

**IMPROVING THE ECONOMIC AND ENVIRONMENTAL
SUSTAINABILITY OF THE UNIVERSITY OF WITWATERSRAND'S
PUBLIC TRANSPORT SERVICES THROUGH ADOPTING SHARED
TRANSPORT MODELS**

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in fulfilment of the requirements for the degree of Master of Science in Engineering by advanced coursework and research.

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DECLARATION

I declare that this research report is my own unaided work. It is being submitted to the degree of Master of Science to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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(Signature of Candidate)

..... day of,

ABSTRACT

The research explores alternative sustainable shared transport modes that can be integrated successfully to the University of Witwatersrand's (Wits) public transport solutions for commuting students and staff. This study aimed to explore, through successful adoption of the shared transport solution WITSIT at Wits, whether single occupant car use could be reduced and significantly improve the Wits transport solutions both economically and environmentally, while providing all student access to alternative commuting options. A survey was distributed to the survey participants via an interactive website to expose the survey respondents to the concept of WITSIT share transport solution, where they could access an online questionnaire. Although the questionnaire introduced the concept of a truly integrated solution, the study focused on the carpooling aspect of the shared transport solution, due to the level of maturity due to little or no exposure to share transport models. Using the data collected from the responses, coupled with specific parameters collected in the literature survey, the average land required per vehicle and the cost of that land the economic and environmental indices could be calculated for the worst case and five scenarios. The worst case scenario represents single occupant vehicle journeys. Four of the scenarios represent carpooling with one, two, three and four passengers respectively. The fifth scenario represented the most likely outcome based on the current carpooling trends. The scenarios also compared carbon emissions reduction target for South Africa's Transport sector, established at COP15, interpolated for Wits Commuters. The reduction target for Wits commuters for 2011 would come to 1 704 T CO₂ eqt, which equates to 1 539 journeys and parking bays. This equates to a land reduction of 53 859m² through saved parking bays, with a value of R 151.29 million. The analysis revealed that if Wits commuters carpoled with just one passenger, the current 4500 vehicles on campus could reduce by 2 250 vehicles (1.5 times more than the target), resulting in a reduction of 2 702 T CO₂ eqt. (1.6 times more than the target) equating to a land requirement savings of 78 750m² (24 891m² more than the target) to the value of R 221.21 million (R69.92 million more than the target). By implementing the proposed WITSIT carpooling solution significant environmental and economic benefits could be achieved with possible social spin-offs leading to more advanced shared transport solutions.

In memory of a fellow Engineer and dear friend, whose focus on sustainable truths will not
be forgotten
Craig Teasdale

&

I would also like to dedicate this to my husband. Without his support, none of this would be
possible
David Blundell

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NOMENCLATURE

BRT: - Bus Rapid Transit

CCS: - Carbon Capture and Storage

CDIAC: - Carbon Dioxide Information Analysis Centre

COP17: - Congress of the Parties

CO₂: - Carbon Dioxide

DEA: - Department of Environmental Affairs

DoT: - Department of Transport

ETS: - Emissions Trading System

EU: - European Union

GDP: - Gross Domestic Product

GHG: -Greenhouse Gas

GPS: - Global Positioning System

GW: - Gigawatt

GWC: - Growth without Constraint

IEA: - International Energy Agency

IPCC: - Intergovernmental Panel on Climate Change

ITS: - Integrated Technology Systems

JBA: - Journey-based Affect

LCA: - Long-term Co-operative Action

LTMS: - Long-term Mitigation Scenarios

Mt: - Million ton

MtCO₂ eq: - Million ton Carbon Dioxide equivalent

NAMAs: Nationally Appropriate Mitigation Actions

OECD: Organisation for Economic Co-operation and Development

P2P: - Person 2 Person

RBS: - Required by Science

RFID: - Radio Frequency Identification

SVS: - Small Vehicle Systems

TCRP: - Transit Cooperative Research Program

TPB: - Theory of Planned Behaviour

UCT: - University of Cape Town

UNFCCC: - The United Nations Framework Convention on Climate Change

USA: - United States of America

USEIA: - United States Energy Information Agency

USEPA: -United States Environmental Protection Agency

Wits- University of Witwatersrand

GLOSSARY OF TERMS

THIS GLOSSARY OF TERMS HAS BEEN ARRANGED IN ORDER OF SEQUENCE NOT ALPHABETICALLY

Private car ownership: An individual who has purchased/financed a vehicle for personal use or commute.

