Cycling in the Stellenbosch area

Improving the traffic situation and stimulating the use of non motorized transport

Internship at the University of Cape Town

Supervisors:

Dr. Ir. M.J.W.A. Vanderschuren (University of Cape Town, UCT)

Prof. Dr. Ir. M.F.A.M van Maarseveen (University of Twente, UT)

By:

J.N. (Hans) de Jong

Date:

11/24/2008

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

University of Twente

Enschede - The Netherlands

Preface

You have in front of you the report of my Bachelor project completed at the University of Cape Town (UCT), South-Africa. For 4,5 months I have been working at the Centre for Transport Studies, at the department of Civil Engineering. It was a great pleasure for me to work in a culture and environment that has been totally new to me. It did not only contribute to my knowledge of civil engineering, but it also helped me to develop myself socially and culturally. That's why I want to thank the people that helped me to settle down in Cape Town and at the university. Special thanks go out to Marianne Vanderschuren (UCT) and Martin van Maarseveen (Universiteit Twente, UT) for their assistance during the execution of the project.

Hans de Jong

Cape Town (South Africa), 2008

Summary

A growing economy always goes hand in hand with a growing demand for transport. Because most of the time this demand is met by motorised modes, it causes problems related to congestion, pollution and safety. A possible solution to these problems is to encourage and improve the use of non motorised transport (NMT). That this is applicable worldwide, is demonstrated by the Bicycle Empowerment Network (BEN) that operates in countries like India, Brazil and South Africa to promote cycling. The cooperation between BEN, the University of Twente and the University of Cape Town is the reason for this research. The focus of this research was on Stellenbosch, a city in South Africa. Stellenbosch was compared to Houten (in the Netherlands), where the city structure is designed in such a way that the cyclists are the "kings of the road". The main objective of the research was to examine the potential for NMT in Stellenbosch.

An analysis was executed to show the characteristics of Stellenbosch as well as of Houten. The most important advantage that Stellenbosch has is the grid-structure of the road network, which makes the city accessible for cyclists. However, at the moment this causes problems with through (motorised) traffic and parked cars. This is where the main characteristic of Houten becomes useful: a network where the cyclists have absolute priority and where the car driver is guest. Some roads are even closed for motorised transport (MT). The main differences between the two cities are the difference in age distribution and unemployment rates. A city with more young (< 30), unemployed people do require a different approach (because of less knowledge, less responsibility).

To see how the actual traffic situation is in Stellenbosch, it is necessary to model the traffic flows (not done in this research). A requirement to make this possible is the availability of an origin/destination-matrix (OD-matrix). This has been created for the internal and external traffic flows into Stellenbosch. However, it turned out that with the available data it was not possible to create a sufficient valid one. It is needed to obtain more specific information to describe the different zones and to obtain a better distribution of the trips.

Despite the invalid OD-matrix, it was still possible to work on the potential for NMT. With assumptions made for the average speed of transport modes (e.g. 16km/h for cycling) and income (e.g. people with an income >6000 rand per month never change their car for a bicycle) it was possible to ascribe new modes to the all the trips. The main source for all the trips information was the National Household Travel Survey 2003 (NHTS). The following table shows the potential for NMT:

NMT	46.6%	**+ 19.2 %**	27.4%	**NMT**	**(Non Motorised Transport)**
MT	49.4%	**- 19.2 %**	68.6%	**MT**	**(Motorised Transport)**

It was shown that there is a potential for NMT, which could involve much improvement for Stellenbosch. It was also shown that sufficient facilities need to be created for cyclists. However, the traffic has to be modelled to see what the actual situation is and to see what improvements are needed. This modelling can only be done if the right data and information is available and if this is combined with the right method.

Table of Contents

List of Charts

List of Figures

List of Tables

1 Introduction

This chapter provides an introduction to the research project focussing on cycling potential in Stellenbosch. Points of importance during the execution of the project are mentioned. First, some background to the project is provided. Furthermore, the aim, methodology, scope and limitations are summarised. The introduction ends with an overview of the report that follows.

1.1 Opportunities for Cycling

Cycling has a good potential in contributing to urban mobility and the quality of urban space. Bicycle ownership will improve the accessibility of destinations for those who previously could be considered to be captive to walking (and informal public transport). It is important, however, to acquire knowledge about how people are using their bicycles within the context of their activity schedules and household livelihood strategies (trip purposes, trip length, travel modes and routes, timing, etc.) after the distribution process. How do revealed behavioural changes relate to the local potential for cycling demand? An objective is also to assess the impacts on employment (self employed and other), household income, time and money budgets, internal household interaction, access to health, employment, and education, and participation in other activities.

1.2 Bicycle Partnership Program (BPP)

I-CE, a Dutch foundation, that operates in developing countries focussing on the development of these emerging countries through specific bicycle promotion programs. The BPP aims to promote cycling, based on cycle-inclusive planning, which can make a significant contribution to fighting poverty, improving urban mass mobility at low cost, traffic safety in a sustainable environment and more generally, the quality of life.

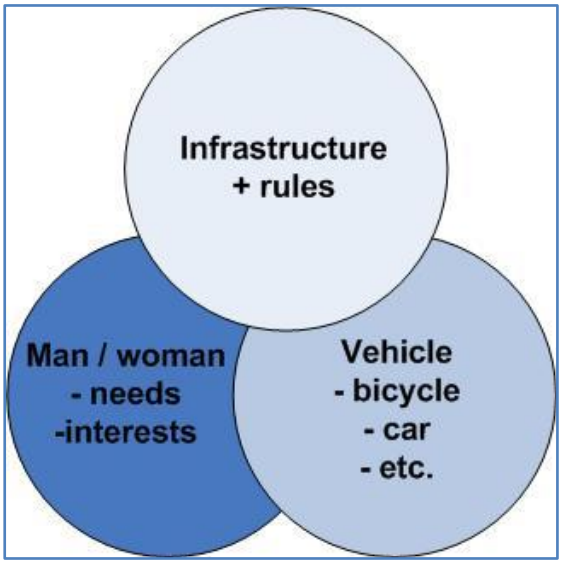


Figure 1; interaction person and vehicle and

BPP, therefore, assists local authorities, civil society organizations (CSO's) and other partners increasing or improving a local process making it possible to use a bike as a means of transportation.

As long as the significance of cycling in the fight against poverty, the improvement of safety, the environment and the quality of life is denied or ignored and as long as local partners do not have the necessary means and know-how to develop and implement policies themselves, development cooperation to help obtain direct results for improving the living conditions for the urban poor makes sense. In order to be efficient and significant, cycling has to be taken into account in many public and private policies, strategies and sectors of activity as a transport mode in its own right. For a city, this means for example that planning and design have to include cycling in all fields, whereas the industry has to market bicycles that correspond to the technical and financial capabilities of the cyclists. An integrated approach to the overall traffic and transport system is needed: it is not only the person as a citizen and traffic participant with his or her own needs and interests, his or her vehicle (the bicycle) and the road or

infrastructure and its rules and operation, but it is the interaction between these three points. There is interaction between the person and vehicle, vehicle and rules, rules and person and between all the three. This is outlined in figure 1 *(I-CE, www.cycling.nl)*.

1.3 Cycling Academia Network (CAN)

The Cycling Academia Network, part of the Bicycle Partnership Program, was established to carry out research on themes that relate to cycling-inclusive city and transport planning with a focus on cities in Africa, Asia and Latin America. The research aims to contribute to development goals regarding poverty alleviation, emission reduction strategies, sustainable spatial planning and design. Researchers and students from all continents come together to exchange experiences and information on a regular basis. The interaction between students from different institutions provides the opportunity to do international comparison studies.

Transport is the motor of the economy, but it comes at a price. According to the International Road Federation (2006), South Africa has the highest number of road fatalities per 100 000 inhabitants in the world. Anybody who travels during peak hour knows about congestion and emissions contribute towards brown haze and global warming.

In the developing world the positive effects (of economic activity) are NOT equally distributed. A large part of the South African society is marginalised due to racially motivated land use planning that occurred during the apartheid era, putting them on the periphery of the cities far from economic activities. Those who have work have to devote large portions of their income to travel. The unemployed are trapped in the townships.

The CAN network has identified eight interlinked themes that should be researched:

1. Identification of cycling demand needs, behaviour and potential
2. Impact assessment of travel demand management related to cycling
3. Contribution of cycling to poverty alleviation and social inclusion
4. The interaction between urban form, transport networks and cycling
5. Establishing a pro-cycling argumentation related to environmental and safety factors
6. Cycling-inclusive planning methods and processes
7. Design of cycling facilities (NMT-PT interface, intersections)
8. Vision for the city

(Vanderschuren, 2005)

1.4 The University of Cape Town and the University of Twente

The transfer of expertise is supported by an international knowledge network set up by the University of Twente and the International Institute for Geo-Information Science and Earth Observation (ITC) in the Netherlands, together with three partners in developing countries: the University of Cape Town (UCT) in South Africa, the Indian Institute of Technology Delhi (IIT-Delhi) in India and the Universidade Federal do Rio Grande do Sul in Brazil.

Based upon this collaboration, it is possible for students from each country to carry out research in one of the other countries and experience a new country and culture. The affiliations contribute to a good working environment and provide proper guidance. The opportunities offered through

exchange and comparison (cooperating in a worldwide project, the good guidance and the chance to gain international experience etc.) are the main reasons to start this research project.

1.5 Research project

This research project focuses on the South-African city of Stellenbosch and the potential promotion of traffic modes such as walking and cycling. A city where the use of NMT (together with an excellent spatial structure) is applied perfectly is the Dutch city Houten. Because of the good effects on safety and satisfaction in the city (much better than in other comparable cities) caused by the spatial structure and the local policy, the example of Houten is being used worldwide. It is plausible that the example of Houten will be a good way to improve the city of Stellenbosch. Certain characteristics of the spatial structure and the local policy will be applicable and could probably improve the situation.

To lead the research and to realize the improvement of the (traffic) situation in Stellenbosch, a vision is needed. Due to a lack of a communicated vision on the use of NMT in Stellenbosch, it was decided to adopt the Cape Town vision. It is assumed that the underlying thoughts are comparable, so that it is reliable to "copy" the vision. The vision statement (with corresponding objectives) runs as follows *(City of Cape Town, 2005)*:

"The city will be a place where all people feel safe and secure to walk and cycle, NMT is part of the transport system, public space is shared between all users (NMT, special needs people and motorized users) and everyone has access to urban opportunities and mobility."

An important goal in realising this vision, as set out by the City, is to:

"Increase cycling and encourage walking by creating a safe and pleasant bicycle and pedestrian network of paths to serve all the citizens in the municipality area."

The primary objectives of this goal are as follows:

- Increase cycling and enable walking as modes of travel,
- Create safe pedestrian and cycling environments,
- Develop a quality, attractive and dignified environment, and
- Promote a changed culture that accepts the use of cycling and walking as acceptable means to move around in the city and elicit more responsible NMT behaviour.

Further secondary objectives of the policy that could be achieved though the successful implementation of the policy, are:

- Integrated land use development appropriately suited for non-motorized transport,
- The social and economic empowerment that non-motorized transport can affect through improved low-cost mobility, and
- The development of a safer streetscape that allows non-motorized transport users their fair share of the available public space in the mobility network environment.

The vision statement and corresponding objectives for the city as a whole are logically not fully applicable on the research project because the scope of the research is much smaller. It is more of a steppingstone, to give some handles for the execution of the project.

To create a more targeted research and to keep in line with the vision statement, the research question is the following:

How can the principles of the spatial structure (and the local policy) of Houten (Netherlands) be used in Stellenbosch, in such a way that a move towards non-motorised transport is encouraged without the increasing the number of accidents in the municipality?

A number of sub-questions are formulated to further detail the research focus:

1. How can the traffic situation in Stellenbosch be assessed?
2. What data and information is needed to assess the traffic situation?
3. How is the current traffic situation in Stellenbosch?
4. What are the unique characteristics of Stellenbosch and Houten (that create the excellent spatial structure)?
5. What are the differences and advantages of both cities?
6. Which characteristics and/or measures of Houten should be implemented in Stellenbosch?

1.6 Research methodology

What the research questions already indicate is that traffic in the city of Stellenbosch will be analysed (and modelled). Much information is needed to create a good model: e.g. road networks, traffic counts, information about the local municipality. Moreover experience regarding the creation of e.g. OD-matrices is required. Much of this information is not difficult to obtain, but specific information should be extracted from e.g. household surveys. Information about the structure of Stellenbosch and Houten could be asked for by the local municipalities. Once both cities are mapped, they will be compared to each other and the possible improvements for Stellenbosch will be discussed.

The objectives of modelling the traffic flows from and to Stellenbosch are to see:

- What the current situation is regarding congestion and traffic flows,
- Where the bottlenecks are located,
- If either the current situation improves after implementing measures or
- The bottlenecks are shifted to other locations.

The different steps taken point by point:

- Literature review (on NMT related issues)
- Collect data and information about Stellenbosch and Houten
- Analyse the municipality of Stellenbosch and Houten (road network and inhabitants)
- Compare both cities and look for possible measures
- Model the traffic flows from and to Stellenbosch
- Discuss assumptions and factors influencing NMT (non motorised transport)
- Calculate the potential for NMT
- Develop recommendations and conclusions for Stellenbosch

1.7 Shortcomings and restrictions

During the execution of this project certain challenges became visible at different levels. It was not possible to obtain all of the desired information, due to a dependence on external people. Another critical difficulty is the data used. Within the National Household Travel Survey (NHTS, 2003) Stellenbosch is seen as one single zone. This makes the data more aggregated than desired, which

jeopardises the quality of potential results. The same applies to the use of data from different sources at one time.

Also a lack of time has influenced the execution of this project. It was not possible to give every part the same attention, which means that some parts may need further research.

1.8 Structure of the report

The report starts with a short description of the background of the country and of Stellenbosch. Points that could be important during the execution of the project are summarised. Thereafter a best practice analysis is given for both Stellenbosch and Houten. Both cities are described in detail, with issues like the road network, the supply and demand of the traffic and the use of different traffic modes being discussed. The comparison of the cities makes it possible to see what the positive and negative properties of each city are. The comparison contains most of the information outlined in the previous chapter. To see how the traffic situation is now, an OD-matrix will be created for Stellenbosch. To make this possible, a zoning of Stellenbosch will be made. Once it is known how much traffic flows in and out Stellenbosch, the focus will shift to NMT. First some important factors that influence the use of NMT will be discussed followed by a calculation of the potential use of NMT in Stellenbosch. The report ends with the conclusions and recommendations where Stellenbosch and Houten, the OD-matrix and the potential of NMT are discussed.

2 Introduction to South Africa and Stellenbosch

Chapter two gives a brief introduction to the country of South Africa and the city of Stellenbosch. This is done because it is impossible to work properly on a project in another country without any knowledge of the history and backgrounds. It is possible that because of historical issues you have to approach certain aspects differently.

2.1 South Africa

The Republic of South Africa is a country located at the southern tip of Africa . It is bordered by the Atlantic and Indian ocean and Namibia, Botswana, Zimbabwe, Mozambique, Swaziland, and Lesotho, an independent enclave surrounded by South African territory. South Africa is a member of the Commonwealth of Nations. The economy is the largest in Africa and 24th largest in the world.

South Africa has experienced a different history to other African nations because of early immigration from Europe and the strategic importance of the Cape Sea Route. European immigration began shortly after the Dutch East India Company founded a station at what would become Cape Town, in 1652. The closure of the Suez Canal during the Six-Day War highlighted its significance to East-West trade. The country is relatively developed infrastructure made its mineral wealth available and important to Western interests, particularly throughout the late nineteenth century and, with international competition and rivalry, during the Cold War. South Africa is ethnically diverse, with the largest Indo-European, Indian, and racially mixed communities in Africa. Black South Africans, who speak eleven officially recognized languages, and many more dialects, account for nearly 80% of the population.

Racial strife between the white minority and the black majority has played a large part in South Africa's history and politics, culminating in apartheid, which was instituted in 1948 by the National Party (although segregation existed before that time). The laws that defined apartheid began to be repealed or abolished by the National Party in 1990, after a long and sometimes violent struggle, including economic sanctions from the international community.

Regular elections have been held for almost a century; but the majority of South Africans were disenfranchised until 1994.

South Africa is often called the "Rainbow Nation", a term coined by Archbishop Desmond Tutu and later adopted by then President Nelson Mandela. Mandela used the term "Rainbow Nation" as a metaphor to describe the country's newly developing multicultural diversity after the segregationist apartheid ideology. By 2007, the country had joined Belgium, the Netherlands, Canada, and Spain in legalizing same-sex marriage.

2.2 Stellenbosch

The town of Stellenbosch is located approximately 50km east of Cape Town, and falls within the boundaries of the Cape Wine lands District Municipality. The town hosts a large university including its residences and hostels, and is the centre of the wine and viticultural industry in the Western Cape. Stellenbosch is also an important tourist destination due to its historical significance and its central position along the Cape wine route.

The town's population varies from between 65 000 to 85 000 depending on the academic calendar. However, the population is increasing, which has led to increasing urban sprawl and a consequent increase in pressure on the existing transport infrastructure.

In addition, a steady increase in the number of low-income households and a growing resident student body, coupled with increasing congestion and growing tourist numbers has amplified the need for a comprehensive overview of the towns NMT infrastructure (UCT, January 2008).

2.2.1 History of Stellenbosch

Stellenbosch is the second oldest European settlement in the Western Cape Province after Cape Town, and is situated approximately 50 kilometres away along the banks of the Eerste Rivier. The town became known as the City of Oaks due to the large number of oak trees that were planted by the founder to grace the streets and homesteads. The town is home to the University of Stellenbosch. The Technopark is a modern corporate and research complex situated on the southern side of the town. Stellenbosch is said to be the heart of Afrikanerdom due to the large number of academics and students who have lived and studied there.

The town was founded in 1679 by the Governor of the Cape Colony, Simon van der Stel, who named it after himself. Stellenbosch means "(van der) Stel's forest". It is situated on the banks of the Eerste River ("First River"), so named as it was the first new river he reached and followed when Jan van Riebeeck sent him from Cape Town on an expedition over the Cape Flats to explore the territory towards what is now known as Stellenbosch. The town grew so quickly that it became an independent local authority in 1682 and the seat of a magistrate with jurisdiction in 1685.

The Dutch were skilled in hydraulic engineering and they devised a system of furrows to direct water from the Eerste River in the vicinity of Thibault Street through the town along van Riebeeck Street to Mill Street where a mill was erected. Early visitors commented on the oak trees and gardens.

Soon after the first settlers arrived, especially the French Huguenots, grapes were planted in the fertile valleys around Stellenbosch and soon it became the centre of the South African wine industry. The first school had been opened in 1683 but education in the town began in earnest in 1859 with the opening of a seminary for the Dutch Reformed Church and a gymnasium which known as *het Stellenbossche Gymnasium* was established in 1866. In 1874 some higher classes became Victoria College and then in 1918 University of Stellenbosch. The first men's hostel to be established in Stellenbosch was Wilgenhof. In 1909 an old boy of the school, Paul Roos, captain of the first team to be called the Springboks, was invited to become the sixth rector of the school. He remained rector till 1940. On his retirement the school's name was changed to Paul Roos Gymnasium.

Stellenbosch (municipality) has a population of around 118.000, not counting students. This estimate is based on formally housed residents. As such it is almost certainly understated, as the Stellenbosch region also includes a number of informal settlements. The population of Stellenbosch is primarily Afrikaans speaking, with large English and Xhosa speaking minorities. The black population mostly speaks Xhosa as their home language, with whites speaking Afrikaans or English, the coloured (mixed-race and Khoisan decent) is primarily Afrikaans speaking and are in the majority. In 1833 the population for the Stellenbosch District was 16137. This comprised 8555 slaves, 6066 'Whites', 1220 'Hottentots', and 296 'Free Blacks'. *(several internet resources)*

Figure 2; South Africa (Google Earth)

Figure 3; Stellenbosch (Google Earth)

3 Best practice analysis of Stellenbosch

Chapter three describes the city of Stellenbosch. It starts with an introduction of the city and its population, followed by a description of the road network and it's characteristics. The chapter continues with an overview of the supply and demand side of the traffic (supply = what the network offers, demand = what the road users ask). The chapter ends with a short description of the impact of various issues (e.g. pollution and congestion).

3.1 Introduction of Stellenbosch

This section will give a description of the city of Stellenbosch, the inhabitants of Stellenbosch and the (most) important businesses in the city. The description of the city will be founded on the data from the NHTS (executed in 2003, to map the traffic behaviour in South Africa) and the census (executed in 2001, to map the population in South Africa).

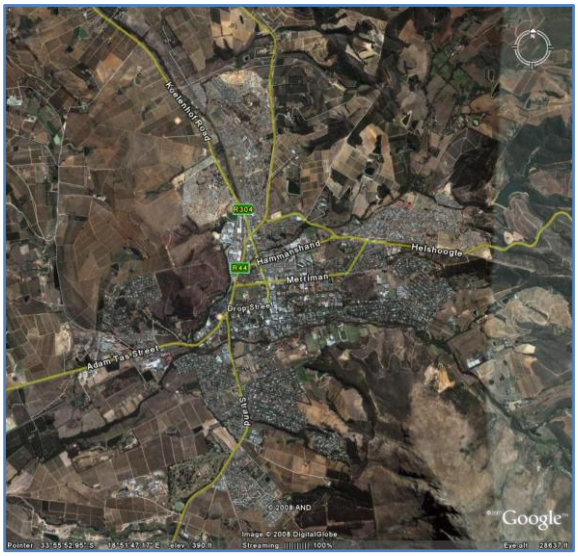


Figure 4; Stellenbosch (Google Earth)

The city of Stellenbosch is part of the municipality of Stellenbosch. The whole municipality has a population of almost 120.000 people. There are probably much more inhabitants, but they are not counted during the census. In the city of Stellenbosch there are almost 65 to 85 000 people (depending on the season). The data from the Census 2001 gives information for the whole municipality, and all the different wards that are arranged. The most important data is shown in the graphs on the next page (further data can be found in annex 1). The most important conclusions are that:

- Many languages are spoken
- Unemployment levels are high
- Most households have a low income
- Many people go to school

The data from the NHTS (that focuses on the city of Stellenbosch) gives comparable results. Therefore, the following conclusions can be made about the influence on the transport system:

- The different languages and origins influence the system, because the different people have different cultures (attitudes and beliefs). This influences the interaction between people.
- The great number of unemployed people has probably the most influence on the safety in the transport system. The unemployed people are on the streets with in most cases no destination or goal.
- Low incomes for most household's means that the available traffic modes are mostly limited to minibuses or walking. It also means that there will probably be a great potential for bicycles, because it is a cheap vehicle.
- That many people go to school means that many (young) children are on the road. This does not have a direct effect on the transport system, but it does require a safe city.

Another issue that could be of interest are the tourists that are in the city. The tourists are often unfamiliar with the city and can not find their destination, which causes “search traffic”. This has a great influence on the congestion and safety of the transport system.

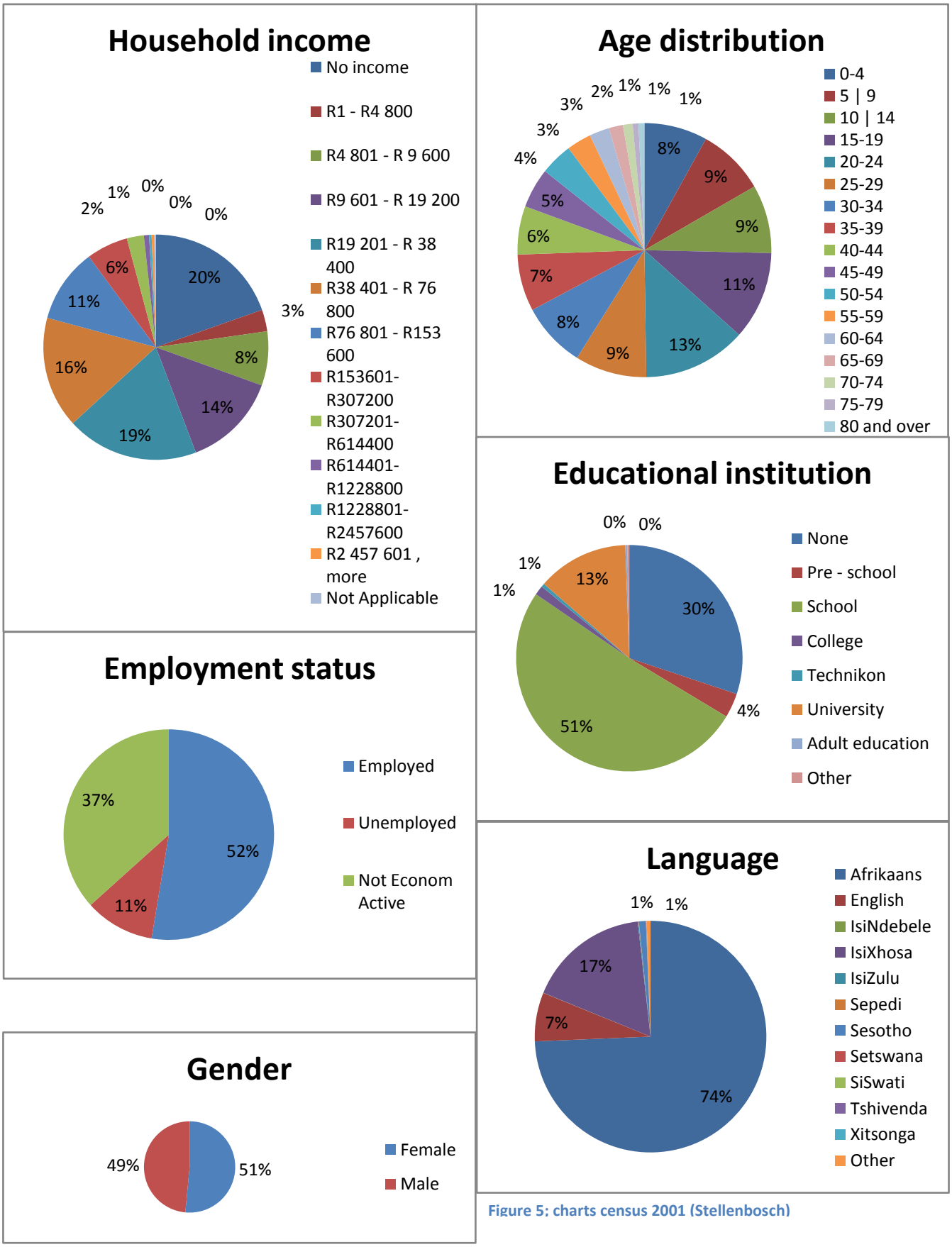


Figure 5: charts census 2001 (Stellenbosch)

3.2 The municipality of Stellenbosch

Stellenbosch is famous as an export quality wine producing area as well as a premier tourism and day-trip destination. The town's economic sector with the highest growth rates are tourism related services. The facilities and establishments include: 257 smaller accommodation establishments, over 143 up-market restaurants, 125 wine estates and several major golf estates. The Stellenbosch municipality offers some 3,000 beds in the town and surrounding countryside.

