And so before implementing systems in a city it is necessary to do research on the role of the auto-rickshaw and other transport vehicles in that specific city.
- Sustainable auto- rickshaws are being developed by multiple organizations and companies. An example is Bluebird, a company which develops battery and motor hybrid systems to enhance the range of conventional electric vehicles. This company designed already an electric auto- rickshaw and the solar- electric version is under development. This company is aiming specifically on the western market. Cooperation between the Tuktuk company and companies like Bluebird is recommended in order to share knowledge.

These recommendations appear to be most important for the current urban mobility situation. It is possible that more recommendations for further research can be formulated in the future or when the goal of the Tuktuk project changes.

## CRITICAL REFLECTION

While conducting the research there were several shortcomings and limitations. Culture differences and language have played an important part of the difficulties. Furthermore, it has become clear that my personal expectation of the knowledge of the Indian experts was too high. At the end of this report it is possible to reflect in a critical way on the process.

### Multi level

In the beginning the perfect scenario of how to conduct the research was made. The aim was to give a multileveled sketch of the urban mobility systems with opinions of Indians from different levels of society. It appeared to be difficult to include interviews with people from a lower level of society, due to a cultural barrier and consistency of the research. With the help of an interpreter basic questions could have been asked to the rickshaw drivers. Though, harder questions about the future and with the grading system were going to be hard. People in India live from day-to-day, especially the lower people of society. A combination of the culture and consistency, made me stick to interview experts in the field of transportation and not with the lower levels of society. These experts could not only provide me with information about the current urban mobility system, but could also give insight in the future. By grading the different scenarios a liaison between the interviews was accomplished.

### Scenarios

The making of the scenarios was one other difficulty. Before going to India, four scenarios were made. These four scenarios included too much variables. This resulted in complex scenarios, which the respondents did not understand. Furthermore, these initial scenarios were too long, and could not be graded in one single interview. This had been the reason to change them in including only two elements (quality public transport and rising middle class). These latter were easier to understand and to grade for the respondents. The impact on the urban mobility system was still hard to grade. During the interviews an explanation was multiple times given about the interpretation of impact on the urban mobility system, as compared to the current system. Here fore, the grades on this aspect should be interpret in a general way and one should not stick to the grades given.

### Respondents

During the period in India, it appeared that a shortcoming was the small amount of respondents. In order to give a clear and more genuine scenario, a questionnaire with more respondents is included in the research. It could be concluded from the answers on the questionnaire that the respondents of the questionnaire had generally an affluent background. Thus, a limitation is that respondents of the interviews and respondents of the questionnaire both had the same background. Lower levels of society are not included in the research.

## Factors

The creation of future scenarios is very complex. A broad range of factors play a role in developments and changes. Due to the time frame of the research only several developments are included within this report. More developments, as for example social and political, are also important to consider when making scenarios. The factors which are elaborated in the research, still have their limitations. Not every aspect of all factors are discussed here. The scope of the research has to be marked out.

The above mentioned shortcoming and limitations, made it necessary to change initial ideas and actions. Although these changes were made, the ultimate goal of giving an answer on the main question was accomplished and recommendations to the Tuktuk company are given in the conclusion.

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## APPENDIX 1

### Grades of the respondents in Chandigarh

	Ravinder Pathak (CTU)		Rupinder Singh (Arrivesafe)		Umesh Sharma (PEC)		Harman Singh (Arrivesafe)		Vandana Disodia (CSTA)		Navdeep		Kaduna Sharma (CCE&T)		<u>Averages</u>	
	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<u>Imp</u>	<u>Lik..</u>
<b>Scenario 1</b>	3	5	4	5	2	5	2	5	4	5	2	5	2	5	<u>2.7</u>	<u>5.0</u>
<b>Scenario 2</b>	3	4	5	3	3	3	3	3	5	4	3	3	2	2	<u>3.4</u>	<u>3.1</u>
<b>Scenario 3</b>	4	1	1	1	2	2	2	1	3	0	4	1	3	4	<u>2.7</u>	<u>1.4</u>
<b>Scenario 4</b>	5	2	2	1	5	0	4	1	3	0	5	1	4	0	<u>4.0</u>	<u>0.7</u>