Travel modes: Alternative transit methods which include; walking, bicycles, motorbikes, vehicles, busses, taxis, vans and busses. (Not an exhaustive list)

Sustainable business value-driven models: Business models centred on a service economy where the business places focus on a multiplicity of stakeholders and moves beyond self-interest. Shared value is created by increasing the quality of life of those impacted by its activities, which in turn secures self-interested achievements. Ultimately environmental benefits can be realised through transforming product-oriented economies into service economies.

Shared space: A concept that aims to improve the sharing and use of limited public space within cities to facilitate the process through land-use policies, access control and restrictions, modal separation (Bus Rapid Transit or BRT, cycle lanes), parking, time zoning of activities, shared surfaces and limiting of speed in certain areas.

Shared knowledge: Encompasses the use of: integrated technology systems (ITS); maps; schedules; interactive media; behaviour change communication mechanisms in support of educating commuters; and providing real-time integration with shared space and shared modes.

Car-free city zones / cities: Physical areas or space in cities, that are normally utilized for vehicle movement, that have been zoned off during certain times of the day, or a couple day for pedestrians or city dwellers who utilise the space for both work and living.

Sustainable transport: Less car intensive means of urban transport which embodies economic, environmental and social sustainability most simply described as people having equal access to transport resources which leads to reduced cost for commuters and reduced impact on the environment.

Carpool/ing OR Lift clubs: Independent commuters offer the use of private vehicles which is governed by mutually agreed, informal established rules of etiquette defined by the members of the carpool or lift club.

Carpoolers: Member of the carpool or lift club.

Shared cost schemes: A method of sharing the cost of carpooling or lift clubs governed through pre-determined terms agreed by all carpool members.

Car-sharing OR Fleet-sharing services: A system that makes use of a leased fleet of company-owned cars for which the member books a time for the car or vehicle usage. (Interchangeable terms as cited in different sources include; Short-term car rental, Time-shared vehicles services, Instant rent-a car services.

Car-sharing OR Fleet-sharing member/ship: Individuals who formally sign-up with a company who provides car-sharing or fleet-sharing services, to gain access to these services with agreed terms and rates.

Inter Transit: Successful integration of public transport within a city which provides shared transport services leading to ideal space, cost and time sharing.

Shared transport modes/models/solution: Concept of fleet ownership of standard vehicles that are managed by an organisation who further sells the use of the fleet at a predetermined hourly rate to a group of individuals. These type of models aim to improve the efficiency of transport examples include taxi sharing, small bus sharing, bicycle sharing, car-sharing, ride-sharing and integrating existing transport systems to increase overall flexibility and service levels of those existing modes.

WITSIT service: WITS Inter Transit (WITSIT) services refers to the proposed inter transit model developed in this study that has adapted parts of existing carpooling systems in South Africa and International systems. As discussed in Section 5.2, the proposed model is suggested to evolve through different levels of maturity. During this study due to maturity of the WITS environment and limitations, only the carpooling facet of the ideal inter transit model has been analysed while the more mature model has been introduced for purpose of future research. The evolution of this model is intended to reach the ideal state of inter transit.

WITSIT Carpooling service: The term to indicate a part of the intended full service, where only carpooling infrastructure is place and made available to the WITS students and staff.

WITSIT Share transport model: The term to indicate the most mature level of the WITSIT service and infrastructure ideally to make available to the WITS students and staff.

Emergency WITS Service: A service provide by WITS where a fleet of vehicles kept on the university grounds is made available to the commuters at short notice instead of using their own vehicles or if no carpooling arrangement could be arranged. Commuters would be able to book the vehicle online 30 minutes before use and would only be required to pay per hour of use. This service introduces the commuters to true share-use transport systems

1. INTRODUCTION

This research aims at exploring alternative sustainable shared transport modes that can be applied successfully to the University of Witwatersrand's (Wits) transport solutions for students commuting to and from Wits. Benefits include possibly alleviating the surrounding areas' traffic, Wits parking congestion, economic strain on commuters and reduced land use for parking bays. More specifically, the research could lead to the establishment of a viable option to replace the conventional single occupant private vehicle that could significantly improve transport modes economically and environmentally.

Sustainable transport, as constructed by Coafee (2008) embodying economic, environmental and social sustainability, is most simply described as people having equal access to transport resources. Coafee (2008) sets an agenda for less exclusive sustainability, where the focus is placed on equality and justice within which all people have the right to public space¹. Thus the availability of public space and the quality of local environments become an issue of social justice, which will ensure that current generations' needs can be met as well as ensuring that future generations have access to public space with sustained reduced cost of access, while minimizing impact on the environment due to reduced space requirement while providing the same level of service.