The Stellenbosch region, including the towns and rural surrounds of Franschhoek, Stellenbosch Town, Pniel and associate farm estates, is amongst the fastest growing medium sized town economies in South Africa averaging 7.5% real Gross Regional Product (GRP) growth per annum over the past years. However, within this context of overall growth, chronic poverty, unemployment and appalling living conditions are common.

The average income per capita is estimated at R1091, however this is highly skewed - for example in the Kayamandi township, only 12% of the population have an income in excess of R1,000 per month, and 40% live on less than R500 per month (South African Census 2001)**.** The total labour force is 39,000 of which 26,000 individuals are formally employed while 6,000 individuals work in the informal sector. However, unemployment is estimated to be between 40% and 60% in some parts of the area. The traditional agricultural sector (high quality fruit and wine) has experienced rapid growth since the mid 1990s due to the opening up of the export market. 41% of total land is currently under agricultural cultivation. The success of local viticulture has led to a steep rise in the number of vineyards (from 26 in 1994 to 104 in 2001). The diversification into tourism has given extra security in terms of additional income to these wine farms, which were visited by 1,672,000 visitors, mainly day-trippers, in 2001.

The fastest growing sectors (banking, trade, tourism) need skilled or semi-skilled labour rather than unskilled. However, unskilled labour is widely available and in need of employment. The informal sector is relatively underdeveloped and requires integration – currently the only possibility is a market in town. The main economic developments in Stellenbosch take place either along routes into the centre or in the southern and western suburbs. In the last few years many offices have left town centre locations to relocate to the suburbs.

In common with the majority of other South African settlements, Stellenbosch is deeply divided with great social disparities. The strongest population growth rates and increases in housing stock have in the past years occurred in the city centre and the northern part of Stellenbosch, in particular in the townships of Kayamandi, Ida's Valley and Cloetesville. In common with much unplanned development, the townships have rapidly extended outwardly rather than through in-fills. The overall majority of housing stock in Kayamandi consists of informal shacks, while overcrowding in Cloetesville and Ida's Valley have reached unacceptable levels. The contrasts are also extreme: whereas Kayamandi accommodates approximately 22,000 people within just over one square km, in many parts of Stellenbosch gross dwelling unit and household density remain relatively low at around 10 duandha (equivalent to 1000 dwelling units per square kilometre) (Stellenbosch Integrated Development Plan 2005).

Stellenbosch shows wide socio-economic disparities with particularly high levels of poverty and unemployment. Opportunities to take part in the informal sector in Stellenbosch are very limited. There is a general lack of social integration between the various groups, i.e. the large Xhosa population group lives predominantly in Kayamandi, while the coloured groups live in Jamestown, Cloetesville and Ida's Valley. Crime levels and social problems are particularly pronounced in Ida's Valley and Cloetesville and distinct settlement patterns have developed, i.e. the central and northern

parts of Stellenbosch are poor and overcrowded, while the South of Stellenbosch is rich *(Pro-Poor Tourism Pilots in Southern Africa, www.pptpilot.org.za)*

.

The municipality of Stellenbosch is divided into 18 wards, with wards 8 to 15 being the most important ones, consisting of Stellenbosch Town with its townships. The wards are as follows (a map can be found in annex 3):

1. Wemmershoek; Langrug; Mooiwater; Franschhoek; Rural area north of the R45
2. La Motte; Groendal; Rural area south of the R45
3. De Novo; Muldersvlei; Bottelary; Devon Valley; Devon Vale; Lynedoch (west of the R310); Vlottenburg (west of the R310)
4. Lynedoch (east of the R310); Raithby; Jamestown
5. Vlottenburg (east of the R310); Techno Park; Die Boord (east of Formosa and south of Van Reede); Dalsig; Brandwacht; Paradyskloof; Blaauwklippen Valley
6. Klapmuts; Rural area south of Klapmuts up to and including Nietvoorbij Farm
7. Onder-Papegaaiberg; Plankenbrug; Die Boord (west of Formosa and north of Van Reede); Stellenbosch Central (south of Paul Kruger and West of Bird and Herte); Krigeville
8. Kayamandi (Zones F, G, H and I)
9. Kayamandi (Zones A, B, C, D and E and Costa Land)
10. Kayamandi (Zones J, K, L, M, N and O)
11. Elsenburg; Koelenhof; Cloetesville (west of Long and north of the Terraces open space)
12. Cloetesville (east of Long and south of the Terraces open space); Tennantville; Welgevonden Estate
13. Stellenbosch North (bordered by the railway line in the west; Dr Malan, Helshoogte Road and Kromme River in the north; Lelie, Cluver, Banghoek and Verreweide in the east and Merriman in the south)
14. Stellenbosch Central (bordered by Krige, Herte and Bird in the west; Merriman in the north; Marais, Bosman and Die Laan in the east; and Hofmeyr and the Eerste River in the south)
15. Stellenbosch East (bordered by Cluver, Verreweide, Marais, Bosman and Die Laan in the west; Helshoogte Road in the north; the eastern boundary of Rozendal and Karindal in the east; and the Eerste River in the South
16. Idas Valley and Lindida (excluding Gratitude Park and the erven east of Gorridon)
17. Gratitude Park; Idas Valley (east of Gorridon); The Ridge; the Idas Valley; the Jonkershoek Valley; the Banghoek Valley; Kylemore (South)
18. Johannesdal; Pniel; Lanquedoc; Groot Drakenstein; the Dwars River Valley

3.3 Road network and hierarchy

This section describes the current road structure of Stellenbosch. It will be made clear where different types of traffic modes are allowed, and which facilities are available. The different road types that exist in Stellenbosch will also be discussed. The specific properties, arrangements and profiles will be given. The different types of junctions will also be discussed.

3.3.1 Road network

Annex 2 shows a detailed street map of Stellenbosch. It can be noticed immediately that Stellenbosch has a central region that all the main roads lead to. The structure could be seen as a grid structure. There are both advantages and disadvantages:

Advantages:

- *Short distance to destinations*
- *Various possibilities for reaching destinations*

Disadvantages

- *Many streets with through traffic*
- *Poorly manageable distribution of traffic*

Beyond the main roads, there are several districts created. Because Stellenbosch was a small city in its early days and it was developing over the years, it had to expand. That is why the new districts are situated on the borders of the “old” centre.

The main through routes form a diamond-shaped network of roads. This makes (or should make) almost every part of the city accessible to the traffic. Between the main through routes, secondary roads are created. These link the main roads to create a better accessible centre. Some of these secondary roads are one way roads. This puts pressure on the surrounding streets, because people have to make a detour to reach their destination.

3.3.2 Facilities and important places

Some important places that attract (much) traffic are places like schools, sports fields and shopping centres. In Stellenbosch there are several primary and secondary schools as well as the University of Stellenbosch. Most of the schools (primary and secondary) are situated outside of the city centre, at the borders of the “old” city. These locations are often less busy with traffic than locations inside the centre. This makes the environment of the schools safer and more attractive.

Sports facilities are also located outside the city centre. The sport fields (athletics, soccer, rugby etc) are in a green area with no traffic, which makes it an attractive and calm location for sporting.

The shopping centres (and other shops) can be found in the city centre. The shopping centres often have their own car parks, but in the centre there are also other parking facilities. Because the shopping areas also attract high volumes of traffic, this could be a reason for the one-way streets to distribute the traffic more efficiently.

3.3.3 Road types

In Stellenbosch are different types of roads and streets. There are main through roads as well as secondary roads. Especially the secondary roads have a number of variations in arrangement, of

which a few will be discussed here. The pedestrian and (sparse) cycling facilities will also be discussed. All will be illustrated with photographs.

3.3.3.1 Main through roads

Figure 6; main through road in Stellenbosch

The main through roads (figure 6 and 7) can be divided into two categories. Those that distribute traffic from one to the other side of the city and those that leads the traffic into the city.

The main difference between these two is that the roads into the city have roadways that are separated by a central reserve.

Both types have sidewalks on both sides of the road. Another difference is that on the roads through the city there are pedestrian crossings (with traffic signals) and lay-bys.

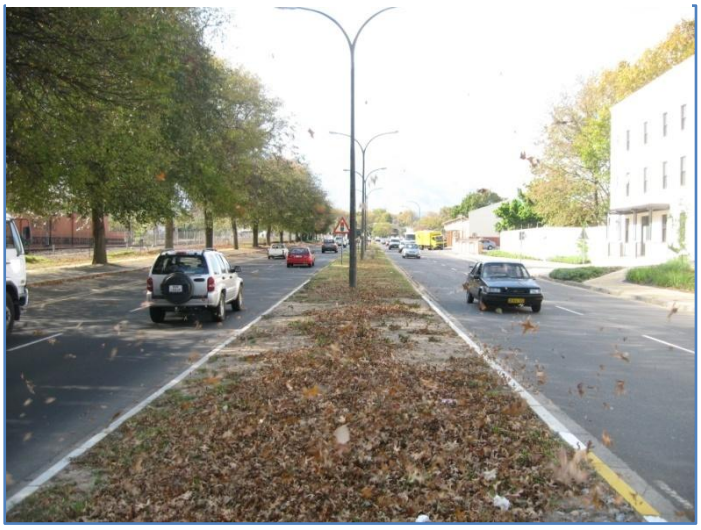


Figure 7; main through road into Stellenbosch

There is not only one maximum speed for this type of road. The maximum speed differs at different sections: from 50 to 80 km/hour. Logically, the maximum speed is lower on the roads through the city, where more pedestrians and other traffic can be found.

3.3.3.2 Secondary roads

Figure 8; one-way secondary road, Stellenbosch

Figure 9; secondary road, Stellenbosch

The secondary roads distribute the traffic through the whole city. It can be said that there are two types of secondary roads in Stellenbosch: one-way roads (figure 8) and two-way roads (figure 9).

The distinction between these two roads is a result of the available space. The figures show that the one-way road is (very) narrow, especially where there are parked cars. However, the streets with one-way traffic are (should be) safer than the others. This is among other things caused by the smaller volumes of traffic and the smaller crossing distance on the road.

On both sides of the road are sidewalks. This makes it safe and attractive to walk through the city. However, there are only pedestrian crossings near junctions and not nearby important shops or buildings.

As with the main through roads, all the secondary roads have an asphalted road surface.

3.3.3.3 Walking and cycling paths

Figure 10; NMT path, Stellenbosch

Cycling paths do not exist in Stellenbosch. The few people that do use the bicycle ride on the “car-roads” or on the walking paths along the main roads.

The facilities for pedestrians are much better. At all road types are sufficient paths. The paths are of sufficient width at all places and easy to walk on. The walking paths distinguish themselves from others by the pavements (stones instead of e.g. asphalt). The walking paths are not only created in the centre of the city, but also outside of the centre (next to the main road into Stellenbosch are also walking paths).

In the neighbourhood of the university in Stellenbosch there is a street where pedestrians have priority at all times. This is done by the use of road signs, the construction of elevated crossings for pedestrians and the narrowing of roadways to reduce the speed of motorised traffic. This idea is shown in figure 10.

Figure 11; priority for pedestrians, Stellenbosch

That pedestrians and cyclists can use the same road without problems, is shown in figure 11. In the middle of a shopping area a path is created, where only non motorised traffic is allowed. There are bicycle sheds and sufficient space to walk or cycle.

3.3.4 Junctions

Figure 12; junction with roundabout, Stellenbosch

Figure 13; junction with robots, Stellenbosch

Figure 14; junction without devices, Stellenbosch

It can be said that there are three types of junctions in Stellenbosch: junctions with a roundabout, junctions with a traffic signal and regular junctions (with just a stop or yield sign). As can be seen in the street map of Stellenbosch, the traffic signals can only be found at junctions with the main through roads. There could be a number of reasons for these locations: to overcome the speed difference with the secondary roads (to make it safer to cross and join the traffic) or to regulate and distribute the traffic better throughout the city centre. Roundabouts can not be found often, even though it has some good properties such as a reduction in the number of road accidents and a higher capacity in comparison to tradition intersections. Most of the junctions are regular ones. Here the following rule applies "who arrives first, has priority". In most cases this works well, but it also causes (many) accidents.

Figure 12 shows a junction with a roundabout. Most important is that near the roundabouts it is not allowed to park your car. This is (probably) done to create a more convenient junction. The figure also shows the special facility for pedestrians to cross the junction. Cars must stop at the pedestrian crossing to give priority to the pedestrians. There are no facilities for cyclists, such as separated cycle paths.

The same applies for the two other types of junctions. The robots are also equipped for pedestrians and the "regular" junctions also have pedestrian crossings, where there are no facilities for cyclists. It is notable that robots differ from robots in e.g. the Netherlands. Here the robots are placed at the "halt-line" and at the other side of the junction.

3.4 Supply side

This section describes the supply side of the traffic in Stellenbosch. It discusses the parking facilities for bicycles as well as for cars and the facilities for public transport.

3.4.1 Parking facilities (bicycle and car)

Figure 15; bicycle shed, Stellenbosch

Parking facilities (for cars) are only created in the city centre (see street map in annex 2). This is probably also done because there are several one-way streets, where you can not park your cars. On the main through roads are lay-by's situated on the sides of the roads. This doesn't create much parking space, which leads to problems with parking on busy days in Stellenbosch. The houses in Stellenbosch, just like most companies, have their own parking facilities. These are often situated on own territory, behind fences (e.g. to prevent theft).

Figure 16; car park, Stellenbosch

For cyclists there are hardly any parking facilities available. There are (almost) only facilities at non-public places (e.g. university or companies). In public places are actually no facilities needed, because there is very little bicycle traffic (it could also be that there are few cyclists because of the lack of facilities).

That there are no other facilities needed for cyclists in public places, can be seen in figure 15. It shows an almost empty bicycle shed, which reflects the actual status of cycling in Stellenbosch.

Figure 16 shows a car park in the centre of Stellenbosch. Car drivers are directed to the different car parks by traffic signs. It is shown if the car parks are occupied.

3.4.2 Public Transport facilities

The Western Cape Province has a railroad network, with stations at the “important” places like Cape Town, Stellenbosch, Strand, Belville and Simon Town. It is possible to go by train from e.g. Cape Town to Stellenbosch for working or studying. The departures are irregular (and limited) and the service is not very reliable. Another issue is safety: it is not wise to travel on your own and certainly not when it gets dark outside. Regular bus services are not available in Stellenbosch (or from e.g. Cape Town to Stellenbosch).

Minibuses can be found everywhere throughout the city. It is an informal form of public transport, which covers the whole city and its townships. The buses can transport ± 15 persons and it is a very cheap form of transport and it is therefore often used by the less wealthy inhabitants (often from the townships). Because the buses are riding through the whole city centre along all the important locations, it is a popular mode of transport.

Figure 17; minibuses park, Stellenbosch

3.5 Demand side

This section describes the demand side of the traffic in Stellenbosch. It discusses the ownerships of different vehicles, the use of different vehicles and the modes that people use to go to places like shops, work and schools.

3.5.1 Bike ownership

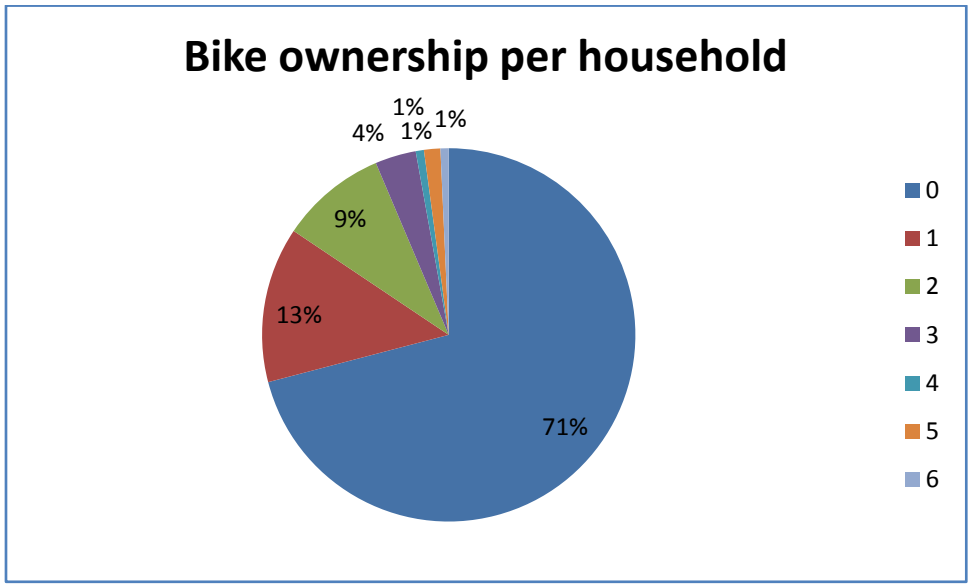


Chart 1; bike ownership per household (NHTS)

The chart shows that most of the households in Stellenbosch (71 %) have no bicycle in possession. Only 29 % of the households have one or more bikes in possession. This means that if you look at the average household size, 3,3 persons per household (census 2001), that the ownership per person is almost near to zero.

At this point, the ownership of bicycles, could be improved. It is known that the purchase value of a (refurbished) bicycle costs just as much as the use of a minibus taxi for two months (Vanderschuren, n.d.). It seems to be beneficial for many people who use the minibuses to buy a bicycle. There have already been many strategies tried to promote the use of bicycles, without any success.

3.5.2. Ownership motorised vehicles

Table 1; ownership motorised vehicles Stellenbosch (NHTS)

Number	Motorcycle/scooter	Car/bakkie (company)	Car/ bakkie (household)	Minibus /combis	Truck
0	99.29%	95.74%	51.77%	99.29%	100.00%
1	0.71%	4.26%	31.91%	0.71%	0.00%
2	0.00%	0.00%	13.48%	0.00%	0.00%
3	0.00%	0.00%	2.84%	0.00%	0.00%

Table 1 shows the ownership of motorised vehicles in Stellenbosch (or the availability for private use). The car or bakkie is actually the only vehicle owned by the households. The use of a car from friends or relatives is also included in this category. Almost half of the households have a car available. This means that mean value per 1000 inhabitants ≈ 210 cars.

3.5.3 Bike use

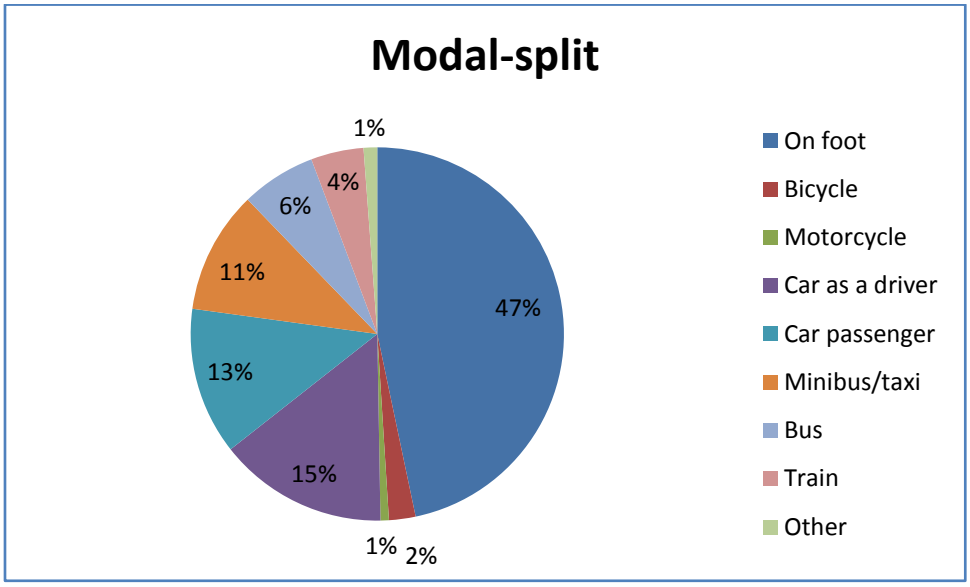


Chart 2; modal split in Stellenbosch (census 2001)

Chart 2 shows the modal split for Stellenbosch. It indicates which travel modes people are using in Stellenbosch. The conclusions relating to the bicycle and motorised vehicle ownership also come forward from this chart. Almost half of the trips are made on foot. This could also mean that half of the people have no bicycle or car to use. It is also important to know that only 10 % of the trips are made by public transport (bus and train) and 11% by minibuses (this could also be seen as a form of public transport) and taxis. Because the trips made by minibuses are often inside the borders of the cities, these trips could probably also be made by NMT.

However, it is unknown to which distances the modal split applies. Better conclusions could be made if there was data available for short trips (< 7,5 km, this could be travelled by bicycle) and longer trips (>7,5 km).

3.4.3 Trip mode and purpose

To know what and where facilities have to be made for walking or cycling and to know which trips could be encouraged to be made by other transport modes, it has to be known which mode people use for the most important trips. This is demonstrated in the charts on the next two pages. There is also a chart included about the trips that people make daily. Explanations will follow the charts.