CTU= Chandigarh Transport Undertaking

Arrivesafe= NGO occupied with safety on Indian roads

PEC= Punjab Engineering College

CSTA= Chandigarh State Transport Authority

CCE&T=Chandigarh College of Engineering and Technology

### Grades of the respondents in Delhi

	Hariharan Ramachandran (Delhi University)		S.K. Sarkar (IUT) & (SP&A)		Anumita Roychowdhury (CSE)		Renu Popli (DTC)		Muktesh Chander (Delhi Traffic Police)		<u>Averages</u>	
	<i>Impact</i>	<i>Likelines</i>	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<i>Impact</i>	<i>Likeliness</i>	<u>Impact</u>	<u>Likeliness</u>
<b>Scenario 1</b>	2	4	3	5	3	4	2	3	3	5	<u>2.6</u>	<u>4.2</u>
<b>Scenario 2</b>	4	5	4	3	4	5	3	5	4	4	<u>3.8</u>	<u>4.4</u>
<b>Scenario 3</b>	2	1	1	0	2	0	4	1	3	3	<u>2.4</u>	<u>1.0</u>
<b>Scenario 4</b>	3	1	2	0	4	0	5	0	4	1	<u>3.6</u>	<u>0.4</u>

IUT= Institute of Urban Transport

SP&A= School of Planning and Architecture

CSE= Centre for Science and Environment

DTC= Delhi Transport Undertaking



## APPENDIX 2

### Questionnaire about urban mobility on the website of Arrivesafe!!

1. Are you an inhabitant of;
  - a. Chandigarh
  - b. Mohali
  - c. Panchkula
  - d. Other
2. What mode of transport do you normally use to go to work/school?
  - a. Bicycle or other non-motorized transport (e.g. cycle rickshaw/walking)
  - b. Motor bicycle
  - c. Car
  - d. Auto-rickshaw
  - e. Public transport
3. What is your overall opinion about public transport?
  - a. It is a cheap way of transport
  - b. It is only for the poor
  - c. Buses are dangerous and overspeed often
  - d. Buses are in poor condition
  - e. Buses are less polluting than private cars
  - f. Other;
4. Do you think public transport will be improved in the next 10 years?
  - a. Yes, definitely.
  - b. Maybe, if depends on the priorities of politicians and other influential people
  - c. No, it will stay the way it is
5. According to your vision, why do most people use the auto-rickshaw?
  - a. Because public transport is badly maintained and overcrowded
  - b. Because auto-rickshaws are flexible and can bring you from door to door
  - c. Because taking an auto- rickshaw is cheaper than a private car
  - d. Other;
6. What is in your opinion the future (next 10 years) of the auto- rickshaws in Indian cities?
  - a. The majority of auto-rickshaws will disappear, since public transport is going to be improved. A shift from auto-rickshaw to bus will be visible.
  - b. Auto-rickshaws will still be present, but in a less polluting way. Vehicles are going to be hybrid, electric or battery run.
  - c. The auto-rickshaw scenario will be same as the current scenario.
  - d. Other;

7. In India there is a shift going from public to private transport, what is the underlying reason?
  - a. Owning a private car is a status symbol
  - b. More people are able to afford a private car
  - c. Public transport is inconvenient and is not running on time
  - d. Other;
8. You are most safe on the road, by using;
  - a. A public bus
  - b. A two-wheeler
  - c. A three-wheeler
  - d. A private car
9. Which of the following scenarios is most likely to happen by 2020?
  - a. Quality of public transport will be improved. The gap between poor and rich people of society will persist; a small middle income class is visible.
  - b. Quality of public transport will be improved. The gap between poor and rich people of society will become smaller; a greater middle income class is visible.
  - c. Quality of public transport is poor. The gap between poor and rich people of society will persist; a small middle income class is visible.
  - d. Quality of public transport is poor. The gap between poor and rich people of society will become smaller; a greater middle income class is visible.
10. Which of the, in question 9 mentioned, scenarios will have the biggest impact on urban mobility systems by 2020?
  - a. Quality of public transport will be improved. The gap between poor and rich people of society will persist; a small middle income class is visible.
  - b. Quality of public transport will be improved. The gap between poor and rich people of society will become smaller; a greater middle income class is visible.
  - c. Quality of public transport is poor. The gap between poor and rich people of society will persist; a small middle income class is visible.
  - d. Quality of public transport is poor. The gap between poor and rich people of society will become smaller; a greater middle income class is visible.

**THANK YOU FOR ANSWERING THE QUESTIONS!!!**