To focus the scope of this study, the University (Wits) was identified as an appropriate environment to test the feasibility and adoption rates of sustainable transport solutions. Several variables support the appropriateness for the selection of Wits and its commuters: ease of obtaining informed responses for the development of the model; fairly homogeneous target group; clustering of localities (Main Campus, Business School; Education Campus and Medical School/Hospital are all in fairly close proximity); and the introduction of concepts and practice of alternative transportation strategies to a cohort of young people, many of whom will be influential leaders and ambassadors of the University

¹ Public space is defined as 'all areas that are open and accessible to all members of the public in a society, in principle though not necessarily in practice' (Orum and Neal, 2010: p. 1), an apt legal-economic definition in the context of this study describes most open type of public space, the quintessential public forum and includes places like 'streets and parks which "have immemorially been held in trust for the use of the public and...have been used for purposes of assembly, communicating thoughts between citizens, and discussing public questions"' (Neal, 2009)

who can therefore spread the concept to the wider community. It is these leaders who may already play a role to their peers and in their community.

The current transport model at Wits is predominantly made up of car journeys facilitated to accommodate a single person's transport needs. Private car ownership is expensive and leads to congestion, increased parking requirements, air and noise pollution, and increased stress levels. As a former Wits undergraduate student, alternative transport was not a viable option due to the lack of flexible departure times associated with public transport or carpooling, as well as the lack of easily accessible transport infrastructure. Wits commuters are also dispersed widely geographically, thus creating a barrier to entry in establishing frequent and flexible lift clubs or carpools. Although there is evidence that small carpools have been established, particularly amongst commuters travelling from Lenasia, the majority of Wits commuters are yet to develop a preferred choice of an alternative transport solution or model. This may pose a large barrier to adoption and must be carefully considered.

More recently, in attempts to reduce the negative impact of transport on the environment, a carbon emission tax was implemented on 1 September 2010 by South African legislation, as reported by BuaNews (2010), the aim of which is to manage environmental changes by including regulatory interventions. However this tax is transferred to the end user and thus the cost of private car ownership will continue to increase due to fuel costs that are attributed to the availability of a finite energy resource, the open road tolling system as established by the Gauteng Freeway Improvement Project in line with user-pays principles, as well as the limitation on parking increasing demand with the limited supply at the University (South African National Road Agency, 2009).

Most recently, the proceedings of the recent COP17 conference (Nov, Dec 2011) held in Durban, South Africa had three main priorities, all with the aim of mitigating the effects of carbon emission resulting in climate change. These included:

- 1) The securing of a second commitment period for developed countries under the Kyoto Protocol to which progress must be made under a Long-term agreement of Co-operative Action (LCA) that will include a negotiation track, particularly including carbon emission reductions for developing countries;

- 2) The capitalisation as well as the operationalization of the Green Climate Fund, which was approved last year to assist countries with their mitigation and adaptation plans. It is envisaged that this fund will have capital investments of \$100 billion per year;
- 3) The finalisation and adaptation of sector plans that will progress towards the implementation of national adaptation plans.

At the close of the event, it was still not evident how South Africa's Department of Transport had planned to implement adaptation strategies; however an initiative to offset the carbon emission due to the travel of delegates was facilitated by the Department of Transport (DoT), which had been partnered by the eThekweni Municipality. This initiative was achieved by providing 300 bicycles to COP17 delegates to commute in and around the venue as well as the greater Durban city area. In the light of supporting the low carbon transport initiative, collaborative efforts among eThekweni Municipality, the Department of Environmental Affairs (DEA) and the KFW Development Bank, on behalf of the Government of Germany, led an ambitious non-motorised transport initiative where the eThekweni Municipality will pilot an integrated transport system. This involved the establishment of a cycle network between municipal administration buildings, completing the green circuit link to move tourists to entertainment nodes and rail terminals, universities and residential areas. The initiative should serve as an example to the other metropolitan municipalities, including Johannesburg (Mobility, 2011). This initiative promotes the need to develop innovative, economical and environmentally-viable solutions that integrate with or replace the need for the use of privately-owned transport models.

Shared transport models provide opportunities to realise reduced transport cost, lowered carbon loading per person per km travelled and to establish socially-responsive communities. Shared transport models have developed over the last decade, but primarily consist of flexible fleet services, short-term car rental, time-shared vehicles, instant rent-a-car and car-sharing between commuters. (Barth et al., 2008)

Ultimately, the adoption of less complicated shared transport, such as car-sharing and integrated public transport systems, could improve the probability of South Africa adopting a more sophisticated form of shared transport models as defined by Shaheen et al.