3.5.3.1 Charts of modes to important places

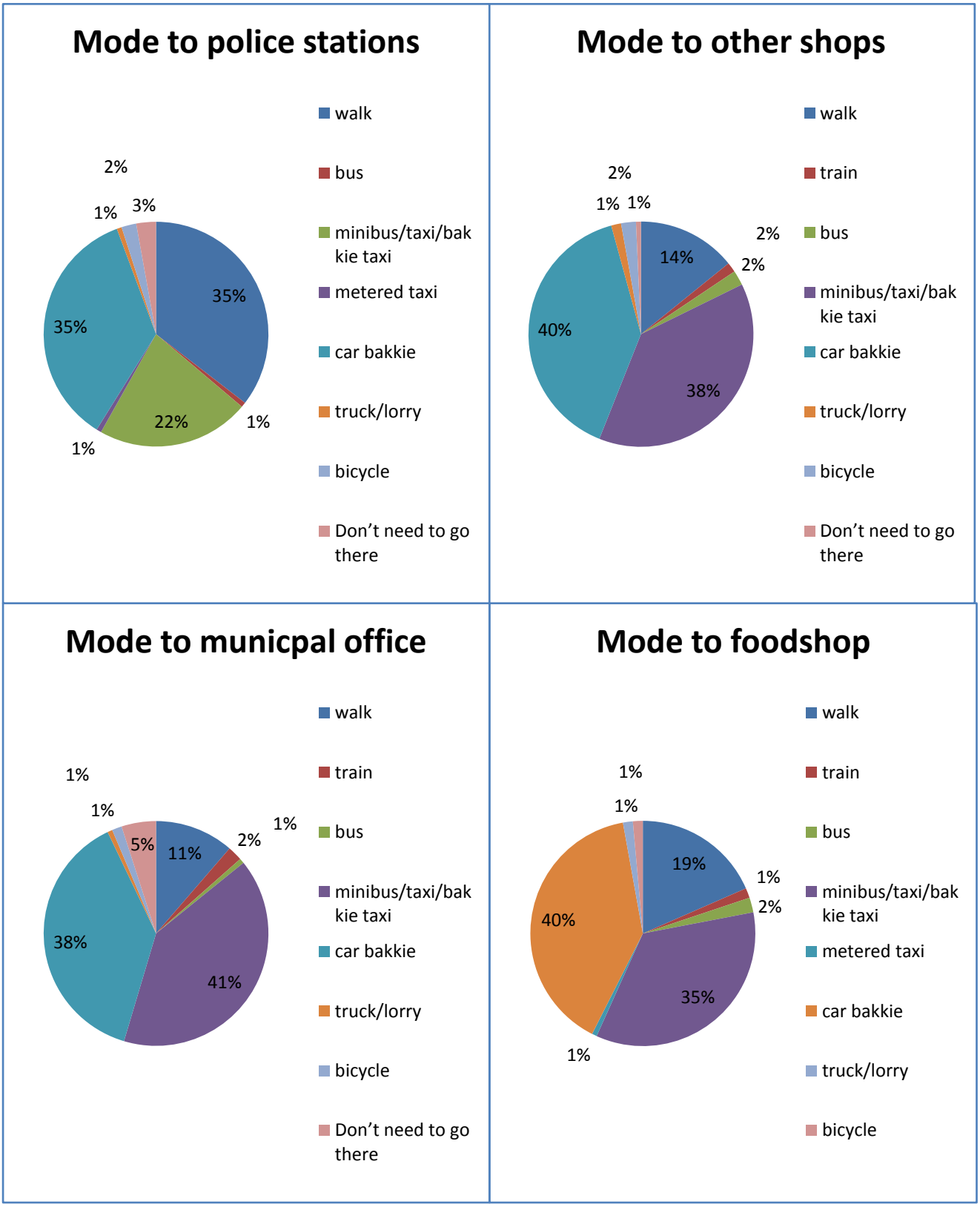


Chart 3; mode to important places 1 (NHTS)

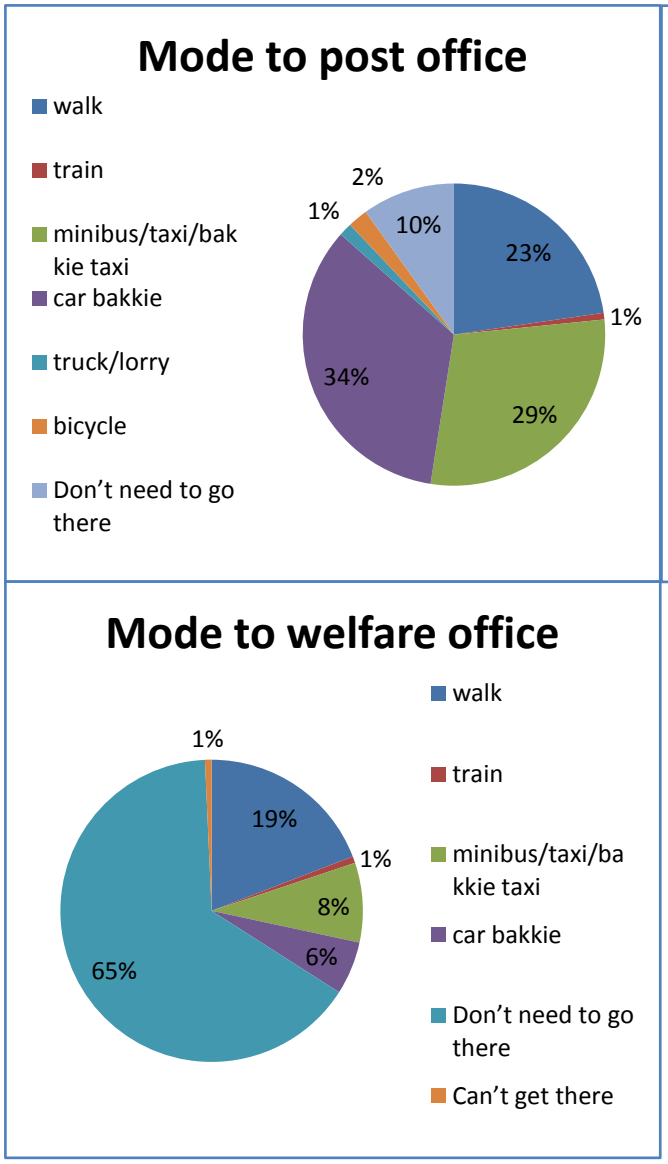


Chart 4; mode to important places 2 (NHTS)

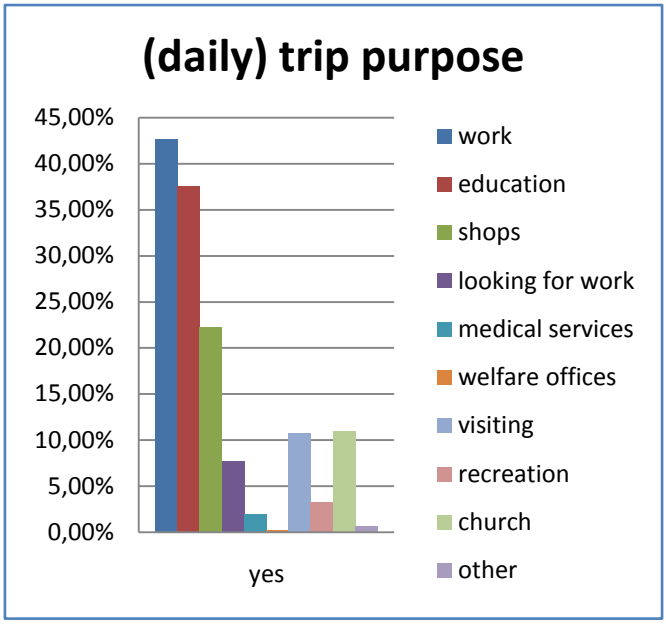


Chart 5; daily trip purpose (NHTS)

3.5.3.2 Explanation charts of modes to important places

Almost all charts show that people use the car or the minibus the most to go to places located in the city centre. This contrasts with the results from the modal split, which shows that many trips are made by walking. The "daily trip purpose" chart shows that the trips to work and education are made the most every day. It is therefore plausible that these trips are mostly made by walking. This can be examined with other data from the NHTS, shown in chart 6:

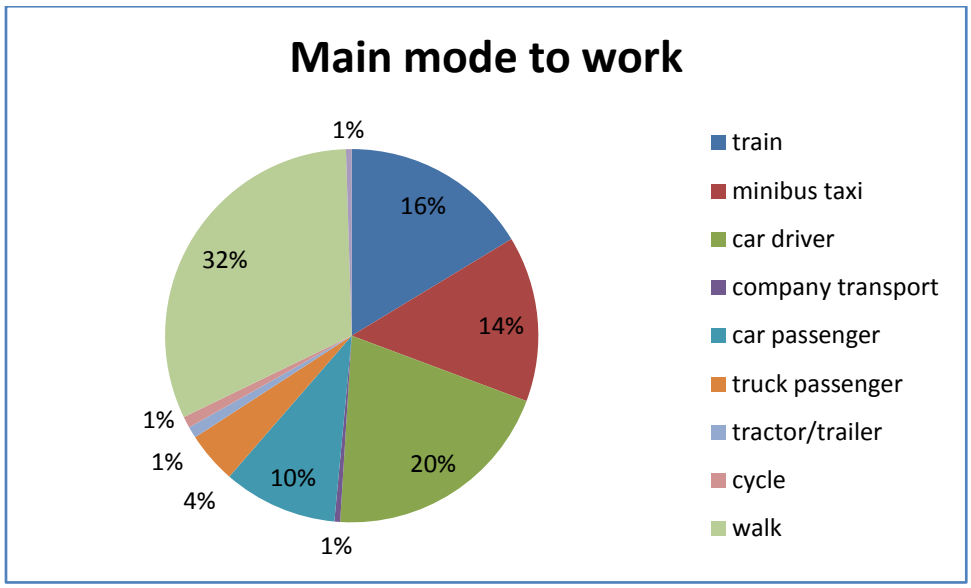


Chart 6; main mode to work (NHTS)

Here it is made clear that the greatest portion of trips to work is made by walking (32 %). This confirms the conclusions made earlier about the modal-split. Data about the mode used for educational purposes is unfortunately not available.

3.6 Impacts

This section describes the impact of the traffic on different issues: safety congestion and pollution in the city of Stellenbosch.

3.6.1 Safety

This section describes the road safety in Stellenbosch. Aspects such as the number of accidents and comparisons to other cities will be given. It also has to be known where the accidents take place (e.g. at what type of junctions).

Annex 4 shows the statistics of all the (traffic) accidents in the Stellenbosch area for the last two years (31and05and2006 to 31and05and2008) (*Stellenbosch Traffic Service*). It shows that there are a high number of accidents. The main conclusions are that:

- Most accidents happen at priority junctions (with traffic signals or stop sign) with straight travelling traffic.
- Most accidents happen over the weekend.
- 22 of the 55 fatal injuries are pedestrians (40 percent).
- Most accidents involve cars.

However, if cycling increases, the use of motorised vehicles also needs to change. More bicycles on the road will require a safer road environment, which will not be influenced in a positive way by cars. The presence of motorised vehicles next to cyclists has a negative effect on safety. So the use of motorised vehicles has to decrease (equally) with the increasing use of cycles. Safety can also be improved by facilities for cyclists, e.g. separated cycling lanes or priority at junctions.

3.6.2 Congestion

The traffic situation in Stellenbosch has been mapped earlier, for use in the Stellenbosch Town Transport Master Plan. Figure 18 and 19 shows the average speed of a (motorised) vehicle in the morning and afternoon peak hour in Stellenbosch Town. It is shown that particularly in the centre of the town the congestion problems are the greatest. The problems occur in the afternoon and in the morning often at the same streets and places. It should be noted that travel time analysis could show long delays even where there are low traffic volumes. Sometimes this happens where there is a short green phase allocated to the minor movement at a signalised intersection.

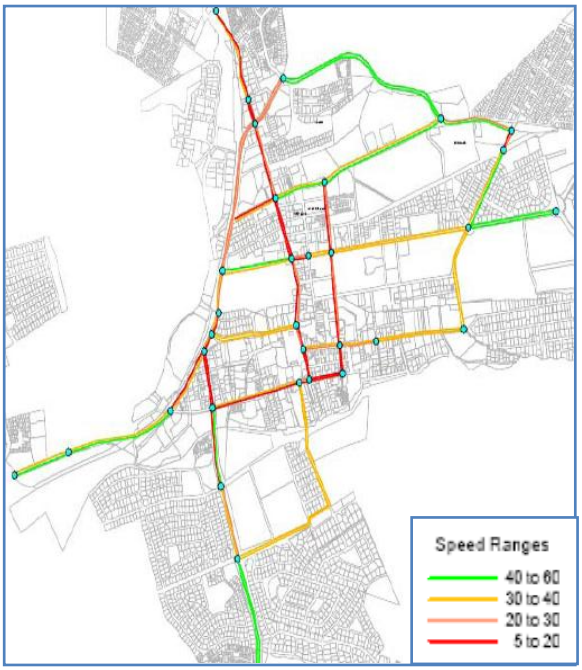


Figure 18; average speed in afternoon peak hour (Arup)

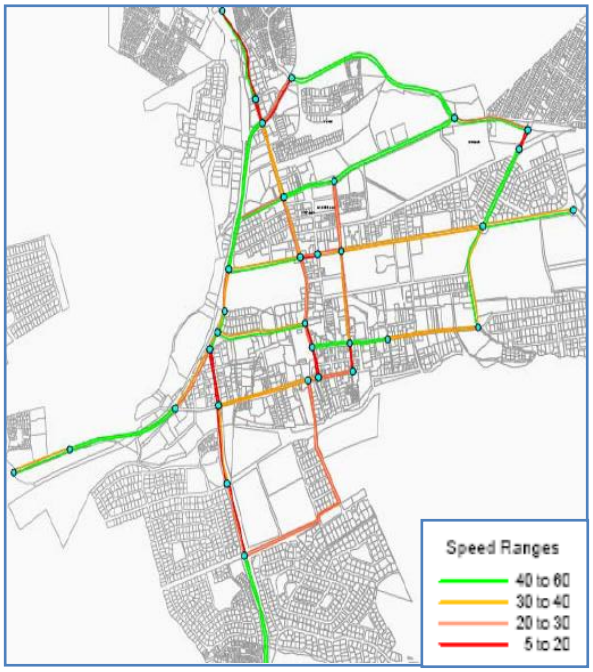


Figure 19; average speed in morning peak hour (Arup)

3.6.3 Pollution

If it can be achieved that people change their mode from minibuses and cars (partly) to cycling and walking, it will have a positive effect on the (air) pollution in Stellenbosch. The use of a bicycle has no negative effects on the environment, both on air and noise nuisance.

There is no information or data available concerning the different types of pollution.

4 Best practice analysis of Houten

Chapter four describes the city of Stellenbosch. It starts with an introduction of the city and its population, followed by a description of the road network and its characteristics. The chapter goes on with an overview of the supply and demand side of the traffic. The chapter ends with a short description of the impact of a couple of issues (e.g. pollution and congestion).

4.1 Introduction of Houten

This section gives a short description of the important characteristics of Houten that could be of relevance to the transport system in the city of Stellenbosch. It deals mainly with the composition of the population, but it also describes the most important activities that take place in Houten.

Figure 20; Houten (Google Earth)

Houten (figure 20) is a small city (44.500 inhabitants; male/female ≈ 49 %and51 %) located in the middle of the Netherlands. It is located near the big city of Utrecht, which is of great importance for the environment of Houten (both for the economy and the employment). Most of the inhabitants are in the age category of 25 to 45 years and the number of immigrants is almost 13 percent. The inhabitants are divided over almost 16.700 households, which makes the average household size 2,65 (as opposed to 2,25 for the Netherlands as a whole). The population growth is approximately 2,5 % per annum. Another important statistic is the amount of children being educated: 5370 at primary education (25 schools) and 1662 at secondary education (one school) and 1530 at higher or university education (outside Houten) *(Centraal Bureau voor de Statistiek [CBS], 2008).*

All of the schools are situated inside the ring road, where conflicts with cars are less. Other important buildings, such as the railway station, the shopping centre and the city hall, are located in the middle of the town. This makes these places easily accessible to everyone. The company grounds on the other hand, are located outside the ring road. The grounds attract high volumes of motorised traffic, which is undesirable in a low-traffic city centre.

It is also important to know how many people are working in a city, and in which sector. Unfortunately it is not known how many inhabitants of Houten are working outside the city (who need to travel out of the city each day). Table 2 gives the various numbers.

The number of people that are not working and taking advantages of social security, is 2783. The unemployment figure (registered people looking for a job) is approximately 5 % of the labour force. Here labour force means people who work 12 or more hours a week.

Houten was not always composed and did not always have the characteristics as described above. Since the end seventies, Houten was appointed as a centre of urban growth.

It had to accommodate the population growth in the region and be an important and attractive suburb of Utrecht. What has been done to meet those needs, will be explained in the next section. It also explains what makes the spatial structure of the "new" Houten so special.

Table 2; Job characteristics Houten 2006 (Houten municipality)

Sector	Houten		Province Utrecht		Netherlands	
	Number	Percentage	Number	Percentage	Number	Percentage
Total	16390		581050		6975400	
Agriculture, forestry and fishery	260	2 %	3500	1 %	97300	1 %
Extraction and industry	2760	17 %	75300	13 %	1241000	18 %
Commercial services	9370	57 %	307600	53 %	3275400	47 %
Non-commercial services	4000	24 %	195100	34 %	2361600	34 %

4.2 Road network and hierarchy

This section describes the specific road structure of Houten (see figure 21 and 22). It will be made clear where different types of traffic modes are allowed, and which facilities are available. It should become clear what makes the spatial structure of Houten a special one. The different road types that exist in Houten will also be discussed.

4.2.1 Origin of the spatial structure

Houten was designated as a centre of urban growth (it is situated six km southern of Utrecht) in 1979.It was a small, rural village with 4000 inhabitants. Before 1979 the municipality had said that the village should keep its rural character. A ring road (diameter three km) was created that was only accessible for motorised traffic. Inside the rind road a district-system (see figure 23) for living as well as shopping was created. The centre had to be a new railway station. From the east to the west of the city, along the station and centre, a "green axis" was created. This was also the main route for low speed traffic. Inside the ring road, living areas and a town centre were created. Outside the ring road company grounds were created. Every living area has a connection with the ring road and is interrelated to a car-free zone. Except for some service traffic and busses, cyclists and pedestrians will not meet any car traffic while travelling from area to area (or to the centre). The good harmony between urban form and transport developments provided for a low car traffic speed inside the districts. Some of the measures are narrow streets and corners. It has always been an objective that cyclists and pedestrians should reach every destination safely.

Because the cyclists and pedestrians are important, main arteries are created, with as direct as possible connections between living areas and the city centre. Together the main arteries are star-shaped, with the centre and railway station as the midpoint. The network for low speed traffic consist of secondary cycle routes (a "mesh" of 150 m * 150 m) and primary cycle routes (a "mesh" of 300 m * 300 m) that mostly converge with the residential and neighbourhood roads. The meeting points of motorised traffic and cyclists and pedestrians on these main arteries are very limited. If there are meeting points, the motorised traffic has to give right of way. This is supported by speed limiting measures. The main arteries are distinguished by the type of road-surfacing, width and

lighting. The main arteries come together directly under the railway station, in the middle of the city centre.

This is also the most important meeting point in Houten: the town hall and shopping centre are situated nearby.

Figure 21; road structure (old) Houten 2 (red=car, blue=bicycle)

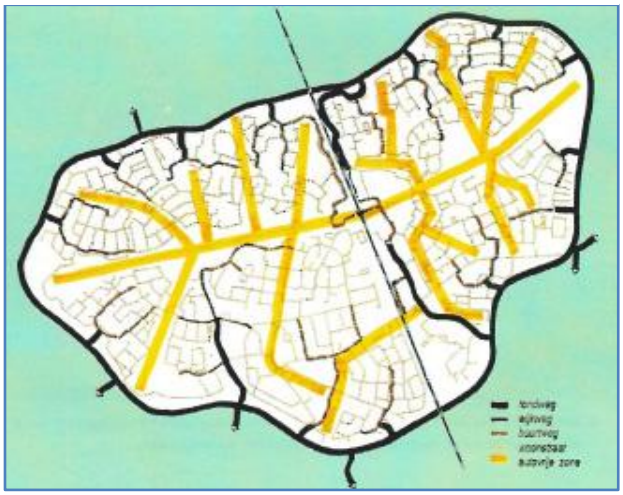


Figure 22; road structure (old) Houten 1

Figure 23; districts in (new) Houten (Houten municipality)

The ring road is fully dedicated to motorised traffic. It opens up the living areas and the central area, and is separated from the buildings by a noise barrier. In principle every destination in Houten is accessible by car, even when coming from outside of Houten. But if you want to make short movements (from area to area, or to the town centre) you have to use the 8,6 km long ring road.

Motorised traffic coming from the ring road will be taken further by short district roads. These district roads, prohibited for cyclists, soon become neighbourhood roads and then residential roads. The last two categories are also used by cyclists. In residential roads all the road users meet each other and there are no pavements.

In 1996 the second phase of urban growth has started. It uses the same principles of urban development as developed in 1979. However, there are some improvements made to e.g. the green structure, the design of the roads and the quality of the houses. It also applies to the "new" Houten, that the important facilities (library, schools, sports facilities) are located along the main (cycle) arteries.

Complete priority for cyclists is not easy to implement. Car drivers coming from the ring road need time to adapt to the changed situation. It is dangerous if the first crossing with a cycle route appears too early. That is why extra curves are sometimes constructed in the car routes. But there are many other measures implemented: squared curves, cycling paths situated higher than the car roads, white blocks, red stakes or narrowing of

roads. Every car driver crossing a cycling route knows there is something special happening.

4.2.2 Road characteristics

This section describes the different road types that exist in Houten and the different type of junctions that originate from that. It will al be illustrated with photographs from the roads and junctions. The roads in Houten could simply be divided into four main types: the ring road, the district road, the neighbourhood road and the residential road. Besides that, there are different types of bicycle paths. These will all be discussed one by one.

In the Netherlands a manual (called ASVV) is used for the designing of traffic provisions. It is written by the CROW, an organisation that aims "to make knowledge applicable in practice". In the description of the different road types, characteristics and/or rules from the ASVV will be used. When designing traffic provisions, designers use "design vehicles" that are described in the ASVV. For different types of vehicles there are descriptions and dimensions given in the ASVV. The main user of the road will be its design vehicle (e.g. bicycle for a cycling path or a bus for a bus lane).

The traffic principle is very clear:

1. The ring road, max. speed = 70 km/h, not accessible for low speed traffic.
2. The district road, max. speed = 50 km/h, not accessible for low speed traffic, often of limited length to emphasize the connection between traffic and residential area.
3. The neighbourhood road (every district has a neighbourhood road), max. speed = 30 km/h, with at least on one side of the road a sidewalk, joint use of low speed traffic, the neighbourhood road open up in principle every residential road in the district, width = 5,5 m.
4. Residential roads, no sidewalks, width = 4,5 m (more variations possible).
5. The carriers (the main cycle routes), 3,5 m. broad solitary cycling paths (also accessible for mopeds).

4.2.2.1 Ring road

Figure 24; ring road Houten (Houten municipality)

The ring road (figure 24) is created around the borders of Houten. It is the only opportunity for car drivers to reach other districts. To create a good and high quality connection, the road is only accessible for motorised traffic. Also because of the maximum speed of 70 km/hour it wouldn't be safe to permit NMT on the ring road. The length of the ring in total, is approximately 14 km, with a linking road (1,2 km) in the middle of Houten. This also separates the "old" and the "new" Houten, and actually creates two ring roads of 8,7 and 7,7 km.

The junctions, where people leave the ring road to enter a district or leave the ring road to e.g. the highway, are all controlled with traffic signals. These traffic signals are managed in such a way, that public transport has an (almost) absolute advantage.

Design guidelines:

Advantages:	within the ring road there is no through traffic a clear (hierarchical) structure is possible
Disadvantages:	heavy traffic loadings in (approach roads to) ring road sometimes it is necessary to take a longer diversionary route in order to reach destination

With a design speed of 70 km/h, the minimum traffic lane width is 3.25 m. If the traffic lane width is greater than 3.50 m, there is a danger that vehicles will overtake illegally, which destabilizes traffic.

4.2.2.2 District road

Figure 25; entrance to district road (Houten municipality)

The district roads (figure 25) are connectors between the ring road and the districts. To bridge the difference in speed (70 km/h on the ring road and 30 km/h on the neighbourhood roads), the maximum speed on the district roads is 50 km/h. The districts roads are always short, to create a safe and peaceful environment. As on the ring road, on the district roads only motorised traffic is allowed.

The junctions with the neighbourhood roads have to be (very) safe, because motorised traffic could come in contact with NMT. That is why at most of the junctions measures are taken to reduce the speed of the motorised traffic. Measures such as speed bumps, narrowing of the road or road markings are used.

Design guidelines:

With a design speed of 50 km/h, the minimum traffic lane width is 3.10 m

4.2.2.3 Neighbourhood road

The neighbourhood roads (figure 26) are mainly meant to "distribute" the people through the districts. Cyclists and motorised traffic use the same roads, which brings the maximum speed for motorised traffic to 30kmandh. As on the junctions with district roads, on the neighbourhood roads measures are also taken to prevent speeding.

Figure 26; neighbourhood road (Houten municipality)

Design guidelines:

For a neighbourhood road (with parking in lay-bys) different guidelines are available: for roads where only passenger cars are present (PCU) and for roads where goods vehicles and busses are also present (HGV). There is also a difference in traffic function (moderate or limited). The minimum width of the road is: 6.50 m (moderate, PCU), 7.50 m (moderate, HGV), 4.50 m (limited, PCU) and 5.50 m (limited, HGV).

Footpaths also have guidelines for dimensioning:

The width must be at least 1.80 m., where narrowed for more than 10 m it has to be at least 1.50 m, where narrowed for less than 10 m it has to be at least 1.20 m and at narrowing for "hard" points (lampposts, traffic signposts etc) it has to be at least 0.90 m. A footpath must also have an obstruction free minimum clearance height of 2.20 m (including obstructions such as sun shades, advertising boards, lighting and traffic signs).

4.2.2.4 Residential road

Figure 27; residential road (Houten municipality)

The residential roads (figure 27) are perhaps the roads with the most activity. People are driving their car, cycling and walking on the road. Children are playing outside on the streets or at playgrounds. To let everything move smoothly, everything has to be safely and conveniently arranged. Cars have to be parked at the special parking places, so that roads are free of cars and nothing unexpected could happen. Once again all necessary measures are taken to reduce the speed of vehicles to be below 30 km/h.

Design guidelines:

In the residential areas less than 100 vehicles per hour are passing. The streets are never longer than 200-400 meter (where there is one-sided access) or 400 -600 meter (where there is two-sided access). The traffic lanes must be at least 3.00 m in width with a walkway of at least 1.00 m (if over short distance) or 1.50 m (if over longer distance).

There are also minimum requirements adhered to the design of a residential area:

- *The residential area should not have function for through traffic.*
- *The character of a residential area should not be adversely affected by the volume of motorised traffic.*
- *The impression that the road is divided into a carriageway and a footpath should be avoided; so there should be no continuous difference in elevation.*
- *Traffic signs should not impede range of vision.*
- *There should be adequate parking provision for residents.*
- *That part of the road which is intended to be for parking should be marked as such by a "flagstone" marked with a "P" or a traffic sign marked with a "P".*
- *The distance between provisions for reducing traffic speeds should be such that they create conditions which stimulate very slow driving speeds (they should not be more than 50 m apart).*
- *There should be sufficient public lightning to ensure that the speed reducing provisions are clearly visible at night.*
- *Children's play areas should be clearly marked and if possible closed off from the area of road used by vehicular traffic.*

4.2.2.5 Cycling paths

The cycling paths (figure 28) are the main arteries in Houten. They connect every location in Houten and they can take people everywhere on their bicycles. Different types of cycling paths can be found in Houten: wide main cycle roads, small "connecting" roads or cycling streets. Cycling streets are exceptional, because cyclists and car drivers use the same path. The car is a guest on the cycling street and must give priority to cyclists and adapt to their speed.

Figure 28; cycling path (Houten municipality)

To make the cyclist visible at all times, measures are taken at different places. Measures to reduce the speed of traffic that crosses the cycling paths and to reduce the speed of e.g. mopeds and scooters are taken. Everything is done to make it safe and comfortable for cyclists to use the cycling routes. To make junctions with district roads safe, the cycling path is at some places constructed higher than the crossing road. This makes the cyclists visible from further away.

Design guidelines:

For (segregated and independent) cycle tracks with one-way traffic is the minimum width 2.0 m, for two-way traffic it is 3.50 m.

When partial closing of a foot or cycle path is desired (e.g. to banish motorised traffic), the poles have to be at 1.20 m apart.

Checklist used for bicycle provisions (the important points):

- *Align cycle routes to be as short as possible.*
- *Limit the nuisance of motorised traffic.*
- *Create sufficient crossing facilities so that the barrier effect of traffic arteries is avoided.*
- *Don not forget shelters.*
- *If necessary, limit the difference in speed between cyclists and cars.*
- *Ensure the width is sufficient (also to accommodate snow ploughs).*
- *Make sure the slopes are not to steep.*
- *Pay attention to the aspect of social safety, particularly at tunnels, bridges and greenery.*
- *If possible avoid the need for traffic lights by arranging an intersection in a different manner.*
- *Make sure the road surface is as even as possible.*
- *Make sure there is lighting, particularly on isolated sections and parts where there is discontinuity.*
- *Make sure there is a separate direction signing system if cycle-routes deviate from those of motorised traffic.*

- *Make sure there are adequate bicycle parking provisions (at attraction points, for example bus stops).*
- *Make sure there are facilities for chaining up bicycles at unsupervised bicycle parking provisions.*

4.3 Supply side

This section describes the supply side of the traffic in Houten. It discusses the parking facilities for bicycles as well as for cars and the facilities for public transport.

4.3.1 Parking facilities (bicycle and car)

In the centre of Houten there are good parking facilities for cars and bicycles. Two car parks are created, where the car can be parked for a low tariff. For bicycle there are, especially near the railway station, high quality parking facilities: there are secured and covered bicycle sheds. Also in the direct neighbourhood of bus stops there are (covered) bicycle sheds. This is all done to make public transport more attractive. A further advantage is that people who really need to park their car in the centre, do not have many problems with finding a parking place.

In the residential areas the cars are as much as possible “banished” from the streets. There are parking places near the houses, where more cars can be parked together. The “banishing” of cars from the streets makes the streets more visible and it creates a better view for e.g. playing children. This is all done to increase the safety on the streets.

For the parking facilities of bicycles, just as for cars, there are design guidelines. It is prescribed where parking facilities have to comply (e.g. the number of bicycle parking places for an urban hospital must be at least 30-50 per 100 beds).

4.3.2 Public Transport facilities

Houten has a well developed public transport network. In the “old” part of Houten 50 % of the houses is located within walking distance (400 m) from the railway station. The other houses are within cycling distance (800 m). For the “new” part of Houten a second railway station was created, so that everyone there also has short connections to a railway station. Because of the growing use of the train and the limited capacity, there is work taking place to double the number of rails. The train has a frequency of four trains per hour in each direction.

There are also a number of bus routes to nearby cities and important places (e.g. Utrecht, Nieuwegein). The bus stops are also situated near bicycle-tunnels (or other bicycle facilities), so that it is attractive and easy to take the bus instead of e.g. a car. For the buses there are also special bus lanes created and at traffic signals the buses always get priority. This makes the bus (in most cases) more attractive than e.g. the car.

The municipality of Houten is also very satisfied with the combined use of bicycle and train. The parking facilities for bicycles at the railway station had to be extended several times in the past.

4.4 Demand side

This section describes the demand side of the traffic in Houten. It discusses the ownerships of bikes, motorised vehicles and the use of the different modes.

4.4.1 Bike ownership

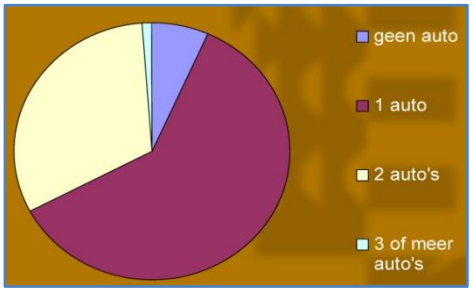
The Netherlands is with good reason known as the leading country in the world concerning the use of bicycles. It can be said that everyone has the possibility to use the bike as a mode of transport. Almost everyone owns one or more bicycles for different purposes: e.g. sports (mountain biking, road racing), recreation, shopping or going to work or school.

4.4.2 Ownership motorised vehicles

Approximately 90 % of the households in Houten own one or more cars. A small amount of the inhabitants own other motorised vehicles. The next table and chart shows these ownership statistics:

Table 3; ownership motorised vehicles (CBS)

	Houten	Houten/1000 inhabitants	Province	Province/1000 inhabitants	Netherlands	Netherlands/1000 inhabitants
Private cars	18748	421	546830	463	7092293	434
Company cars	2087		78293		1070605	
Motorbikes	1346	30	36474	31	552949	34



It can be seen that on average car ownership is (much) lower in Houten than elsewhere in the province and also lower than the average in the Netherlands. This may be a result of the municipality's policy of discouraging the use of motorised transport. That people do not automatically choose the car instead of NMT, will be shown in the next section.

Chart 7; car ownership Houten (Houten municipality)

4.4.3 Bike use

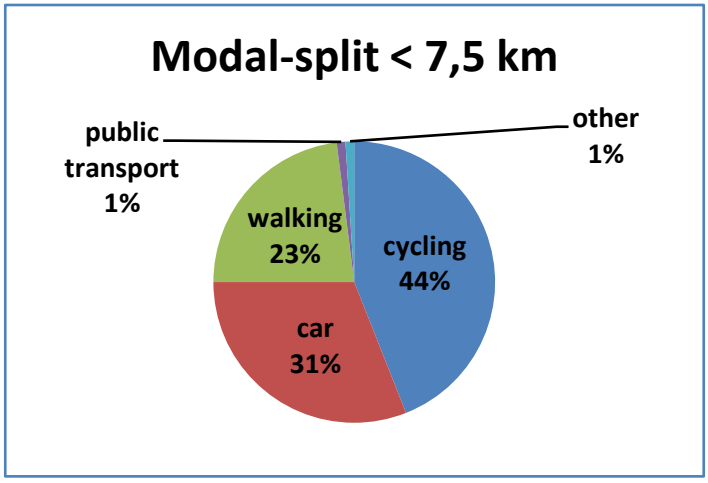


Chart 8; modal split in Houten (Houten municipality)

Chart 8 shows the modal split of trips with a distance not longer than 7,5 km. This covers all the trips made inside the city itself. Most of the trips are made by NMT (≈ 65 %) against 33 % for car and public transport. It is clear that the spatial structure and the local policy have the desired effects.

In the Netherlands there are also problems with cars in the neighbourhood of schools (e.g. because of dropping off children). This problem is also adressed in Houten. Bicycle

tracks that never cross any car roads are constructed to the schools (or schools are constructed along cycle tracks) so that children can go safely to school. The schools are only accessible via a car cul-de-sac at the rear entrance of the schools. Every effort is made to prevent the conflict of cars and bicycles. *(Beaujon, n.d.)*

The same principles apply for other places that attract low speed traffic; they are all located near the bicycle tracks. The municipality also finds that most of the people do their shopping by bicycle. *(de Jong and Bosch, 1992)*

4.5 Impacts

The effects and impacts of the spatial structure and arrangement of Houten will be discussed here. The safety, congestion and pollution in the city will be the subjects.

4.5.1 Safety

The effects of the "special" spatial structure of Houten, can be directly seen in the accident rates of Houten. Table 4 shows the important numbers:

Table 4; traffic accidents Houten 2006 (CBS)

	Houten	Province Utrecht	Netherlands
Traffic accidents	11	602	8039
Died persons	0	45	811
Injured persons	12	632	9051
Victimsand1000 inhabitants	1,45	2,87	---

The table only shows the number of accidents registered by the police. The real number of accidents is most probably higher, because less serious accidents are often not reported to the police. Even so, the number is still extremely low. The number of victims per 1000 inhabitants places Houten as the third safest city in the Netherlands. It also shows that it is one of the safest cities in the provinces. The city is approximately four times safer than comparable cities.

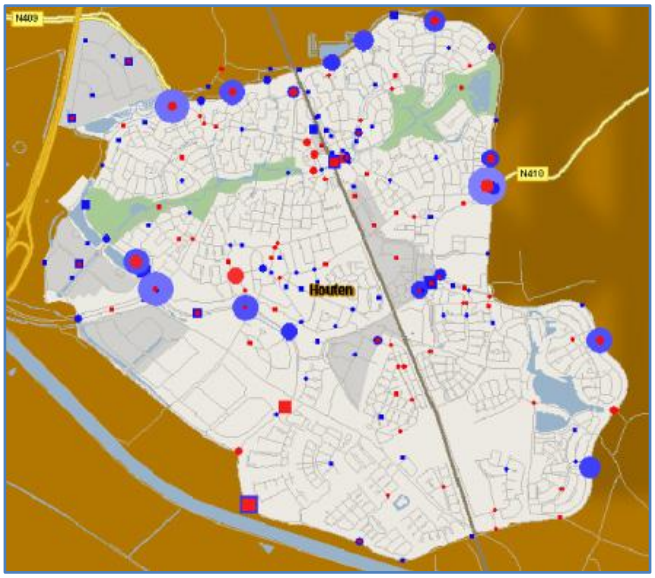


Figure 29; location of accidents Houten (Houten municipality)

To see what the causes of these low accident rates are, it should be examined where the accidents took place. Figure 29 shows the locations of accidents during the period 2003 to 2007 in Houten:

Most of the accidents took place at junctions with the ring road. This can be explained by the high difference of speed. Where the maximum speed at the ring road is 80 km/h, the maximum speed at the crossing roads (in and out the different districts) is 50 km/hour.

With such a difference in speed, it could be difficult to join the traffic on the ring road.

The good view on the streets in the districts (caused by the specific parking e.g.) and the separation of slow and fast traffic both contribute to the low number of accidents inside the different districts.

This makes it safe for children to play on the streets in front of their houses and it also encourages the use of non motorised transport (bicycle and walking) inside the city.

Nevertheless, this good safety record has another side. The children in Houten are used to a pro-cycling environment, but outside of Houten everything is different. Just because everything is controlled in such a good way, children going to the secondary school in the big cities are not yet adjusted to that. To solve this problem, the municipality has made an educational video about the cycling routes the children are going to use and about traffic safety in general.

4.5.2 Congestion

Not much information is known regarding the congestion on the ring road of Houten. However, it is so that currently there is much traffic on the road from road construction activities which always causes problems with the traffic flows. At the moment a new connection to the A12 motorway is being constructed, which causes this working traffic. However, the use of cars is 25 % lower than elsewhere.

4.5.3 Pollution

In contrast with the good effects on the safety, the effects on the pollution stay the same. There is no noticeable reduction in the emission of CO_2 (with respect to the use of the ring road) and only a minimal reduction in the emission of NO_x (with respect to the reduction of short trips by car).

Nevertheless, there are some positive effects for the environment. The noise nuisance in the districts is at a low level, caused by the low speed and small amount of cars. Only in the direct surroundings of the ring roads are minimal effects noticeable, but these are places with not much houses. The only cause of noise nuisance in the districts comes from the rail road the crosses the city. However, because the houses here are also situated at a sufficient distance from the rail road, the effects are also limited to a minimum. This is illustrated in figure 30 and 31.

Figure 30; noise nuisance by car (Houten municipality)

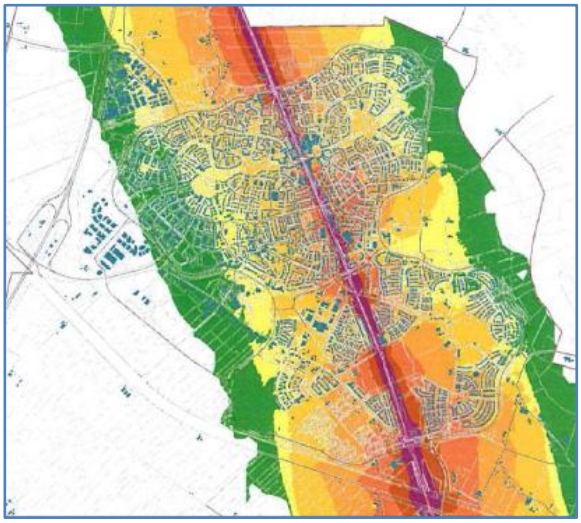


Figure 31; noise nuisance by train (Houten municipality)

5 Comparison of Stellenbosch and Houten

Chapter five can be seen as a summary of the previous two chapters. It compares the characteristics of Stellenbosch and Houten. Similarities, differences, advantages and disadvantages of both cities will be discussed. The same issues will be considered as in the analyses.

5.1 Similarities and differences of both cities

This section describes the similarities and the differences of both cities. It has to be clear at which main points the two cities differ and where the similarities are.

5.1.1 City and inhabitants

The municipality of Houten has a surface of approximately 59 km^2, where the municipality of Stellenbosch has a surface of less than 50 km^2. When this is compared to the difference in population (≈47000 vs. ≈ 117000), it can be seen that Stellenbosch has a much higher population density.

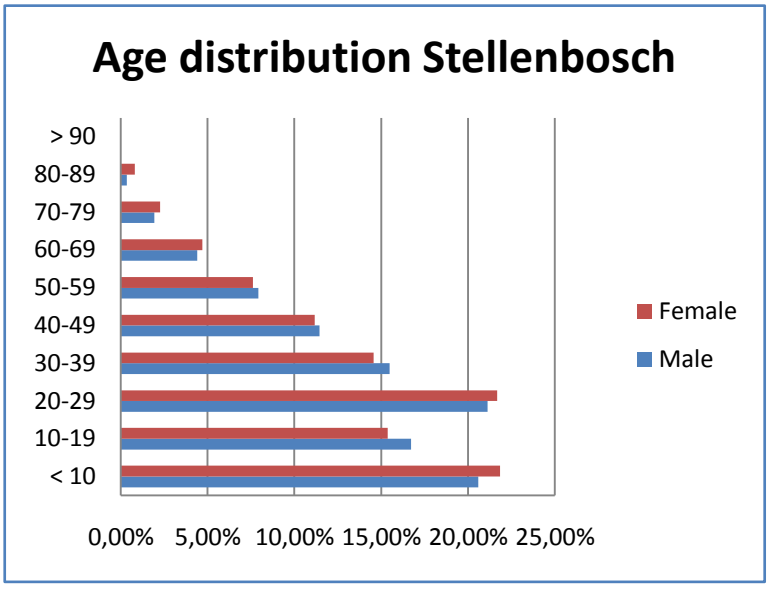


Chart 9; age distribution Stellenbosch

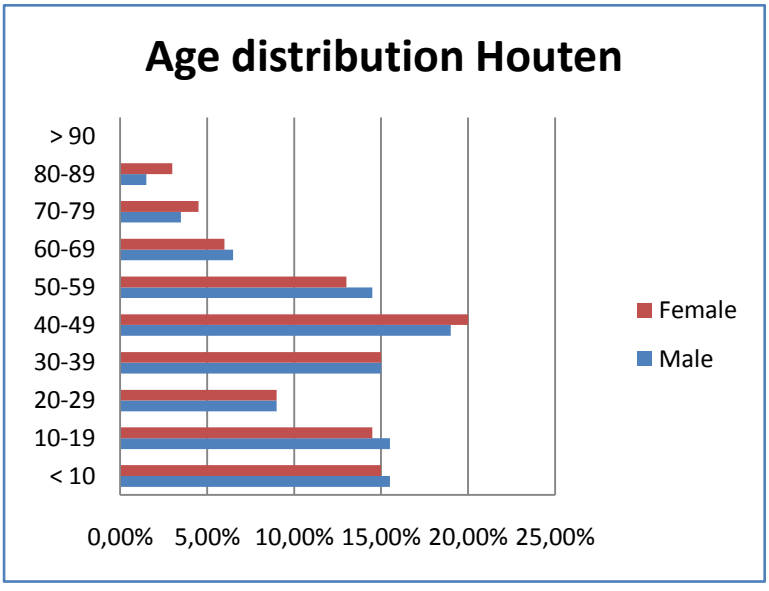


Chart 10; age distribution Houten

The first important difference that could be noticed, is the differing age distribution. Stellenbosch has (far) more people of < 30 years old, where Houten has most of its people aged > 30. This has the greatest impact on the mode choice of the people: the younger people are, the more they are (in potential) assigned to NMT.

It will also influence the way that people should be approached and/or informed.

Another important issue is the education of the population in a city. The number of people that get educated and the level of education are important characteristics. Stellenbosch is a real student town, because the university takes up an important place in Stellenbosch Town. The students are a large part of the population. This also means that they cause a big part of the traffic. 30 percent of the population does not get educated (or never had education).

These are mostly the people that live in the poorer areas like the townships. Compared to Houten where almost all the children go to primary and/or secondary schools, the city of Stellenbosch is considerably the same as Houten concerning the production of school-based trips.

The employment status shows a big difference between Houten and Stellenbosch. A large part of the population (almost 50 percent) in Stellenbosch is unemployed or not economic active. In Houten is this number much lower: somewhere between 5 and 10 %. This also has his impact on the mode choice and the purpose of trips made in the city. In Stellenbosch most trips are not work-related and made by foot.

Houten and Stellenbosch both have their shops in the centre of the city with the residential area's surrounding it. The main difference is that Stellenbosch also has residential areas outside the "main-roads". These are the poorest districts of the city. It is also a difference that the schools and university in Stellenbosch are located more to the borders of the city centre, where in Houten the schools are distributed over the whole residential area(s).

5.1.2 Road network and hierarchy

Since Houten has four different road types, Stellenbosch has only two types. However, the two road types in Stellenbosch are comparable to those in Houten. The ring road of Houten is comparable to the main through roads in Stellenbosch, except that some roads in Stellenbosch do have double lanes. The maximum speed on these roads is also the same: 70 in Houten and between 60 – 80 in Stellenbosch. An important difference in these roads is that Stellenbosch has sidewalk along the main roads. The ring road in Houten is only accessible for motorised traffic.

The secondary roads in Stellenbosch have similarities with the neighbourhood roads in Houten. Both roads are leading people through the city (districts) and are accessible for all types of transport (with sidewalks for the pedestrians. Where the maximum speed in Houten is reduced by special measures like humps, in Stellenbosch is the speeds being reduced by the narrow streets and the parked cars along the road.

Roads where the car is "guest" and the cyclist has complete priority, are unknown in Stellenbosch. Also the cycle paths as build in Houten are not known in Stellenbosch.

Another difference is the way in which the different road types distinguish themselves from the others. In Houten the different road types have different surfaces or pavings and also different road signs and markings. E.g. streets with a low maximum speed have a paved surface, where the ring road (high speed) has an asphalted surface. The lower speed roads are also narrowed by the applied road markings.

5.1.3 Supply side

In Stellenbosch are several car parks constructed in the city centre, where Houten has parking garages in the (shopping) centre. In Houten it also prohibited to park in certain roads or districts, where in Stellenbosch people are allowed to park almost everywhere next to the road. Even on the main through roads are special lay-by's. In the Netherlands the different car parks are situated along a parking route (what prevents that people driving around to find a parking place). Stellenbosch does not have such a facility, what makes it difficult to find a place to park your car. The low use of motorised traffic inside Houten also contributes to the good parking facilities.

The public transport facilities in Stellenbosch are of a very low quality compared to Houten. The trains are not reliable and don not have a frequent timetable. The minibuses are not of the same quality as the buses are in Houten. The capacity in Houten is much bigger and the reach of the public transport services is much bigger.

5.1.4 Demand side

A bigger difference than the difference in bike ownership is almost not imaginable: almost 100 % in Houten against almost 30 % in Stellenbosch. The ownership of motorised vehicle on the other hand, is more similar in both cities.

The number of owned motorised vehicles is also not the same in Houten and Stellenbosch (almost 50 % in Stellenbosch and almost 80 % in Houten). The lower number of cars must have his impacts on issues like safety, parking facilities and type of junctions. It is also explanation for the high number of pedestrian trips.

The modal split in both cities shows some interesting things. The total use of NMT differs almost 20 % and the total use of the car is almost the same. The other part in Stellenbosch uses the minibus/bus a lot. These should be the people that could probably use a bicycle or other types of NMT. Also the large number of pedestrian-trips (47 %) could be potential cycle-trips in Stellenbosch.

5.1.5 Impacts

Because of incomplete information and data it is not possible to make a full comparison of the impacts on Stellenbosch and Houten. It is only possible to compare the safety and congestion in the cities.

Figure 18 and 19 show that most of the congestion can be found on the main through roads. This could be compared to congestion on the ring road in Houten, but also main through roads in the centre of Stellenbosch are congested, what is very undesired. In spite of the missing information about congestion in Houten, is it still plausible that that ring road will be the congested road at busy moments. The difference between Houten and Stellenbosch is that during peak hours also secondary roads in Stellenbosch are congested.

The difference in number of accidents is immense. Not only the number of accidents is high, also the fatal injuries: zero in Houten against 55 (in two years) in Stellenbosch. It is noticeable that most accidents in Stellenbosch occur between cars and pedestrians, and that these accidents happen at crossings. In Houten has not occurred any fatal accident and the accidents that occur, took place at junctions where pedestrians and cars are separated. It can be said that the spatial structure, the separation of motorised and non motorised traffic has a huge influence in the accident rates.

5.2 Advantages and disadvantages of both cities

This section describes the advantages and the disadvantages of both cities. Both cities have their strong and weak points, so that not everything could be used in Stellenbosch. Stellenbosch will probably have some good points that are essential and Houten will have weak points that shouldn't be used in Stellenbosch.

5.2.1 Stellenbosch

Stellenbosch might not be in a bad condition, even though lot of things could be improved to make the city more attractive and quieter. Important points that play a role for this are mentioned here.

5.2.1.1 Advantages

- Good pedestrian facilities through the city (crossing and sidewalks)
- Network of minibuses (also the low price of this service)
- Grouping of shopping and tourist locations
- Different car parks around the centre
- High number of pedestrian trips

5.2.1.2 Disadvantages

- Low use of bicycle
- No cycle facilities
- Mixed use (different modes of transport)of roads
- Parking problems
- An inconvenient street scene (e.g. caused by parked cars)
- Congestion during peak hours
- Accident rates

5.2.2 Houten

The main reason for success for the 'Houten system':

One of the most important reasons is the persistent policy during the last 30 years in considering cyclists and pedestrians normative in residential areas. Politicians, civil servants and advisors deserve appreciation for this. Another reason is the base of the traffic structure: the ring road for cars and the fine grid network of cycling lanes. This is only the basic principle that alone is not sufficient for a successful final result. On all levels, from structure level until the level of organisation of the residential area a lot of unique elements for Houten have been designed by intensive co-operation between traffic experts, city planners, landscape designers and civil engineers.

5.2.2.1 Advantages

- High number of bicycle trips
- Excellent accessibility of the city for cyclists
- Almost no pollution (noise/air)
- Low number of accidents
- Measures + facilities for cyclists

5.2.2.2 Disadvantages

- Traffic priority threatens the character of the environment
- Cost of measures (+ later improvements)
- City build up from "nothing" (hard to apply to existing cities)
- Car users have to make detours
- Often seen as too drastic (for car drivers)

6 Zoning of the Stellenbosch area

Now it is known how Stellenbosch and Houten look like and what the advantages and disadvantages are, it is needed to estimate the traffic flows. An area has to be divided into several zones to make it possible to model these flows. These TAZ-zones (Traffic Analysis Zones) are the bases for the OD-matrix, as well as for the simulation model. Due to the focus of this study is Stellenbosch, there is a need to look for zones in the city centre and zones in the areas outside of Stellenbosch. The areas outside of Stellenbosch cover the people travelling from and to the city. The zones inside Stellenbosch will be based on the main functions of their area. There must be thought of functions like shopping and recreation, working, studying and school and living.

6.1 Wards in Stellenbosch

The municipality of Stellenbosch is divided into several wards. This division into wards is used in the Census 2001 to describe several characteristics of the Stellenbosch population. Because the wards indicate areas with differing properties, this will be the base for the TAZ zones in Stellenbosch. The zoning will be based on the distribution of (annual) incomes per household, and as income is a good indicator for the use of different transport modes. Figure 32 gives a map with the different wards.

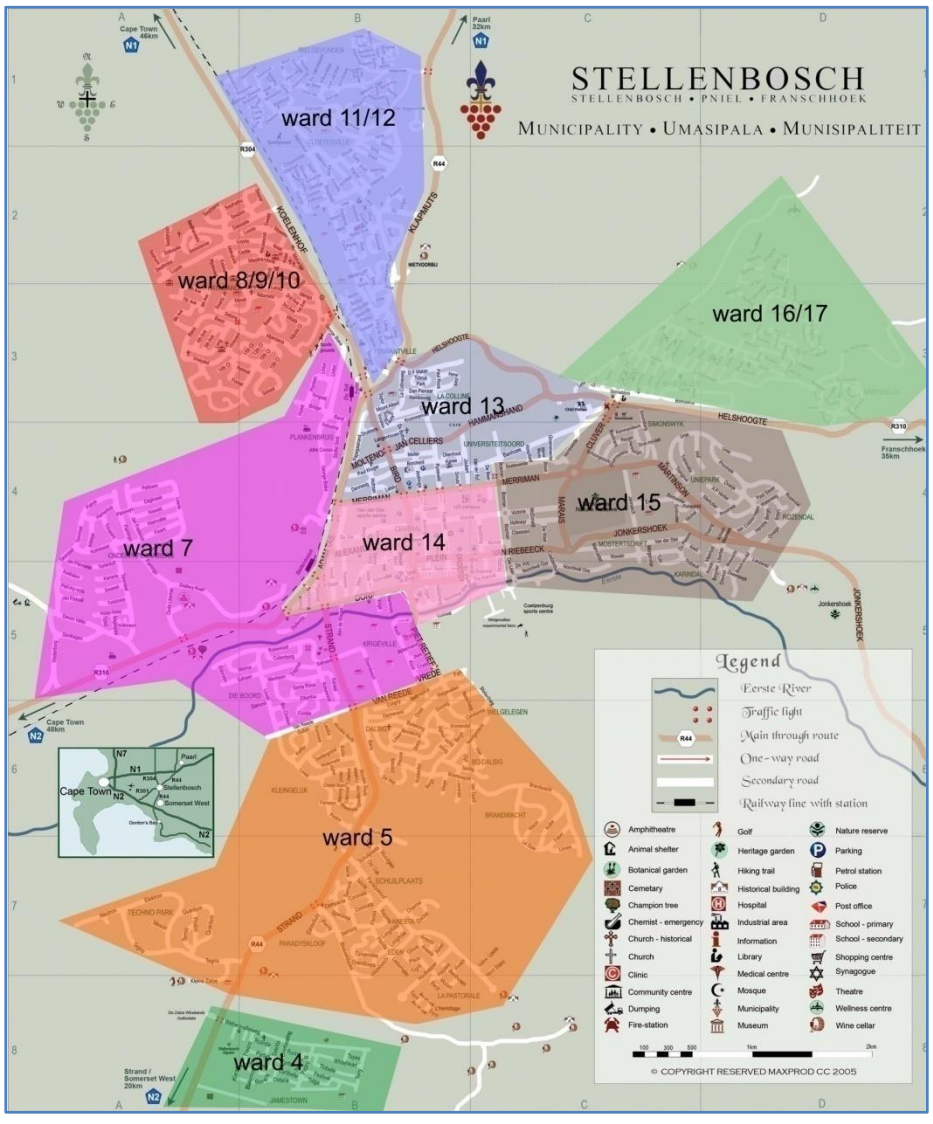


Figure 32; wards in Stellenbosch

Page 46 and 47 gives the charts (chart 11.a/11.i) with the distribution of (annual) incomes per household per ward.

The zones inside Stellenbosch will be mainly based on these data, after which the zones outside of Stellenbosch will be determined.

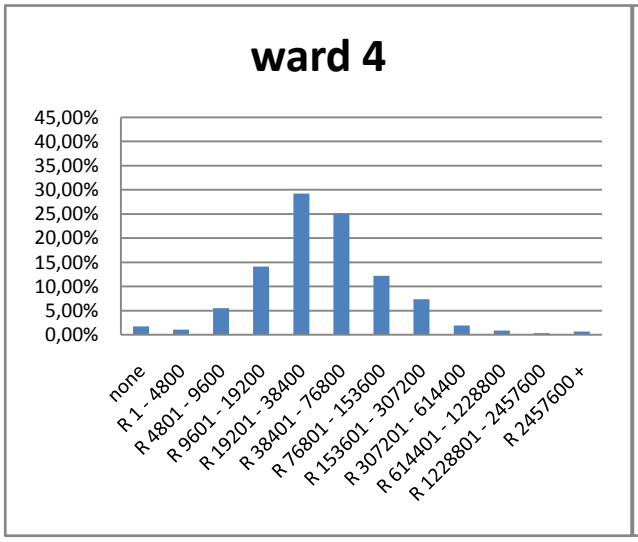


Chart 11a

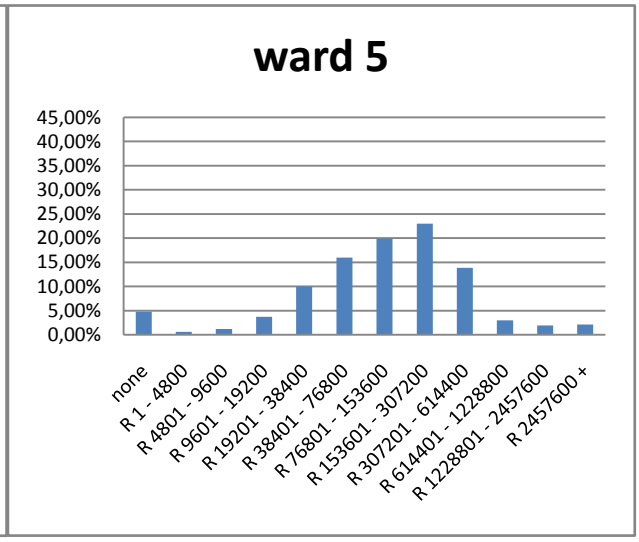


Chart 11b

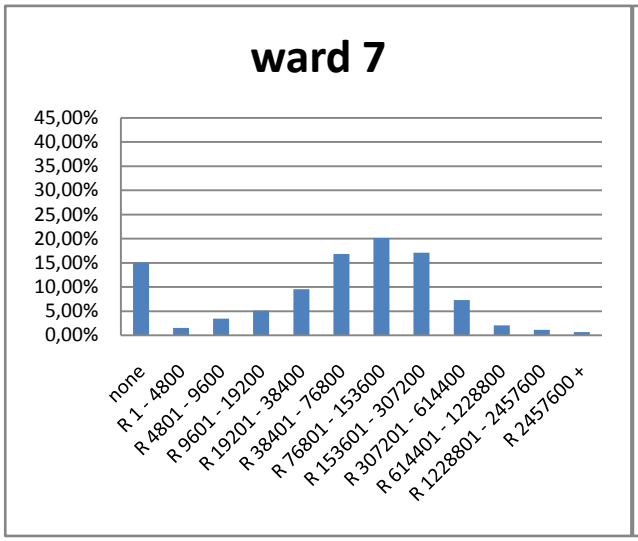


Chart 11c

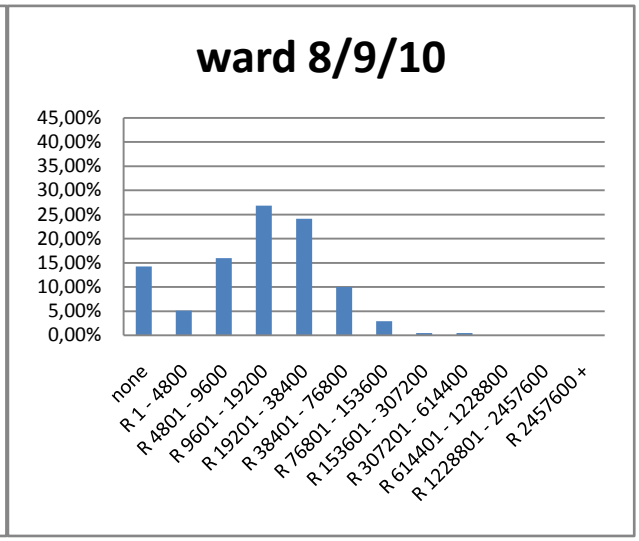


Chart 11d

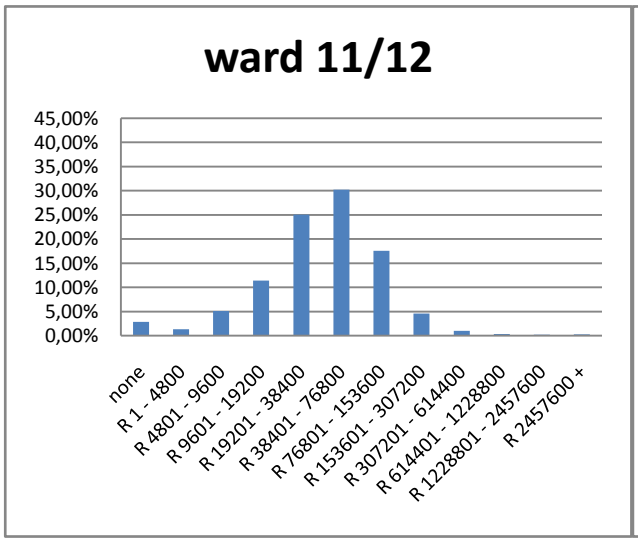


Chart 11e

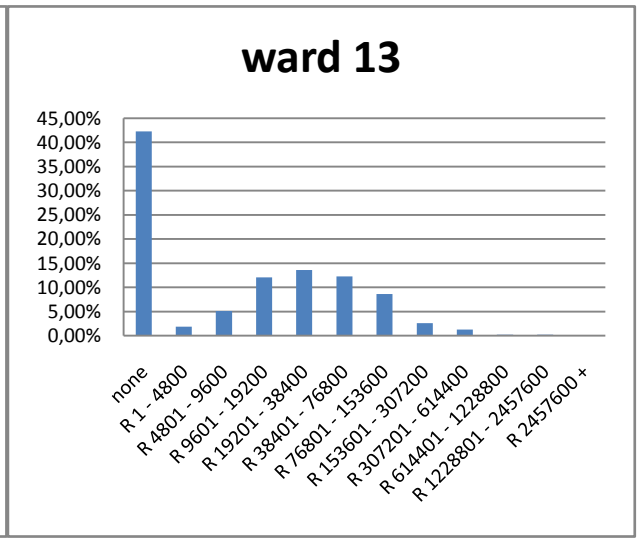


Chart 11f

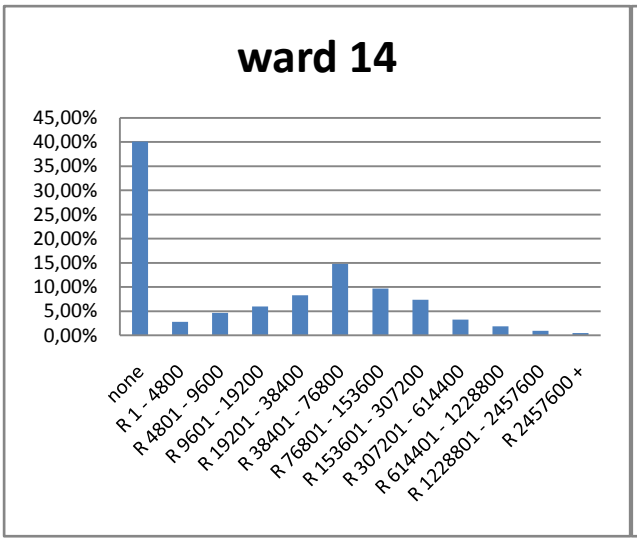


Chart 11g

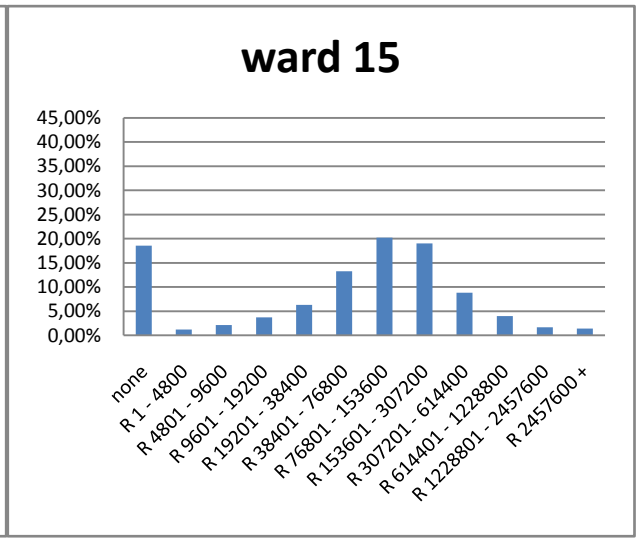


Chart 11h

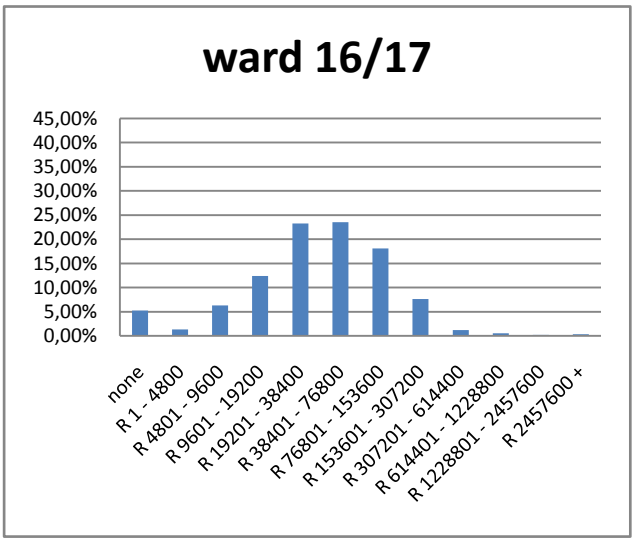


Chart 11 a and i; annual income distribution Stellenbosch (Census 2001)

6.2 Zones inside Stellenbosch

To see where people are travelling to and where people come from, it is needed to create “internal” zones in Stellenbosch. This section describes how these zones are created.

Several residential areas are situated along the different arterials into the centre of Stellenbosch. The centre of the city can be divided into two parts: a part with the university and a part with shops, restaurants and tourist locations. Not all the residential areas along the arterials could be simply put together. The charts with the distribution of incomes have clearly indicated this.

Residential areas on the north side of Stellenbosch are split in two different zones, because there live much more poor people in ward eight, nine and ten. On the other hand, the wards five and seven can be combined into one zones, because the similarities in distribution of incomes. The same applies to the wards 13 and 14. Finally, ward 4, ward 15 and ward 16and17 all need to be detached zones because of the specific distribution of incomes.

The zones correspond with the following districts/areas (see figure 33):

1. Zone 1 covers the area of Kayamandi (township).
2. Zone 2 covers the area of Cloetesville (residential area).
3. Zone 3 covers the areas of Ida's Valley and Lindida (residential areas).
4. Zone 4 covers the areas of Uniepark, Rozendal and Mostertsdrift (residential areaandstudent residences).
5. Zone 5 covers the areas of La Colline (business area), central (residential and shopping area) and Universiteitsoord (student residences and university).
6. Zone 6 covers the areas from Onderpapegaaiberg to Paradyskloof and La Pastorale (residential areas) and Technopark (business area).
7. Zone 7 covers the area of Jamestown (residential area).

6.3 Zones outside of Stellenbosch

Not only are the internal zones important, but also external zones. Because of the traffic comes into Stellenbosch along the different roads, it is important to know where the persons come from.

On the street map of Stellenbosch (annex 2) it can be seen that there are five main roads that lead into the town. These roads all correspond with certain origins and destinations of the travellers.

The zones, based on these access roads, correspond with the following directions and areas (see figure 34):

8. N 1 (Cape Town); Zone 1 covers the people from/going to Cape Town (for instance the region Kraaifontein, Durbanville and ParowandBellville).
9. N1 (Paarl); Zone 2 covers the people from/going to Paarl and Drakenstein (also the direction of Breede valley).
10. R310 (Franschhoek); Zone 3 covers the people from/going to Franschhoek.
11. N2 (Strand and Somerset); Zone 4 covers the people from/going to Strand and Somerset West.
12. N2 (Cape Town); Zone 5 covers the people from/going to Cape Town (for instance the region Blue Downs, Gugulethu and Kayelitsha).

Annex 5 shows a map of Stellenbosch with all the zones and the main arterials. This provides information of the barrier effect due to mobility spines, as well as the accessibility by motorised transport. The motorised transport is named here, because they are the main users of the road. This makes clear where the different zones are being crossed by these roads. It also gives a quick view of the accessibility of the zones.

The main arterials have strong influences on the use of non motorised transport in Stellenbosch. The safety on the arterials is influenced by the speed differing from 60 to 80 km/h (dependant on the location). This speed difference and the poor facilities for non-motorised modes of transport make cycling severely along these roads.

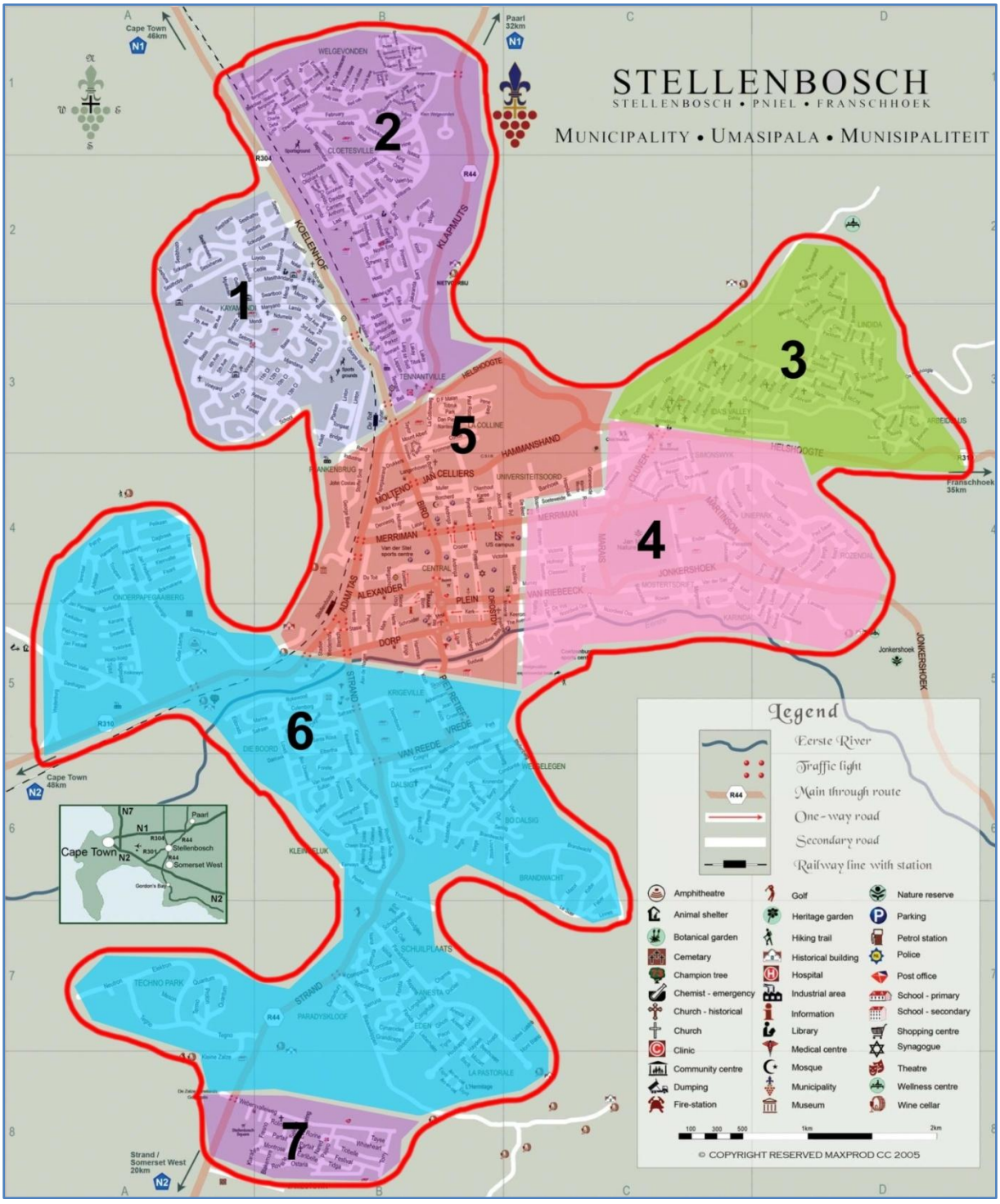


Figure 33; internal zones Stellenbosch

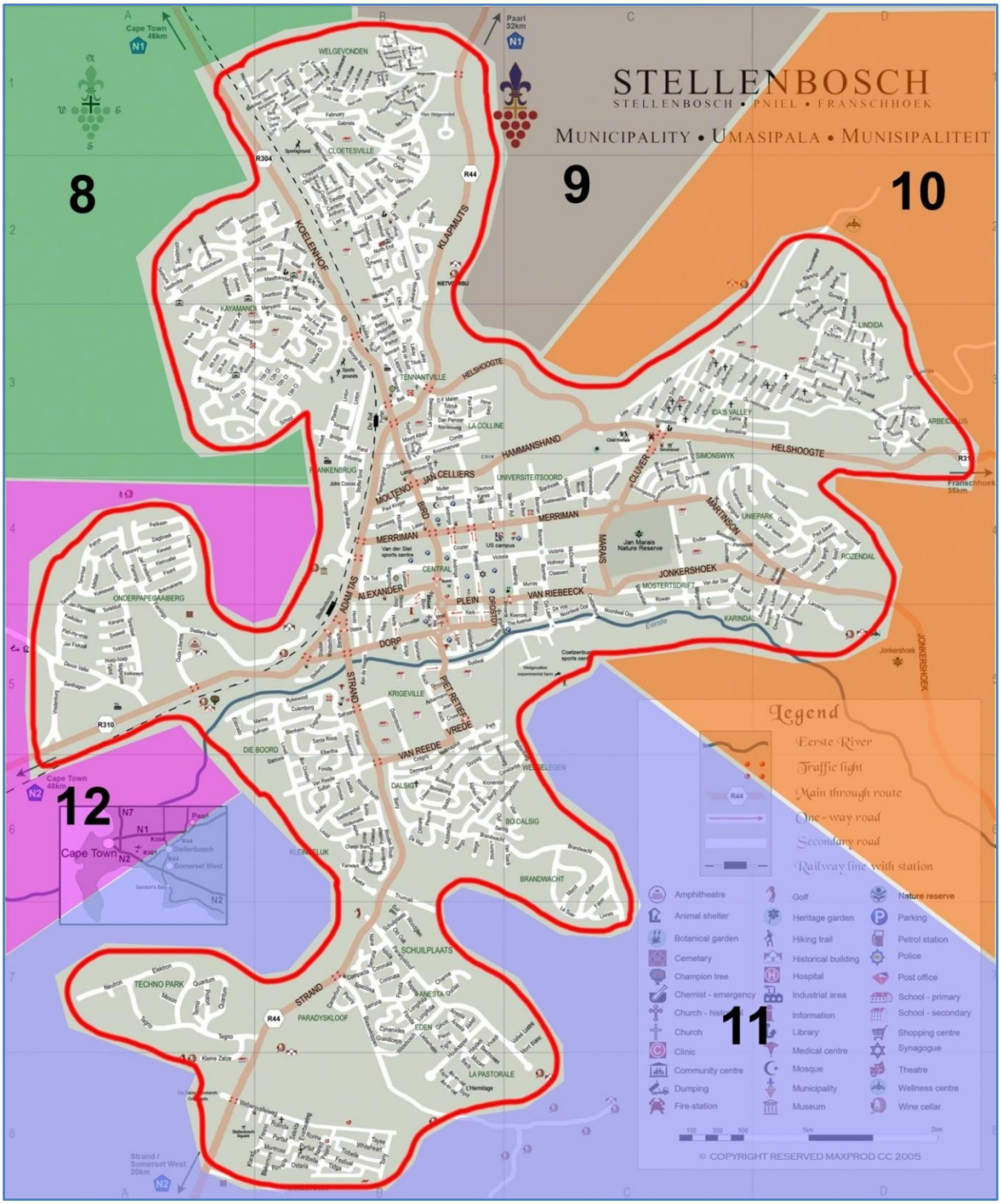


Figure 34; external zones Stellenbosch

7 OD-matrix

Now that it is known how the zoning of Stellenbosch is comprised, the process of creating an OD-matrix (Origin Destination-matrix) for the city of Stellenbosch can be described. The chapter starts with the assumptions and restrictions made: e.g. which data sources and which trip are used. This is followed by the methodology of creating the actual OD-matrix, that is divided into the different purposes. The resulting OD-matrix will be presented at the end of the chapter.

7.1 Theory of an OD-matrix

In traffic modelling, usually the 4-step model is being used: generation, distribution, mode choice and route assignment. An OD-matrix can be drawn up after the mode-choice step as well as after the distribution step. The only difference is that after the mode choice step, the OD-matrix is divided into the different transport modes existing in the network. It depends on the available data which one you choose.

It is also clear that before it is possible to create an OD-matrix, it is needed to calculate the generation/attraction of trips for the different zones. If only the total number of trips for the different purposes is known, the generation and attraction of each zone has to be calculated for the different purposes. For example the work-related trips: it is desired to have the total number of jobs existing in each zone (attraction of trips) and to have the total number of “working”-per zone (generation of trips). If such information is not known, it is needed to make assumptions about e.g. the division of trips over the different zones.

If the generation/attraction of trips is known, these trips have to be distributed. This can be done in different ways. The growth-factor method or a gravity model can be used. The main restriction for the growth-factor method is that there must be an “old” matrix available. Because an old matrix is not available, the gravity model will be used. Different functions can be used here, but the main goal is to make a distinction between the zones, that e.g. there will not be trips from zone 1 to zone 4 (because the distance is too far). When the gravity model is applied, there is an “a-priori” matrix available from where the trips can be distributed. To distribute the calculated row and column totals, the Furness method is used. This is nothing more than some sort of balancing method, to make the “actual” and the “desired” row and column totals corresponding.

7.2 Basic assumptions

This section describes the basic assumptions that are the foundations for the OD matrix. Not only will the different data sources be discussed, but also the different trip purposes that are included in the matrix.

7.2.1 Data sources

There are only two main sources available that provide the information and data for the OD-matrix. These are:

1. Census 2001; the census provides information about the population in the different wards in Stellenbosch. This makes it possible to obtain the information per TAZ. This information will be used to obtain information like number of inhabitants.

2. National Household Travel Survey 2003 (NHTS, 2005); the NHTS provides information about the travel behaviour of the whole population of South Africa. This information will be used to obtain the number of trips made for different purposes.

Both documents do sometimes contain the same sort of information. This is an opportunity to validate the used information. It is mainly information like income distribution that could be useful.

A possible obstacle is that the available data from both documents is not "filtered". All the information that is in it about Stellenbosch is all used in the OD-matrix. It is possible that certain information is inaccurate (e.g. trip length, transport mode).

The NHTS data is based on a 24hr trip-diary. That is why there is chosen for twenty-four hours OD-matrices.

7.2.2 Trip purposes

There are numerous purposes to travel, too much to include all in the OD-matrix. That is why the following subdivision is made to simplify the scope of the matrix:

1. Work,
2. Education,
3. Shopping, and
4. Other.

The modes are not chosen without a reason. These modes are (in some cases) a combination of the different purposes used in the available data. The following describes the various:

- Shopping = food shops, other shops.
- Other = traditional healer, medical services, post office/agent, welfare office, municipal office.

7.3 Methodology

The OD-matrix is built up from two layers, which are created in the following order:

- The bottom layer; these matrices show the total number of trips per purpose.
- The top layer; this matrix shows the total number of trips made from and to Stellenbosch.

All the matrices are divided in to four different parts, the numbers correspond with the following trips (see table 5):

1. Internal trips in Stellenbosch,
2. Trips originating in Stellenbosch with a destination in external zones,
3. Trips originating in external zones with a destination in Stellenbosch, and
4. Internal trips in external zones.

Table 5; empty OD-matrix

From\To	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

These parts will be the basis for the "filling in" of the matrix. First the trips in part one will be distributed, followed by part two and three. Part four will be discussed at last. How the different parts are treated, depends on the available information and trip purposes. This will be discussed in the next section.

7.3.1 Part one

Because the method used is not the same for every trip purpose, these will be separately discussed.

7.3.1.1 Work related traffic

The NHTS provides the total number of internal trips in Stellenbosch. It is needed to come up with a method to distribute these trips over the cells. Because the matrix is for 24 hours, it is needed that every "leaving" trip, must come back. That is why the total number of trips must be divided by two, then all these "home-work" trips are distributed and then the matrix will be reflected. Now both the "home-work" and the returning "work-home" trips are included and the matrix will be symmetric.

To calculate the row-targets, the assumption is made the trip-production is proportional to the most relevant variable (per ward) from the Census. Here is chosen for the total number of employed people.

To calculate the column-targets it would be ideal to have the number of jobs per zone. However, these are not available. Because of this lack of information, a division in terms of percentage is made based on personal knowledge of the area.

Now the Furness method will be used to distribute the row and column totals over the different cells. Normally an a-priori matrix is used for this method, but for Stellenbosch such a matrix is not available. The alternative is the usage of the gravity-model combined with a distribution function. This model creates values for each cell, in such a way that long trips are less attractive than short trips. The formula used to calculate these values is the following (Ortuzar, 2006): $f(c_{ij})=e^{(-\beta*cij)}$, where c is the distance as the crow flies between two zones and $\beta = 0,1$. Now the values ($f(c_{ij})$) are known for each cell in the a-priori matrix.

Finally the Furness method (method of balancing factors) can be started to calculate the number of trips for each cell. The result is the internal OD-matrix consistent with the total number of trips, origin and destination information and a distribution function. Only the reflected matrix has to be added up to get the final (internal) matrix.

Table 6 shows the percentages used for production and attraction of the work trips.

Table 6; production/attraction work trips

TAZ	production	attraction
1	20%	2%
2	16%	6%
3	21%	5%
4	4%	12%
5	12%	50%
6	12%	20%
7	15%	5%
	100%	100%

7.3.1.2 Education related traffic

Here the same method is used as with the work related trips. Only the explanatory variables for the origin and destination totals are different. On the origin side is chosen for the percentage of students per zone (derived from the Census). On the destination side the number of student places per zone is preferable but unfortunately not available. That is why a division in terms of percentage is made based on the numbers of primary, secondary and university schools. Table 7 shows these production and attraction percentages.

Table 7; production/attraction education trips

TAZ	production	attraction
1	32%	10%
2	13%	15%
3	14%	20%
4	4%	10%
5	11%	15%
6	15%	25%
7	11%	5%
	100%	100%

7.3.1.3 Shopping related traffic

Again the same method is used as with the work related trips. Only the explanatory variables for the origin and destination totals are different. On the origin side is chosen for the percentage of inhabitants per zone (derived from the Census). On the destination side the floor area of the shops per zone is preferable but unfortunately not available. Because of that a division in terms of percentage is made based on personal knowledge of the area. Table 8 shows these percentages.

Table 8; production/attraction shopping trips

TAZ	production	attraction
1	23%	19%
2	16%	5%
3	17%	5%
4	5%	5%
5	14%	48%
6	12%	14%
7	14%	5%
	100%	100%

7.3.1.4 Other traffic

Again the same method is used as with the work related trips. Only the explanatory variables for the origin and destination totals are different. Because this is a collection of different kind of purposes, it is not possible to have explanatory variables for the production and attraction of trips. That is why on the origin as well as on the destination side is chosen for the percentage of inhabitants per zone. Table 9 shows these percentages.

Table 9; production/attraction other trips

TAZ	production	attrraction
1	23%	23%
2	16%	16%
3	17%	17%
4	5%	5%
5	14%	14%
6	12%	12%
7	14%	14%
	100%	100%

7.3.2 Part two and three

The work/education trips and the shopping/other trips are not distributed in the same way. That's why they are discussed separately.

7.3.2.1 Work and education related traffic

The total number of trips originating in Stellenbosch is known from the NHTS data. Like the trips in part one of the matrix, the number is first divided by two. Because the data also tells us the destinations of the trips, the column totals are already known. The trips are divided over the cells by the percentage of inhabitants per zone. These trips are distributed over part two of the matrix.

The total number of trips originating outside of Stellenbosch are also known from NHTS data. These number of trips is also divided by two before distributing them among the cells. Because the data tells us only the origin of the trips, they are divided over part three of the matrix according to the percentage of inhabitants per zone.

Because the trips are coming from an 24 hours trip-diary, there second part of the above mentioned trips have to be distributed over the cells in part three instead of part two and vice versa. This can be easily done by reflecting the number of trips. The trips in part two and three of the matrix are now symmetrical.

7.3.2.2 Shopping and other related traffic

Unfortunately there is no information known about shopping and other trips from Stellenbosch to external places and vice versa. That is why these trips are not taken into account. If there was made an estimation for these trips, this would cause a distorted view.

7.3.3 Part four

Part four of the matrix will not be "used". Because there is no information available about the through traffic in Stellenbosch, these cells will be set to "zero". If a matrix would be estimated, this would cause a distorted view.

Possibilities to obtain these numbers of trips (as well as the shopping and other trips from/to Stellenbosch) are a cordon survey or number plate recognition. This makes it possible to match the number plates that leave and enter Stellenbosch within one day.

7.4 Resulting matrices

The resulting matrices are shown below. Table 10 shows the OD matrix for work related trips, table 11 shows the OD matrix for education related trips, table 12 shows the OD matrix for shopping related trips and table 13 shows the OD matrix for other trips.

At last the final matrix for all purposes is presented in table 14.

Table 10; work related trips

WORK		Destination												
		1	2	3	4	5	6	7	8	9	10	11	12	**Totals**
Origin	1	158	266	192	348	1598	603	163	747	403	0	749	933	6159
	2	266	399	301	310	1301	510	190	588	318	0	589	734	5507
	3	192	301	443	476	1577	625	211	759	410	0	761	949	6703
	4	348	310	476	182	492	308	260	147	80	0	148	184	2934
	5	1598	1301	1577	492	1892	1192	1081	430	232	0	431	537	10762
	6	603	510	625	308	1192	878	608	437	236	0	438	546	6380
	7	163	190	211	260	1081	608	406	537	290	0	539	671	4957
	8	747	588	759	147	430	437	537	0	0	0	0	0	3645
	9	403	318	410	80	232	236	290	0	0	0	0	0	1969
	10	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	749	589	761	148	431	438	539	0	0	0	0	0	3655
	12	933	734	949	184	537	546	671	0	0	0	0	0	4554
Totals		6159	5507	6703	2934	10762	6380	4957	3645	1969	0	3655	4554	

Table 11; education related trips

EDUCATION		Destination												
		1	2	3	4	5	6	7	8	9	10	11	12	Totals
Origin	1	1245	1079	1108	522	930	1363	360	821	219	0	541	499	8686
	2	1079	836	718	284	551	731	287	345	92	0	227	210	5359
	3	1108	718	1215	395	634	859	391	353	94	0	233	215	6214
	4	522	284	395	166	277	377	198	104	28	0	69	63	2483
	5	930	551	634	277	616	801	337	289	77	0	191	176	4878
	6	1363	731	859	377	801	1493	678	382	102	0	252	233	7271
	7	360	287	391	198	337	678	356	296	79	0	195	180	3357
	8	821	345	353	104	289	382	296	0	0	0	0	0	2590
	9	219	92	94	28	77	102	79	0	0	0	0	0	690
	10	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	541	227	233	69	191	252	195	0	0	0	0	0	1707
	12	499	210	233	63	176	233	180	0	0	0	0	0	1593
Totals		8686	5359	6232	2483	4878	7271	3357	2590	690	0	1707	1575	

Table 12; shopping related trips

SHOPPING		Destination												
		1	2	3	4	5	6	7	8	9	10	11	12	Totals
Origin	1	3178	1353	1140	522	3885	1470	916						12464
	2	1353	596	456	271	2337	715	319						6046
	3	1140	456	708	370	2517	796	360						6347
	4	522	271	370	178	876	364	242						2824
	5	3885	2337	2517	876	4351	2313	2031						18310
	6	1470	715	796	364	2313	1335	907						7900
	7	916	319	360	242	2031	907	760						5534
	8								0	0	0	0	0	0
	9								0	0	0	0	0	0
	10								0	0	0	0	0	0
	11								0	0	0	0	0	0
	12								0	0	0	0	0	0
Totals		12464	6046	6347	2824	18310	7900	5534	0	0	0	0	0	

Table 13; other trips

OTHER	Destination												
Origin	1	2	3	4	5	6	7	8	9	10	11	12	Totals
1	8076	4903	4161	1204	3939	3160	3179						28623
2	4903	3980	3116	851	2601	2014	1987						19452
3	4161	3116	4960	1163	2784	2248	2291						20723
4	1204	851	1163	377	862	723	730						5910
5	3939	2601	2784	862	2922	2248	2211						17567
6	3160	2014	2248	723	2248	2514	2465						15371
7	3179	1987	2291	730	2211	2465	4433						17297
8								0	0	0	0	0	0
9								0	0	0	0	0	0
10								0	0	0	0	0	0
11								0	0	0	0	0	0
12								0	0	0	0	0	0
Totals	28623	19452	20723	5910	17567	15371	17297	0	0	0	0	0	

Table 14; final OD matrix

FINAL	Destination												
Origin	1	2	3	4	5	6	7	8	9	10	11	12	Totals
1	12657	7601	6601	2596	10351	6596	4617	1567	622	0	1290	1432	55931
2	7601	5810	4591	1717	6789	3970	2783	932	409	0	817	944	36363
3	6601	4591	7325	2404	7512	4527	3253	1112	504	0	994	1163	39987
4	2596	1717	2404	903	2506	1773	1431	251	107	0	216	247	14151
5	10351	6789	7512	2506	9781	6554	5661	719	309	0	621	713	51517
6	6596	3970	4527	1773	6554	6219	4658	819	338	0	690	778	36923
7	4617	2783	3253	1431	5661	4658	5954	833	369	0	734	851	31145
8	1567	932	1112	251	719	819	833	0	0	0	0	0	6235
9	622	409	504	107	309	338	369	0	0	0	0	0	2659
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1290	817	994	216	621	690	734	0	0	0	0	0	5362
12	1432	944	1181	247	713	778	851	0	0	0	0	0	6147
Totals	55931	36363	40005	14151	51517	36923	31145	6235	2659	0	5362	6129	

7.5 Remarks

However, the above used method to create the OD-matrix does have some restrictions. There are several issues not taken into account, which would probably have influenced the generation and distribution of the trips. These issues will be discussed point by point:

- General;
  - Different communities do have a preference for destinations relating to certain purposes. For example: black communities are living mostly in the same TAZ, what makes it unlikely that they make social visits to another TAZ.
  - Many "short" trips, e.g. to the shop around the corner, are not registered in the trip diary. This can lower the trip-totals substantially.
- Education related trips;
  - The number of schools is used to calculate the "attractiveness" per zone. The size of the schools (or the number of students) would be more precisely.
  - In e.g. the townships a lot of education is "informal". These trips are probably not registered.
- Other trips;
  - People coming from outside of Stellenbosch are not taken into account, because the number of these trips is lacking. This is probably a substantial amount, because recreational traffic is also included in this purpose.

7.6 Verifying the OD-matrix

The final OD-matrix, based on own assumptions, should be verified with external/additional information. An OD-matrix with underlying assumptions is provided by Ninham Shand, a leading consulting firm in South Africa. This matrix is being used in a model for the traffic flows in (and around) Cape Town.

However, it encloses only the educational and work trips. The second "problem" is that the zoning used in the model is deviating from the zoning used in this research. This brings along that the numbers for the different zones could differ because the zones are not exactly the same.

The second "problem" is the used mode-choice. In the Ninham Shand-model is another selection of transport modes used. A redistribution to fit the selection of modes used in this research would probably cause a loss of trips.

The next restriction/difficulty of the Ninham-Shand model that has to be dealt with is the time span. It is based on the AM-peak period, whereas the OD-matrix used in this research is based on the trips made during a whole day.

The last difficulty is that both models are based on different years. The Ninham Shand-model has data for the year 2004, whereas this model has data for the period 2001-2003. Because there is roughly no difference, this difficulty will not be taken into account.

Because the only available control data differs too much from the data and method used here, no verification of the OD-matrices took place. If it was done with all the needed assumptions, this would cause a distorted picture of the actual situation. This won't add any value to the results of this research.

8 NMT potential

This chapter elaborates on the OD-matrix created in the previous chapter. It will be made clear what NMT could mean for the city of Stellenbosch and what the effects are on the distribution and modal split of the traffic. First some important characteristic of the different transport modes will be discussed, followed by some basic assumptions and factors that influence the use of NMT. The chapter ends with the "new" modal split of the traffic in Stellenbosch to compare it with the "old" version.

8.1 NMT to important places

To see where the potential use of NMT is situated, destinations have to be known, as well as important characteristics of pedestrians and cyclists. Moreover, important environmental factors need to be indentified. This section describes these issues and it shows where low speed traffic has potential.

8.1.1 Characteristics of travel modes

Some important characteristics of pedestrians and cyclists (and motorised modes) have to be known to create a good view of the (potential) trips. Table 15 shows the most important characteristics.

Table 15; average speed (Behrens, 2002) + distances (CROW)

Mode	Average speed (km/h)	Max. distance (km)	Travel time (minutes)
Walking	4	2	30
Cycling	16	5 (2 for shopping)	19 (8)
Train	40	---	---
Bus	30	---	---
Motor cars	30	---	---
Minibus Taxi's	30	---	---

The table shows that trips < 5 km can be made by bicycle, except the shopping trips that can only be made by bicycle it they're <2 km. Trips for pedestrians get uncomfortable it they're > 2km. However, the maximum distance for cycling is often fixed at 7,5 km in literature.

8.1.2 NMT influence factors

The use of NMT is influenced by many factors. Not only the environment but also the population itself does influence the use of NMT. These different factors will be discussed in this section. Also the existing NMT routes will be indicated.

8.1.3 Environmental factors

An important factor influencing the use of NMT is the slope of the landscape. A steep road is more uncomfortable for cyclists than for pedestrians. Small slopes are not a problem for cyclists if they are not too long. Pedestrians usually have fewer problems with slopes: if slopes are too steep, facilities such as stairs can be built. Figure 35 shows a contour map of the Stellenbosch area (with 20 m lines). Even though the map is not very detailed, it can be said (also from site visit) that the city of Stellenbosch has minimal differences in height. This means that the city is very attractive for the use of the bicycle.

A different environmental factor is the visibility in the city. There is not much overgrowth and the present vegetation is generally low cover. Together with the high number of low rise-building it makes the city very convenient which should mean a safe environment for NMT.

Weather conditions are also very important for the mode choice of travellers. Rain and wind are the main enemies for pedestrians and cyclists. The uncertainty about weather conditions also prevents people from using NMT.

8.1.4 Personal factors

Aside from environmental factors, there are also personal factors affecting the NMT behaviour. The most important one is probably the income of a household. As was mentioned earlier, the purchasing costs of a (used) bicycle are as high as the costs for the use of a minibus-taxi for two months (Phayane, 2002)

The age of inhabitants is also a determining factor: young people are not allowed to used motorised transport where elderly people are not be able to use transport modes as cycling and walking.

The people with the higher incomes on the other hand, will probably never use the bicycle to travel. They have enough money to pay for their cars, their parking facilities and their petrol. They will always choose the most comfortable and easy way of travelling, no matter what the costs are.

Other personal factors that influence the NMT behaviour of people are things like age and health. Older people for example are less healthy and are not be able to ride on a bicycle, what makes them committed to motorised transport.

Other people are committed to motorised transport because they live too far outside of the city, what makes the trips too long for cycling.

8.2 Present NMT-routes

Figure 36 and 37 show a map with the movement of pedestrians (per hour) in the centre of Stellenbosch on a weekday and a weekend day (Arup, 2007). It shows that most of the pedestrian movements are made in the city centre, in the university area and student residences. Furthermore, many movements are made in the touristic shopping area.

Pedestrian movements from the surrounding suburbs into the city haven't been mapped as well. Many pedestrians will come from the township of Kayamandi.

8.3 Important places

Many places in Stellenbosch are possible attractors of NMT. Examples are places like schools, shopping centres and business area's. What the reach of these areas is regarding NMT-modes, is shown in figures 38 and 39. The schools, university and the main shopping centres are marked with several distance indicators. There is chosen for 400, 1000, 2000 and 5000 meters and the additional 7,5 km. 400 and 1000 meters are chosen to show the coverage of the pedestrian network for short distances. A different map for business and work areas is not made, because the reach of the bicycle network is already sufficiently given in the "shopping" map. The figures make clear that the different NMT-modes cover (almost) the whole city. Most of the residential areas have the potential to walk to educational institutes. The 5km-bicycle line is not showed in the education figure, but from figure 39 it is clear that the whole city could be covered by bicycles.

The shopping malls are also fully covered by the 5-km bicycle line. However, trips to supermarkets can not be longer than 2 km according to the literature. As local supermarkets are not marked on the map, it can be concluded that the potential for NMT use will cover the whole city for the purpose of

shopping. These local supermarkets are spread out over the whole city. Even though the business and work areas are not indicated on the maps, it is also clear that they could be reached by bicycle from (almost) every location in the city.

It can be concluded that all internal traffic could be accommodated with non-motorised transport. This means that only the through traffic and the traffic to external zones should use motorised modes. When the maximum distance of 7,5 km for cyclists is used (see figure 39), it can be seen that the whole city is covered.

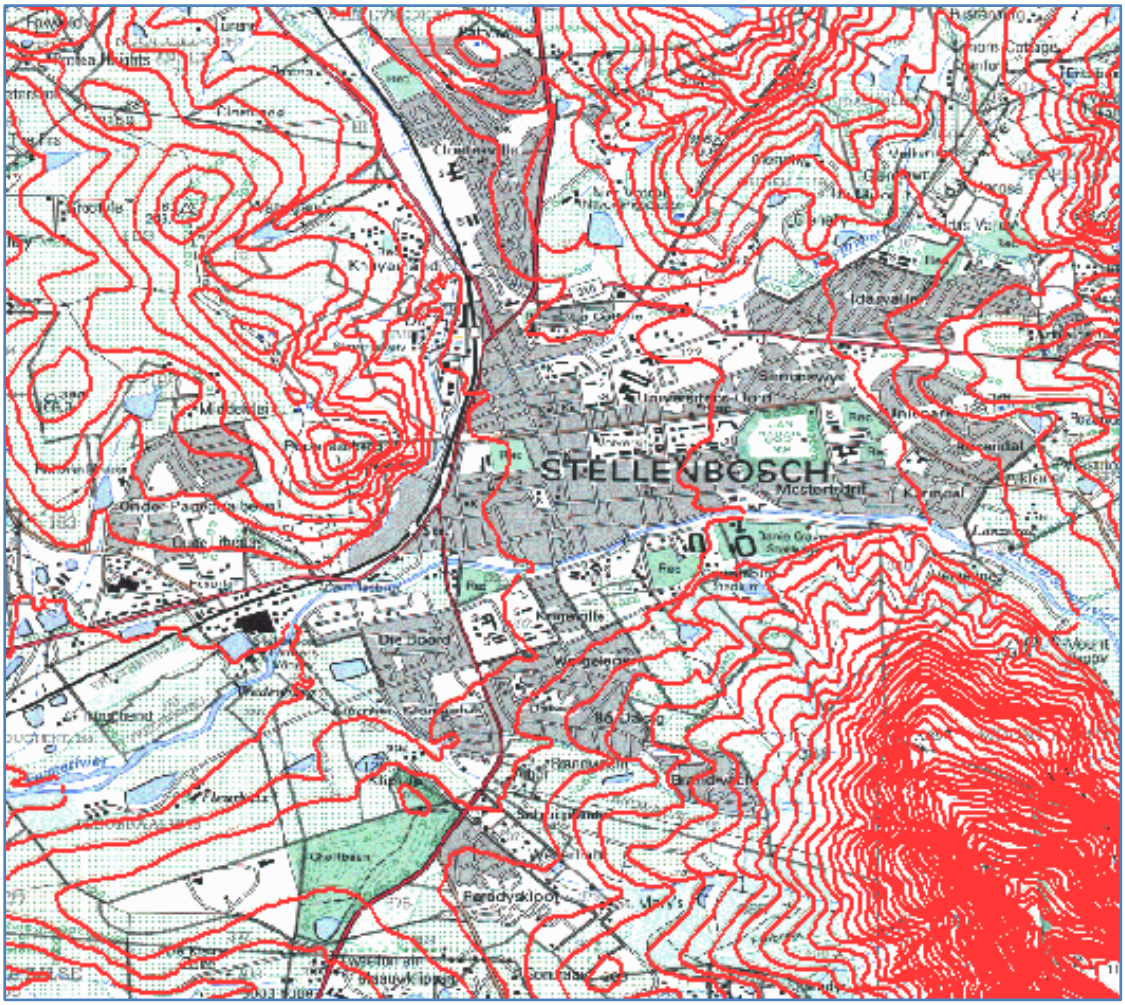


Figure 35; contour map Stellenbosch

Figure 36; pedestrian movement weekday (Arup)

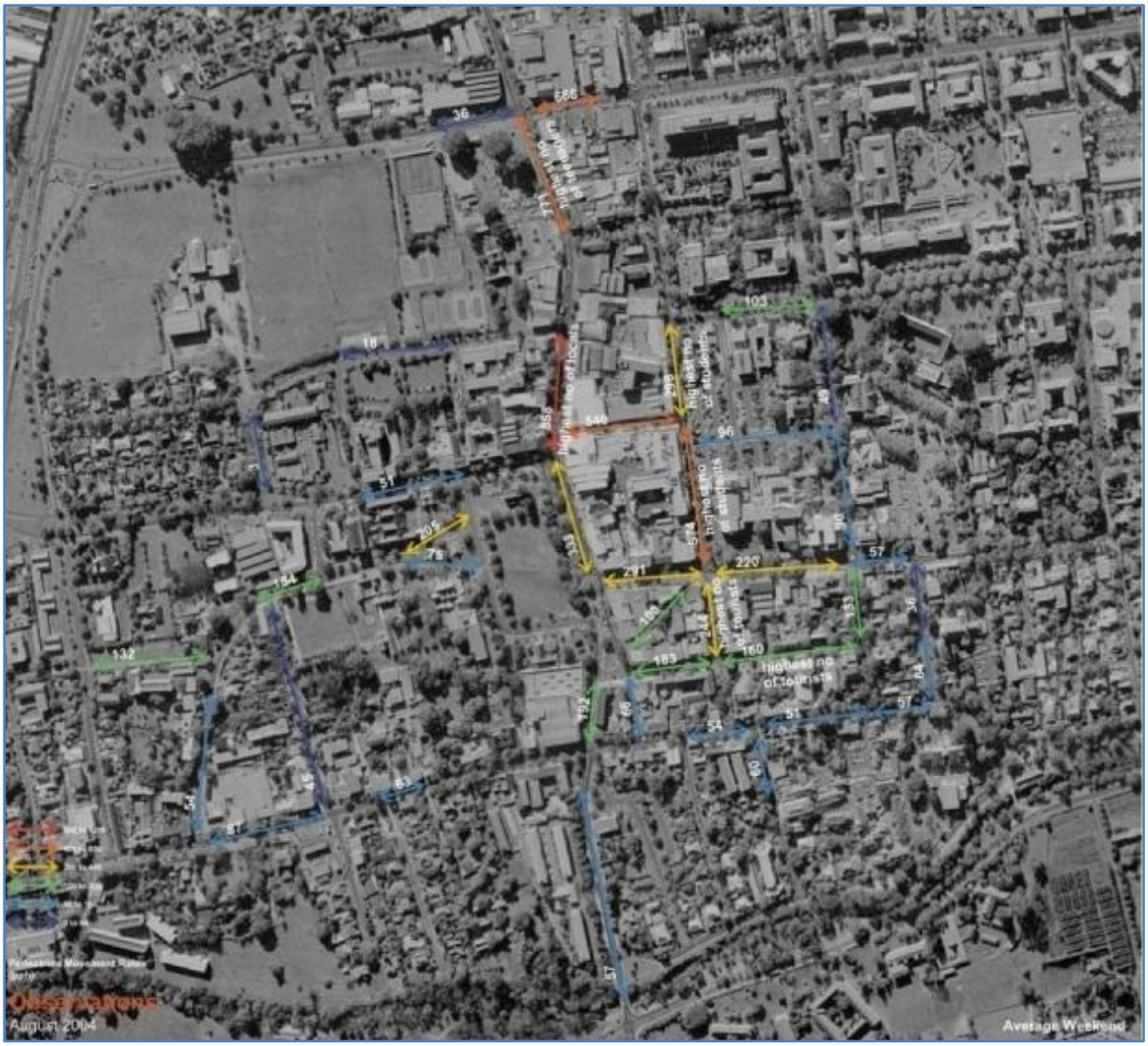


Figure 37; pedestrian movement weekend (Arup)

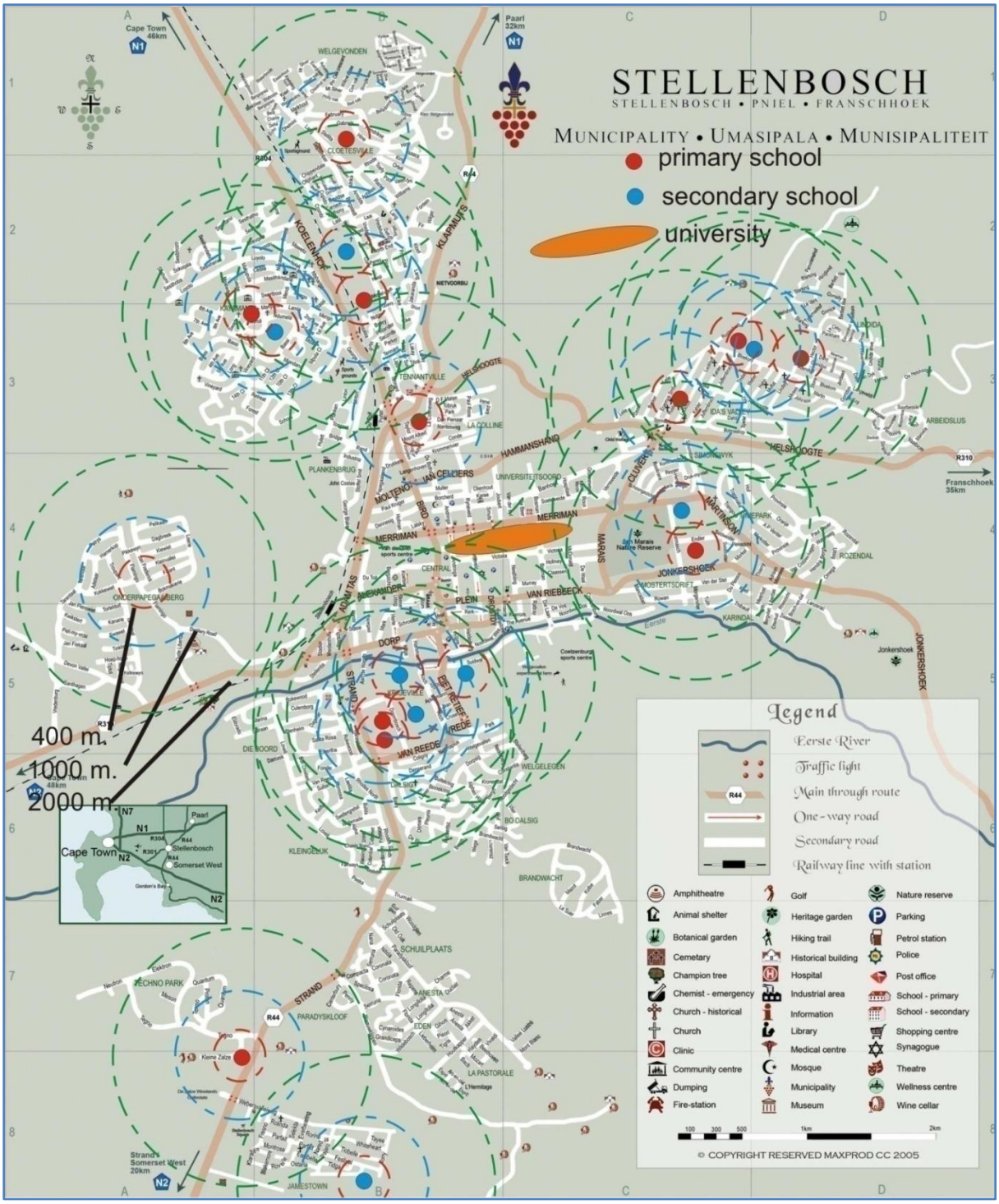


Figure 38; educational institutions Stellenbosch

Figure 39; shopping locations Stellenbosch

9 Potential NMT-trips

Now that it is known what the important characteristics of travellers are, as well as which factors influence the mode choice and how many trips are made, it is possible to see what the potential for NMT is. According to the OD matrix from chapter 7 and some new assumptions made here, it will be made clear how this potential is measured and calculated.

9.1 Vehicle ownership

Now the ownership of bicycles and motorised vehicles are divided regarding to income-groups. Chart 13 and 12 show these divisions.

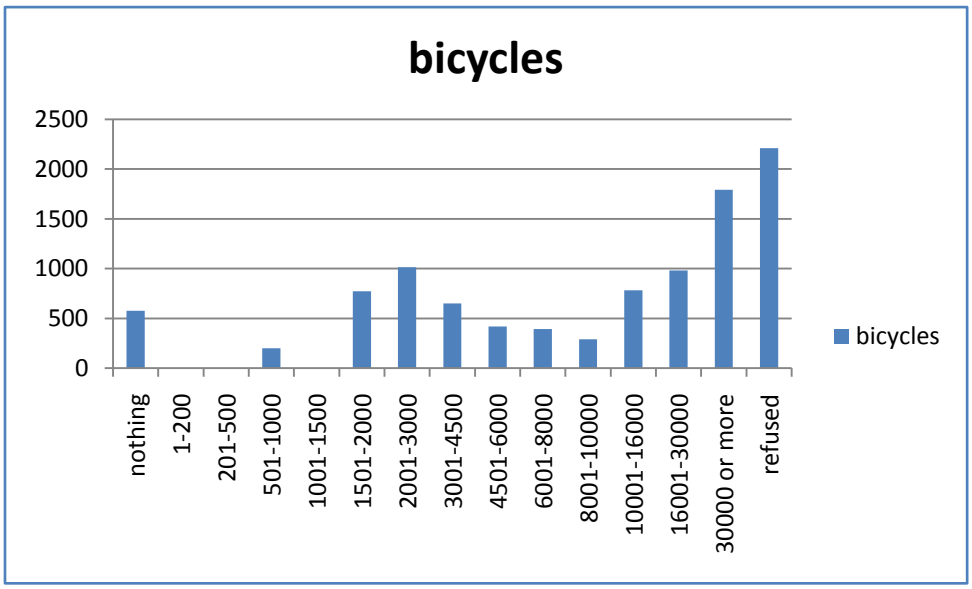


Chart 13; bicycle/income distribution

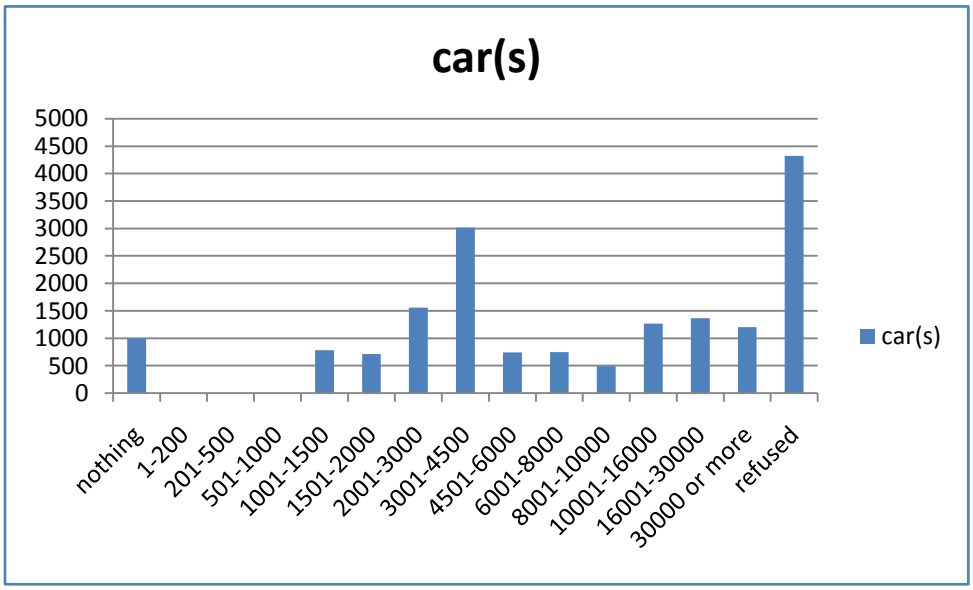


Chart 12; motorised vehicle/income distribution

It is clear to see that most of the ownership of bicycles is situated under incomes higher than R1500 per month. These people have always direct access to bicycles and are expected to use it when desirable. What has to be mentioned again is that people from lower income groups can purchase a bicycle for the same costs of the use of a minibus for four months.

Car ownership is another case, with some more obstacles. It is known that car ownership starts from an income of R3000 per month or higher. Between R3000 and R6000 rand are the owners of cars who are sensitive to alternatives and above an income of R6000 per month most of the people have a car and use them most of the times. These people are not sensitive to make use of e.g. bicycles. That most of the car ownership is located in the income groups starting around R3000, can also be seen in chart 12.

9.2 Assumptions

Keeping in mind the information about vehicle ownership, the properties of transport modes and the maximum distances that can be travelled by each mode, the following (new) assumptions are made to see which trips could be transferred to NMT:

- Public transport will be unaffected (this type of transport should be encouraged).
- Motorised trips shorter than 7,5 km could be made by bicycle
    - Motorised trips from an income above 6000 rand per month will stay motorised.
- For shopping trips the maximum cycling distance is set at 3,5km.
- (motorised trips shorter than 2km could be walked)
- (walking trips longer than 2km could made by bicycle)

Walking trips will also be unaffected, because the distinction between motorised and non motorised is more important than the distinction between e.g. walking and cycling.

9.3 Current situation and future situation

It is known that at the peak periods the city is congested at some places and that accidents occur often. From the OD-matrix the “current” modal split for Stellenbosch could be obtained. Table 16 shows the values for the different modes, for the different purposes and for the subdivision into NMT, motorised transport (MT) and public transport (PT).

To make it possible to transfer the modes of certain trips, it was necessary to adapt the available data from the NHTS. Because only the travel time for each trip was known, the average speed of the different modes was used to calculate the travel distance for all the trips (as per Behrens, 2002). After the distances were known, it was possible to assign a new mode to the trips (if the mode could be changed).

The new situation is also shown in table 16, to make it easy to see the difference and effect of the transferred trips.

Table 16; modal split/NMT potential

TOTAL TRIPS	NEW	OLD	TOTAL TRIPS
walking	24.71%	25.05%	walking
cycling	21.87%	2.32%	cycling
bus	0.35%	0.38%	bus
train	3.65%	3.63%	train
minibus	17.28%	24.04%	minibus
car	30.54%	42.57%	car
other	1.59%	1.99%	other

WORK_EDU			WORK_EDU
walking	32.2%	33.2%	walking
cycling	12.8%	2.7%	cycling
bus	0.3%	0.3%	bus
train	9.5%	9.3%	train
minibus	8.3%	9.3%	minibus
car	32.4%	39.7%	car
other	4.5%	5.6%	other

SHOP_OTHER			SHOP_OTHER
walking	20.62%	20.57%	walking
cycling	26.82%	2.11%	cycling
bus	0.40%	0.45%	bus
train	0.49%	0.49%	train
minibus	22.15%	32.22%	minibus
car	29.52%	44.15%	car
other	0.00%	0.00%	other

NMT	46.6%	27.4%	NMT
MT	49.4%	68.6%	MT
PT	4.0%	4.0%	PT
	100%	100%	

Table 16 shows some interesting numbers. The effect on the total trips is great: an increase in the use of NMT of almost 20 percent (and a corresponding decrease in the use of MT). It is striking that the greatest profit is made by the shopping and other trips (almost 25 percent) and not by the working and education trips (almost 10 percent). This is striking because there are more "restrictions" for these trips before they can be made by other modes. E.g. shopping trips can only be made by bicycle if they are shorter than 2-3,5 km.

On the other hand, it is obvious because these trips often stay within the city, where the work and educational trips originate more often outside of Stellenbosch (what makes the distances too long to travel by NMT). That does not alter the fact that there may be enough opportunities to create an even more non-motorised city centre when measures are taken on the city boundaries to transfer the trips to e.g. public transport or non motorised transport. It must be possible to get people to proceed their trip by another mode.

10 Conclusions and recommendations

This chapter deals with the conclusions and recommendations of the research. It examines successively the analyses of Stellenbosch and Houten, the created OD-matrix and the NMT potential. It will be made clear what the main conclusions are, what should be done better next time and what could be done in further research.

10.1 Stellenbosch and Houten

In this section the cities of Stellenbosch and Houten are discussed. Chapter three, four and five are of most importance for the conclusions and recommendations made here.

10.1.1 Conclusions

The analyses and comparison of both cities has made clear how the cities look like and how similar they are to each other. This was done to see to what extent the structure and design of Houten could be used in the city of Stellenbosch.

The high accident rate of Stellenbosch shows that there is something at fault in the design of the road network. It became clear that particularly the cars cause many problems, not only regarding accidents but also regarding congestion and accessibility of the city centre.

One of the most important differences between Houten and Stellenbosch are probably the difference in age distribution, where Stellenbosch has far more people in the age groups < 30. Furthermore, the excellent facilities for cyclists and pedestrians are a great contribution to the situation in Houten.

10.1.2 Recommendations

To see how the “idea of Houten” could actually be used in Stellenbosch, it is useful to carry out a SWOT analysis for both cities. Despite that this has not been done yet, it is already possible to give some recommendations regarding the improvement of the situation in Stellenbosch.

The presence of a big group of young people requires a different approach than for older people. Younger people need more education on how to behave in the traffic, whereas older people have more experience to do so on their own.

What makes the difference in Houten is that the exclusion of motorised transport in different areas needs to be adapted in some way in Stellenbosch. It has advantages regarding e.g. the parking problems in the centre, the safety for NMT and for congestion in the city centre. It’s obvious that a lower number of cars increases the attractiveness of NMT.

Of course there have to be taken measures regarding the arrangement of roads and facilities for e.g. cyclists to make it possible to use the roads. Consideration should be given to cycling paths, road signs and perhaps adaption of traffic (right of way) rules.

10.2 OD-matrix

In this section the OD-matrices are discussed. Chapter seven is of most importance for the conclusions and recommendations made here. It mainly discusses the creation of the OD matrix.

10.2.1 Conclusions

Due to a lack of information and data it was not possible to create a correct OD-matrix. Many trips are not considered because the purposes (e.g. recreation, family visits) can not be found in the available data sources. Also a part of the trips (shopping and other related trips into Stellenbosch) are not available from the data sources.

There is also a lack of information about the different zones, to calculate the production and attraction of these zones more accurately. Information like the number of jobs per zone, number of student places per zone or the total surface of shopping grounds per zone are desired to calculate the attractiveness for each zone.

Maybe the most important conclusion is that an OD-matrix of this quality can not be used to model the traffic flows in a modelling program like “OmniTrans”. It has to be more accurate qua number of trips as well as qua distribution of these trips. It would give an incorrect impression of the situation, with maybe great consequences such as an even worse situation when measures are taken.

10.2.2 Recommendations

It is clear that a lot of additional information and data should be collected to create more accurate OD-matrices. Not only information on the attraction side, but also on the production side of the matrix. When a subdivision has to be made regarding different modes, additional information has to be known e.g. about travel behaviour of different communities. There should be paid more attention to an up-to-date database with socio-economic data.

What also of importance is, is the time frame used for the matrix. This has not only to do with the use of the matrix (for traffic flows in e.g. peak hours or during the whole day), but also with the data sources used. The NHTS is based on a travel-diary for a whole day, where e.g. the only available control model is based on the morning peak. When different sources with differing time frame are used together, there will always be (unnecessary) uncertainty. This has to borne in mind during the whole process. This means that there should be some sort of standard to validate traffic flows/OD-matrices more easily.

For modelling the traffic flows with a program like “OmniTrans” it also necessary to have a network of Stellenbosch. Currently there is nothing useful available, only a network with the main roads. To model the internal traffic flows, it is necessary to have a network with all the roads of Stellenbosch with the corresponding properties of these roads.

10.3 Potential NMT-use

In this section the potential for NMT is discussed. Chapter eight and nine are of most importance for the conclusions and recommendations made here. It discusses primarily the potential for NMT, but also the considerations for the implementation of a higher use of NMT.

10.3.1 Conclusions

In spite of an invalid OD-matrix, it is still shown that there is great potential for non motorised transport. The numbers used to calculate the NMT potential have no link with the OD-matrix, but only with the trip totals. The only "obstacle" could be the assumptions made. Nevertheless, table 17 gives the different values again.

Table 17; NMT potential

NMT	46.6%	+ 19.2 %	27.4%	NMT
MT	49.4%	- 19.2 %	68.6%	MT
PT	4.0%	----------	4.0%	PT
	100%		100%	

A gain of almost 20 percent is enormous and would hold great advantages for the city. As was mentioned previously, it will bring improvement to the safety in the city, to the flow of the traffic and also to the cityscape. A city with less motorised and more non motorised traffic makes the city more attractive and gives it a good view.

10.3.2 Recommendations

To convert the NMT potential into a real mode choice change, many things have to change. Not only the facilities for e.g. cyclists have to be considered. If the city is adapted to accommodate the higher use of NMT, there has to be developed some sort of policy to get people to use bicycles. This is of high importance, because it can make the whole project/process fail or succeed.

The "low" (9.1 percent) benefit for work and educational trips could be increased if the correct measures are taken. If for example car parks are created on the border of the city and the possibility is offered to transfer to (free) public transport or (free) rental-bikes, there is a new potential NMT group.

Many trips from the income groups < R3000 per month are part of the NMT potential. However, chart 11 shows that the lower income groups have almost no bicycles in their possession. This shows that these people should have the opportunity to obtain a bicycle for a low amount of money. To convince these people to buy a bicycle, they should be advised about the opportunities and the low costs with respect to e.g. the use of minibuses.

References

Arup and Axios consulting (16 April 2007), *Stellenbosch Town Transport Master Plan* [Electronic version].

Beaujon, O. (n.d.). Biker's paradise: Houten (pop. 52000). *Bike Europe, 10-11,* [Electronic version].

Behrens, R. (2002).

Centraal Bureau voor de Statistiek (2008), *Gemeente op maat 2006; Houten,* [Electronic version].

City of Cape Town (2005). *CITY OF CAPE TOWN: NMT POLICY AND STRATEGY* [Electronic version].

CROW (1996), *Recommendations for traffic provisions in built-up areas, ASVV.*

Department of Civil Engineering (January 2008), *Stellenbosch Town NMT Research Proposal,* University of Cape Town [Electronic version].

Department of Transport, Republic of South Africa (2005), *National Household Travel Survey 2003* [Electronic version].

Houten Municipality (23-04-2008), *Presentatie gemeente Houten*

Jong, H. de, and Bosch, T. (February 1992). Houten, model voor de toekomst. *Verkeerskunde, 2, 16 -21.*

Municipality of Stellenbosch (April 2005). *Greater Stellenbosch; 2002-2006 integrated development plan.* [Electronic version].

Phayane, (2002), *document name unknown*

Ortuzar, J. de Dios & Wllumsen, L.G. (2006), *Modelling Transport,* West Sussex: John Wiley & Sons Ltd

Statistics South Africa (2003), *Census 2001* [Electronic version].

Vanderschuren, M. (2005), *CAN documentation,* University of Cape Town.

Vanderschuren, M. (n.d.), *Cycling Academia Network: Enabling People and Alleviating Poverty.*

Websites:

I-CE, www.cycling.nl, opened 25-04-2008

Gemeente Houten, www.houten.nl, opened 05-05-2008

Pro-Poor Tourism Pilots in Southern Africa, www.pptpilot.org.za, opened 12-05-2008

Annex 1; data Census 2001

	WARDS																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
Population group																			
African	3 088	728	1 044	482	126	1 413	182	1 542	8 217	4 505	417	64	149	63	62	71	928	1 107	24 188
Coloured	3 794	7 014	6 828	5 950	1 243	5 412	997	26	170	161	8 023	7 333	785	166	852	5 237	7 804	5 725	67 520
Indian	8	6	9	10	15	6	19	0	0	0	12	27	15	9	7	78	8	10	239
White	1 423	382	1 301	947	4 473	468	5 067	3	8	7	274	246	2 891	3 960	3 470	21	693	126	25 760
Total population	8 313	8 131	9 182	7 389	5 856	7 299	6 264	1 570	8 395	4 673	8 725	7 670	3 838	4 198	4 392	5 408	9 434	6 969	117 706
Gender by age																			
Males 0 to 4	378	381	480	330	177	399	123	78	408	222	378	333	51	9	66	216	423	288	4 740
Males 5 to 14	783	918	963	699	453	789	402	150	618	411	876	675	126	27	228	456	1 008	729	10 311
Males 15 to 34	1 521	1 368	1 527	1 296	894	1 344	1 353	384	2 181	1 131	1 503	1 395	1 635	1 494	780	906	1 632	1 275	23 619
Males 35 to 64	1 104	1 143	1 479	1 119	1 035	1 044	897	159	957	534	1 269	1 077	228	87	549	846	1 443	1 128	16 098
Males 65 +	195	138	156	156	243	90	189	18	69	27	192	159	39	36	195	132	123	138	2 295
Females 0 to 4	444	378	450	339	171	375	138	78	405	219	366	345	51	6	66	195	423	279	4 728
Females 5 to 14	870	888	912	747	432	753	357	141	630	408	876	663	102	18	216	417	987	654	10 071
Females 15 to 34	1 602	1 485	1 701	1 335	993	1 338	1 452	390	2 193	1 224	1 680	1 515	1 218	2 232	1 395	993	1 728	1 188	25 662
Females 35 to 64	1 203	1 272	1 359	1 176	1 197	1 044	1 020	165	858	471	1 386	1 278	312	126	681	996	1 491	1 113	17 148
Females 65 +	219	165	150	189	258	123	333	9	72	27	192	234	75	162	216	252	177	177	3 030
Males Total	3 981	3 946	4 606	3 599	2 808	3 664	2 966	787	4 236	2 322	4 223	3 640	2 078	1 657	1 817	2 554	4 631	3 556	57 071
Females Total	4 332	4 185	4 576	3 790	3 048	3 635	3 298	783	4 159	2 351	4 502	4 030	1 760	2 541	2 575	2 854	4 803	3 413	60 635
Age																			
0 to 4	822	759	930	669	348	774	261	156	816	438	747	678	105	15	132	408	843	567	9 468
5 to 14	1 650	1 806	1 875	1 449	888	1 542	759	291	1 245	822	1 755	1 338	228	48	444	876	1 998	1 380	20 394
15 to 34	3 120	2 853	3 231	2 634	1 887	2 682	2 802	768	4 374	2 355	3 186	2 907	2 856	3 723	2 175	1 896	3 360	2 463	49 272
35 to 64	2 307	2 415	2 841	2 292	2 232	2 091	1 917	327	1 815	1 002	2 655	2 352	540	216	1 230	1 845	2 931	2 241	33 249
65 +	414	303	309	345	501	216	525	27	144	54	384	396	114	198	411	381	297	318	5 337

	WARDS																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
Highest education levels attained by over 20 year olds																			
No schooling	450	375	636	375	90	438	147	63	489	150	312	177	15	0	6	87	285	195	4 290
Some primary	1 110	1 167	1 671	1 098	285	1 179	180	138	1 056	450	1 113	591	75	12	54	345	1 020	741	12 285
Complete primary	459	504	561	447	90	462	69	87	471	264	645	468	45	6	33	282	510	390	5 793
Secondary	1 785	1 827	1 473	1 224	372	1 539	417	429	2 400	1 281	2 124	2 115	369	63	321	1 545	2 052	1 875	23 211
Grade 12	855	750	615	813	771	402	1 308	186	930	639	885	1 272	1 500	1 695	825	825	1 116	801	16 188
Higher	429	216	516	531	2 454	261	2 280	48	150	132	228	276	927	1 089	1 776	525	672	351	12 861
Annual household income																			
None	279	93	42	30	96	126	327	36	300	144	72	24	693	261	240	87	93	57	3 000
R1 - R4 800	105	33	42	18	12	45	33	21	93	57	33	12	30	18	15	21	24	12	624
R4 801 - R9 600	327	147	213	96	24	183	75	42	348	147	117	54	84	30	27	96	120	99	2 229
R9 601 - R19 200	420	336	522	246	75	402	111	93	540	270	243	138	198	39	48	102	324	165	4 272
R19 201 - R38 400	447	507	717	510	201	522	207	93	459	255	534	303	222	54	81	312	486	279	6 189
R38 401 - R76 800	315	324	366	438	321	279	366	45	171	120	507	504	201	96	171	309	498	372	5 403
R76 801 - R153 600	180	120	165	213	399	99	438	12	66	21	234	354	141	63	261	270	351	255	3 642
R153 601 - R307 200	81	48	96	129	462	36	372	3	9	3	39	114	42	48	246	120	141	51	2 040
R307 201 - R614 400	30	15	54	33	279	9	159	0	9	6	12	21	21	21	114	6	36	9	834
R614 401 - R1 228 800	21	6	9	15	60	6	45	0	0	0	9	3	3	12	51	6	12	0	258
R1 228 801 - R2 457 600	0	3	6	6	39	6	24	0	0	0	3	3	3	6	21	3	3	0	126
R2 457 600 +	3	3	6	12	42	0	15	0	0	0	9	0	0	3	18	0	12	3	126
Labour force																			
Employed	2 865	3 102	4 293	3 414	2 652	2 817	2 514	447	2 598	1 461	3 171	2 913	1 080	627	1 410	2 121	3 720	2 325	43 530
Unemployed	711	513	243	168	72	663	54	357	2 091	996	675	660	87	12	48	381	594	627	8 952
Not economically active	1 881	1 683	1 563	1 377	1 455	1 305	2 187	294	1 533	912	2 037	1 719	2 235	3 303	1 980	1 269	2 019	1 788	30 540
Total labour force	3 576	3 615	4 536	3 582	2 724	3 480	2 568	804	4 689	2 457	3 846	3 573	1 167	639	1 458	2 502	4 314	2 952	52 482

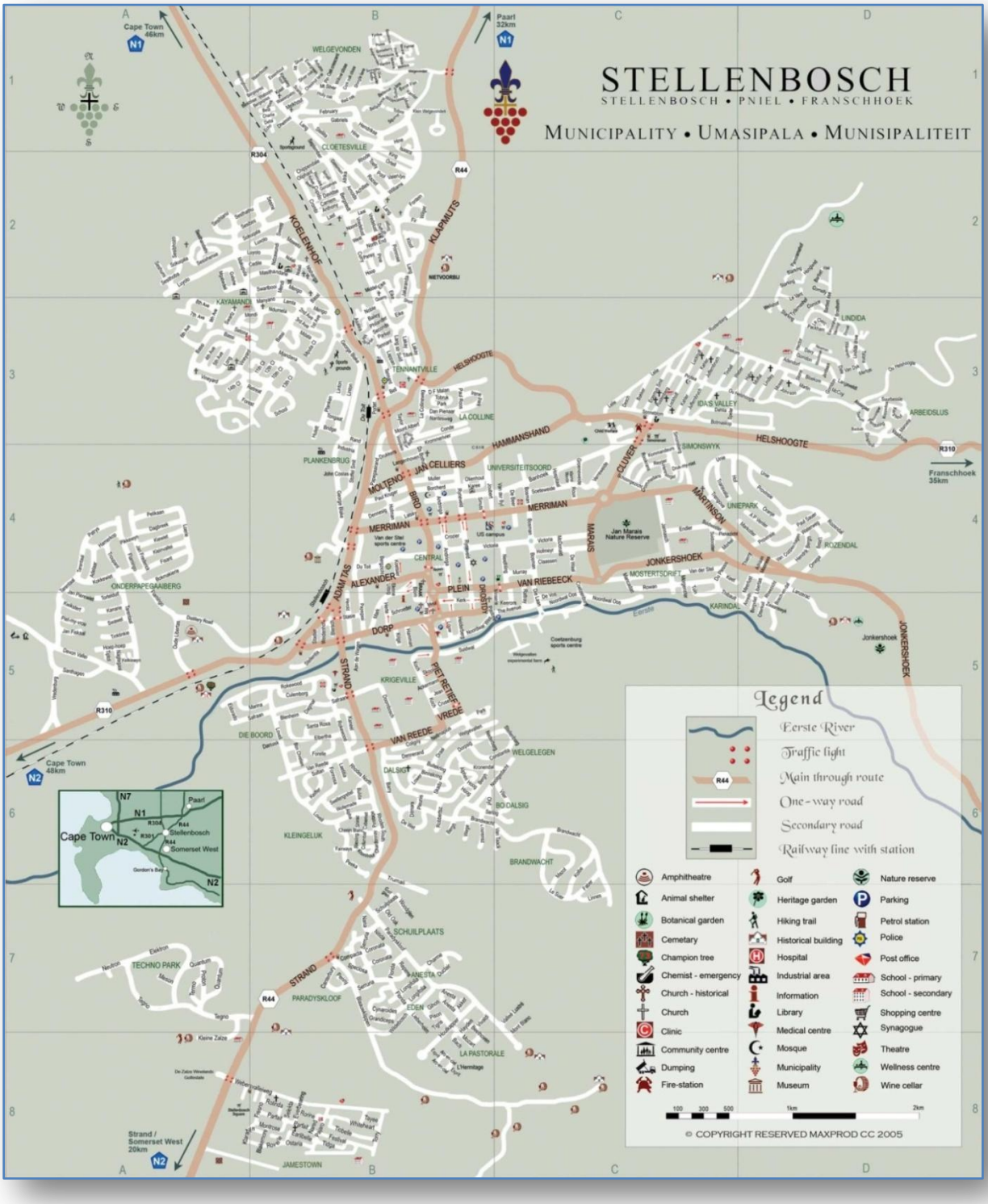
	WARDS																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
Industry																			
Agriculture / Forestry / Fishing	990	1 242	2 391	1 398	267	981	297	33	318	108	606	99	30	15	45	54	804	375	10 053
Community / Social / Personal	261	327	267	282	723	171	789	75	264	267	468	729	360	252	570	513	675	339	7 332
Construction	279	210	87	93	90	210	63	36	231	96	165	195	24	6	36	147	234	123	2 325
Electricity / Gas / Water	18	18	0	0	3	3	9	3	6	6	12	9	0	0	3	3	12	3	108
Financial / Insurance / Real Estate / Business	105	108	177	144	516	102	426	30	186	93	264	252	177	135	243	192	273	111	3 534
Manufacturing	267	309	543	432	336	669	228	63	366	204	360	411	99	39	144	243	510	603	5 826
Mining / Quarrying	0	0	6	3	6	15	9	0	3	3	3	12	0	0	3	3	3	0	69
Other	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	6
Private households	279	225	231	273	126	180	84	63	273	153	234	132	18	3	57	111	300	42	2 784
Transport / Storage / Communication	33	51	45	63	57	66	42	12	36	21	75	84	21	15	36	75	93	72	897
Undetermined	174	168	255	429	288	132	267	78	420	228	396	459	144	54	141	375	216	144	4 368
Wholesale / Retail	498	483	375	366	291	303	321	72	522	303	612	549	210	117	177	435	624	525	6 783
Occupation																			
Craft / Trade	252	261	147	234	84	255	69	51	225	150	339	363	42	9	63	237	354	255	3 390
Elementary	1 527	1 620	2 757	1 767	474	1 653	363	189	1 188	573	1 326	813	90	15	114	513	1 530	918	17 430
Legislators / Senior officials	177	90	177	159	342	111	324	6	30	18	81	90	93	69	144	69	198	54	2 232
Unspecified / Not economically classified	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plant / Machine operators	144	198	240	201	45	219	45	30	165	108	222	186	24	6	36	132	234	228	2 463
Professionals	93	63	135	156	897	51	750	6	27	18	108	135	219	207	510	132	195	69	3 771
Service workers	258	348	234	174	168	129	255	51	366	261	324	312	174	129	126	195	270	210	3 984
Agricultural / Fishery	174	153	174	141	45	111	33	9	105	51	120	21	6	0	9	9	126	33	1 320
Technicians	75	105	138	156	261	75	273	15	57	45	144	300	123	81	171	258	288	198	2 763
Undetermined	96	147	198	246	204	105	135	78	375	201	252	228	150	57	120	246	153	114	3 105
Clerks	105	153	180	258	174	117	288	21	87	51	282	483	159	60	162	363	402	255	3 600

	WARDS																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
Language																			
Afrikaans	4 599	7 446	7 758	6 402	4 704	5 937	4 791	48	243	198	8 433	7 428	2 895	3 369	3 633	5 070	8 487	5 820	87 261
English	720	258	555	549	987	189	1 245	6	18	3	126	213	780	729	651	309	528	222	8 088
IsiNdebele	0	0	12	0	3	0	0	0	0	0	3	0	0	0	0	0	0	3	21
IsiXhosa	2 769	360	666	264	51	1 020	69	1 473	7 746	4 308	138	18	54	12	12	15	354	894	20 223
IsiZulu	24	3	6	3	3	9	6	3	12	18	6	3	9	9	3	0	24	0	141
Sepedi	21	0	3	0	0	12	0	0	9	0	0	0	0	3	0	0	6	3	57
Sesotho	147	57	144	117	9	120	6	36	327	129	9	0	9	6	6	0	6	15	1 143
Setswana	3	0	0	0	0	0	3	0	21	0	3	3	6	3	3	0	0	6	51
SiSwati	0	0	0	3	0	0	3	0	12	9	0	0	3	0	0	0	0	0	30
Tshivenda	6	3	0	0	3	0	0	0	0	0	3	3	0	0	0	0	0	0	18
Xitsonga	0	0	0	3	3	6	0	3	3	3	0	3	3	3	3	3	0	0	36
Other	21	3	33	39	96	9	147	0	0	3	9	9	84	66	84	6	27	3	639
Disability																			
Sight	72	78	90	36	27	207	42	6	90	48	48	132	57	39	27	42	72	18	1 131
Hearing	189	48	54	30	39	108	30	3	51	27	36	84	24	30	12	39	42	24	870
Communication	24	15	21	3	15	27	3	3	9	6	18	39	6	9	3	12	12	15	240
Physical	99	84	126	48	42	87	123	15	72	33	120	72	18	24	21	72	114	60	1 230
Intellectual	36	24	48	24	30	57	48	9	24	6	45	66	6	12	9	24	30	57	555
Emotional	87	30	54	12	18	69	15	6	66	15	63	63	15	12	18	21	24	30	618
Multiple	183	18	48	21	102	105	30	0	30	15	45	135	6	42	3	18	18	6	825

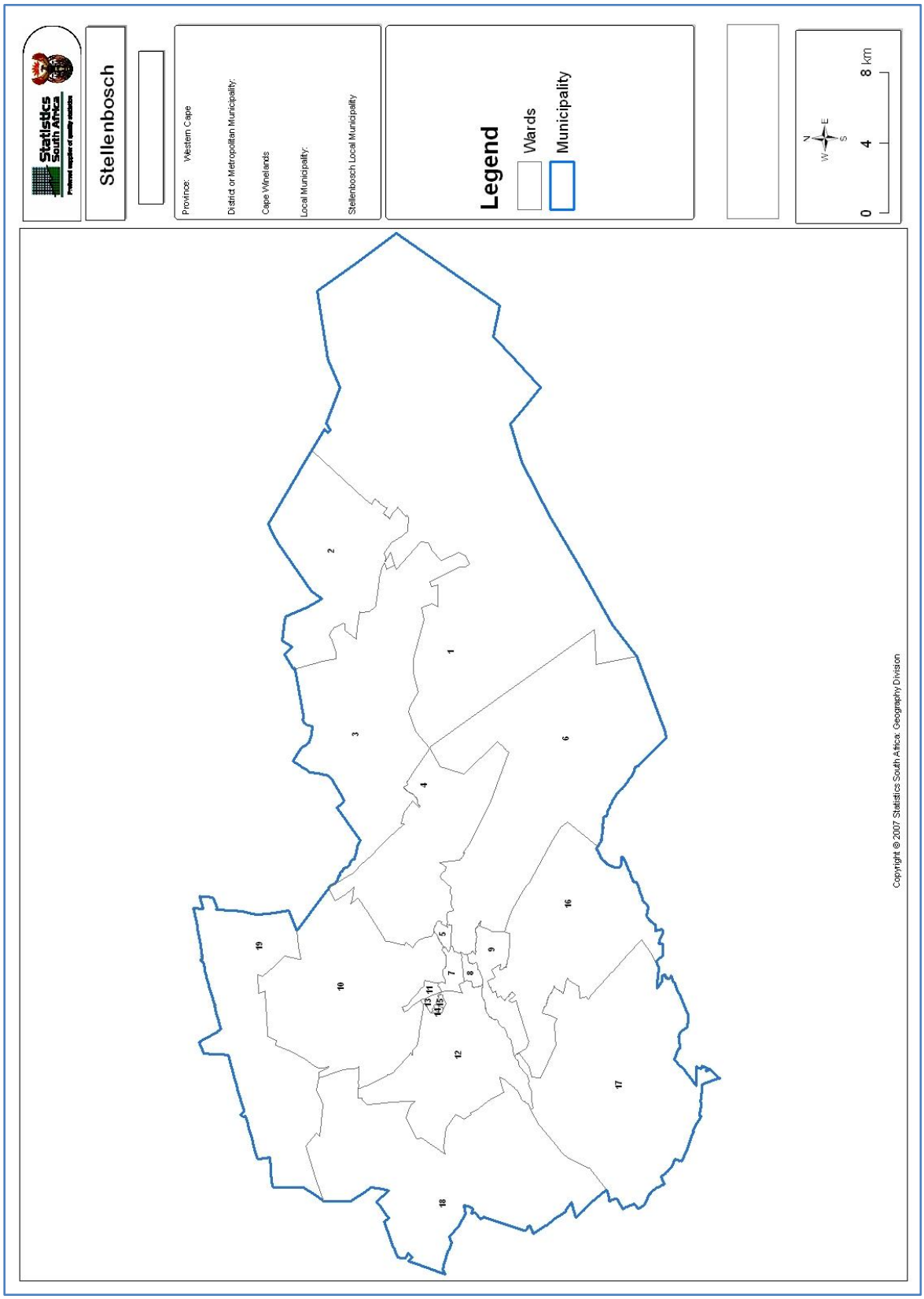
	WARDS																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
Mode of travel for work or school																			
Bicycle	33	33	48	30	207	48	321	12	51	42	69	51	192	201	282	48	60	45	1 773
Bus	510	771	750	528	234	300	159	15	135	63	222	69	87	27	24	15	318	633	4 860
Car driver	387	285	456	579	1 851	213	1 857	33	120	66	423	645	798	543	1 098	543	804	522	11 223
Car passenger	753	576	654	669	840	441	651	51	339	207	570	804	216	102	510	696	1 065	639	9 783
Minibus / Taxi	435	693	255	384	81	180	87	132	639	426	969	1 164	126	12	123	660	1 074	705	8 145
Motorcycle	39	9	12	12	87	0	90	0	66	18	18	15	33	39	48	15	36	21	558
Train	36	51	270	210	42	696	48	87	543	366	339	327	33	9	36	192	168	60	3 513
NA	3 588	3 288	3 036	2 088	1 605	2 883	1 791	618	3 882	1 809	3 462	2 790	570	363	1 059	1 968	3 636	3 075	41 511
Foot	2 499	2 304	3 657	2 832	882	2 304	1 251	618	2 586	1 656	2 589	1 773	1 767	2 892	1 209	1 239	2 208	1 170	35 436
Other	33	120	42	57	33	234	9	0	39	18	63	27	15	9	9	33	66	99	906
Dwelling type																			
Formal	1 146	1 209	2 160	1 605	1 986	1 293	2 148	111	468	333	1 563	1 416	1 629	651	1 290	1 191	1 920	1 236	23 355
Informal	951	384	33	99	6	243	9	234	1 428	642	225	81	3	3	3	99	90	21	4 554
Traditional	93	21	33	21	15	165	9	3	84	39	15	27	9	3	15	39	81	57	729
Other	18	12	9	12	6	12	0	0	12	9	3	3	0	0	0	0	6	0	102
Total households	2 208	1 626	2 235	1 737	2 013	1 713	2 166	348	1 992	1 023	1 806	1 527	1 641	657	1 308	1 329	2 097	1 314	28 740
Source of energy for lighting (number of households)																			
Electricity	1 206	1 254	2 034	1 605	1 995	1 353	2 160	336	1 612	975	1 713	1 521	1 632	654	1 302	1 308	2 046	1 233	26 139
Gas	12	12	3	0	3	3	0	3	0	3	3	0	3	0	6	3	0	3	57
Paraffin	759	132	3	6	0	90	0	9	108	27	3	3	0	0	0	3	6	15	1 164
Candles	231	222	192	126	12	264	6	0	69	15	84	3	0	0	0	18	42	63	1 347
Solar	0	6	0	0	6	3	0	0	0	0	3	0	0	0	0	0	3	0	21
Other	3	0	3	0	0	0	0	0	0	0	3	0	0	0	3	0	3	3	18

	WARDS																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
Refuse (number of households)																			
Municipal weekly	1 566	1 143	288	975	1 836	1 221	2 040	345	1 653	936	1 434	1 524	1 626	651	1 290	1 329	1 833	1 276	22 968
Municipal other	18	21	45	9	9	18	3	3	54	57	27	3	6	6	12	0	33	6	330
Communal dump	99	27	558	99	63	48	12	0	171	24	123	0	0	0	0	0	9	6	1 239
Own dump	507	432	1 320	609	102	399	111	0	108	0	186	0	0	0	3	3	219	24	4 023
No disposal	21	3	21	45	3	27	0	0	9	3	39	0	3	0	0	0	9	0	183
Sanitation (number of households)																			
Flush toilet	1 083	1 038	1 215	1 086	1 896	936	2 091	315	1 860	957	1 611	1 476	1 623	648	1 278	1 320	1 542	1 110	23 085
Flush septic tank	138	213	372	372	81	273	48	3	0	9	33	27	6	3	12	6	339	141	2 076
Chemical toilet	9	9	3	15	3	6	0	0	3	0	3	0	0	0	0	0	3	0	54
VIP	9	9	240	30	6	168	3	0	0	0	33	0	0	0	0	0	18	12	528
Pit latrine	9	30	150	39	9	18	0	0	3	0	33	3	3	0	3	0	12	3	315
Bucket latrine	21	33	99	132	3	81	3	3	3	0	54	12	3	0	0	0	138	9	594
None	936	294	159	66	12	231	21	30	123	54	42	12	3	3	12	6	45	39	2 088
Water (number of households)																			
Dwelling	957	915	1 425	1 260	1 827	1 011	2 109	57	300	204	981	1 293	1 617	615	1 266	1 101	1 734	1 212	19 884
Inside yard	228	405	462	330	147	360	24	63	306	138	672	171	3	30	18	207	153	51	3 768
Community stand	333	84	261	69	15	153	12	195	867	255	60	15	12	3	9	9	36	21	2 409
Community stand over 200m	591	192	57	27	21	180	21	30	513	420	60	45	6	3	9	12	111	21	2 319
Borehole	3	6	24	21	0	6	0	0	0	0	0	0	0	0	0	0	42	0	102
Spring	0	3	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Rain tank	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	6
Dam / Pool / Stagnant water	6	3	0	9	0	0	0	0	0	0	15	0	0	0	3	0	3	6	45
River / Stream	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	6	0	18
Water vendor	75	6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84
Other	21	9	3	3	3	3	0	0	6	3	9	0	0	0	0	0	12	3	75

Annex 2; street map Stellenbosch



Annex 3; ward map Stellenbosch



Annex 4; Accident record Stellenbosch

TYPE AND LAYOUT OF INTERSECTION	
CROSSROADS AND STREETS	
1.1 Traffic Lights	939
1.2 Traffic Officer	3
1.3 Stop Sign	698
1.4 Yield Sign	152
1.5 Other	138
1.6 Un-Controlled	67
1.7 Traffic Circle	144
CROSSINGS	
1.1 Level Crossing	1
1.2 Pedestrian Crossing	25
1.4 On-or-Off Ramps	1
DUAL CARRIAGEWAY	
1.1 On Straight Road	5340
1.2 On Curved Road	1458
SINGLE CARRIAGEWAY (two way)	
1.1 On Straight Road	5361
1.2 On Curved Road	3876
FREEWAY	
1.1 On Straight Road	5337
1.2 On Curved Road	9

TYPE OF VEHICLE	
Motorcar	6187
Minibus/Combi	209
Mini Bus	10
Bus	23
Bus-train	1
Light Delivery Vehicle	1410
Panel van	35
GVM > 3500Kg (greater than)	154
Truck: Articulated	63
Truck: Articulated multiple	21
Motor Cycles: 125cc and under	70
Motor Cycles: Above 125cc	52
Motor Cycles: Tri-cycle	0
Motor Cycles: Quadru-cycle	1
Bicycle	78
Mobile equipment : Driven	0
Caravan / trailer	7
Tractor	6
Animal drawn vehicle	2
Unknown	56

DRIVERS ACTION	
Turning right	911
Turning Left	474
U-turn	41
Enter Traffic Flow	77
Merging	17
Diverging	53
Overtaking: Pass to right	92
Overtaking: Pass to left	45
Traveling straight	3621
Reversing	575
Sudden Start	46
Sudden Stop	165
Busy parking off roadway	49
Busy parking on roadway	1
Changing lane	41
Swerving	104
Slowing down	99
Avoiding object	39
Stationary e.g. waiting in traffic	663
Parked	650
Unknown	618

VISIBILITY		SURFACE CONDITION	
Day Clear	4117	TAR - Dry	4314
Day Misty	62	TAR - Wet	975
Dawn/Twilight	136		
Dark Lighted	1034	Gravel - Dry	14
Not Lighted	369	Gravel - Wet	7

ALCOHOL INVOLVEMENT OF DRIVERS	
Found under the influence	109

RACE		GENDER	
White	4584		
Black	835		
Coloured	2384	Male	5612
Asian	24	Female	2592
Unknown	685	Unknown	322

DIRECTION OF TRAVEL	
North	1
South	0
East	0
West	0
Unknown	8386

PEDESTRIAN ACTION	
Road Crossing: Within marked crossing	1
Road Crossing: Within 50m of crossing	2
Road Crossing: Not a crossing	8
Facing the Traffic	2
Back to traffic	2
Pedestrian Position : Roadway	14
Pedestrian Position : Sidewalk	0
Pedestrian Position :Shoulder	2
Pedestrian Position : Median	2

KIND OF COLLISION	
Head / Rear End	1849
Head On	83
Side Swipe (opposite directions)	605
Side swipe (same directions)	663
Turn Left From wrong lane	0
Turn Right From wrong lane	1
Turn right in face of oncomming traffic	163
Approach at an angle both travelling straight	326
Approach at an angle one or both turning	102
Reversing	231
Single vehicle, overturned	131
Accident with a pedestrian	224
Accident with animal	72
Accident with train	5
Unknown	436

DAY OF WEEK	
SUNDAY	550
MONDAY	721
TUESDAY	730
WEDNESDAY	793
THURSDAY	831
FRIDAY	1079
SATURDAY	785

PEDESTRIAN INJURIES	
Fatal	22
Serious	48
Slight	84
No Injuries	12
Unknown	12

TIME OF DAY	
00:00 - 00:59	86
01:00 - 01:59	107
02:00 - 02:59	116
03:00 - 03:59	75
04:00 - 04:59	57
05:00 - 05:59	59
06:00 - 06:59	67
07:00 - 07:59	380
08:00 - 08:59	304
09:00 - 09:59	244
10:00 - 10:59	289
11:00 - 11:59	340
12:00 - 12:59	349
13:00 - 13:59	343
14:00 - 14:59	347
15:00 - 15:59	342
16:00 - 16:59	406
17:00 - 17:59	413
18:00 - 18:59	246
19:00 - 19:59	216
20:00 - 20:59	198
21:00 - 21:59	136
22:00 - 22:59	162
23:00 - 23:59	149
Unknown	59

SUMMARY

COLLISIONS		PERSONS INJURED	
Fatal	43	Fatal	55
Serious	138	Serious	192
Slight	724	Slight	882
No Injuries	4585	No Injuries	7670
Total Collisions	**5490**	Total Persons	**8799**

Annex 5; Zones in Stellenbosch area