(2004). Shaheen et al. (2004) who promote incorporation of a service economy concept that follows the idea of fleet ownership of standard vehicles that are managed by an organisation who further sells the use of the fleet at a predetermined hourly rate to a group of individuals, claim this system leads to the individuals no longer being required to own, nor incur the cost and responsibility of private car ownership. The fleet of shared vehicles are then available to be utilised by one to four members at a single time. The success of the model predominately depends on the utilisation of the car, which requires efficient back-to-back trips being undertaken by its users. Often the model relies on partnership management, where a car-sharing organisation partners with other businesses such as gas stations, auto manufacturers and local employers. These partnerships allow an affordable service to be provided, due to the economies of scale.

As explored in international car-sharing growth comparison studies, led by Shaheen & Cohens (2006), unfulfilled market potential in new markets like South Africa do exist, and these consumers' transport needs could still be met with an adapted car-sharing model accelerating the adoption through increasing the awareness of vehicle sharing, expertise and technologies. This could provide benefits such as the reduction of traffic congestion and carbon emissions, all of which will provide affordable and flexible transport solutions to a range of users. The model is also adopted more readily if used in conjunction with different modes of available mass transit. Traditionally the car-sharing model requires that vehicles are located conveniently and are easily accessible in street parking. It is reported that in South Africa car theft is significantly higher than International areas, where car-sharing has been adopted. Car-sharing vehicles location and method of access would need to be adapted to a South African context, to minimize the risk of car theft.

Shaheen & Cohens' (2006) worldwide car-sharing growth comparison survey for start-up countries reveal that participants anticipate the emergence of car-sharing in developing countries, such as South Africa. However the operations may evolve differently due to lower labour costs, different technology availability and use thereof, as well as organisational structure.

Shaheen & Cohen (2006) explain that shared transport models need to be supported by electronic and wireless technologies, automated reservations, smartcard vehicle access and real-time vehicle tracking in order to organise, track and collect data that provide

users with information regarding vehicle availability. The vehicles owned by these organisations are typically located in strategic public areas around suburbs to ensure that they are within walking distance of the users.

Furthermore, the shared transport solution can be paired with successful case studies applicable to South African conditions, where the closest model to shared-car use needs to be investigated to provide an integrated, suitable solution for Wits commuters' needs. Carpooling is the most realistic solution and has been successfully implemented at the University of Cape Town (UCT). Ridelink is part of the Green Campus Initiative that provides a free service to the students of the University and is supported by VULA, which is an integrated information student management system. VULA provides real-time data for matching users, based on their travel schedules and routes. A similar, but less advanced system referred to as Greenwheels was established in Grahamstown and used by the local students and commuters of Rhodes University.

It is important to distinguish between the different shared transport models. Ride sharing or carpooling involves the use of a privately-owned vehicle and requires collaborative efforts amongst four to five carpool members, which requires these members to synchronise their travel arrangements to meet each other's departure times. Fleet-sharing is a system that makes use of a leased fleet of company-owned cars for which the member books a time for the car or vehicle usage. The member pays an annual fee to have access to the fleet vehicles at any time, and does not rely on collaborating with other users unless they choose to do so. Fleet-sharing relies heavily on real-time information systems and GPS mapping to locate available vehicles that are in close proximity to the member. There are unique opportunities offered by both models that need to be further explored and integrated to provide Wits with a unique, flexible and affordable transport service that is sustainable.

2. PROBLEM STATEMENT

The following research questions have been formulated in order to test whether this integrated shared transport business model, if adapted to Johannesburg's commuter environment, could be successfully applied to the corporate, private mixed market at Wits, to improve economic and environmental sustainability. This would require a baseline measure of the current transport system made available to Wits commuters, as a basis of comparison for measuring significant improvements of the sustainable triple bottom line measures. This would be achieved through the adoption of the proposed sustainable integrated shared transport model.

To investigate this research question, three subset questions need to be answered:

1. Could significant *economic* improvements, related to Wits commuter transport costs and University parking lot building costs, be realized, if a more sustainable Shared Transport model can be successfully adopted in the Wits transport offering?
2. Could significant *environmental* improvements, related to car emissions and impervious land use for parking lots, be realized, if a more sustainable Shared Transport model can be successfully be adopted in the Wits transport offering?
3. What is likelihood of adoption of the proposed Shared Transport model at Wits University based on testing Wits commuters' responses to their current transport and the proposed Shared Transport model?

3. LIMITATIONS

Data related to the number of parking bays and number of parking permits issued, as well as geographic dispersion of permit holders was not readily made available from the parking office. Wits parking office indicated that the data could not be shared as it was confidential, due to the fact that data was in a format where student details would need to be shared, and thus the students could be put at risk. Transparency is an issue which could lead to a lack of robust data for accurate future planning.

Due to time limitations the survey was based on an existing car-sharing study which had been peer-reviewed (Shaheen et al., 2004) was leveraged, in the interest of distributing the survey in time. This survey was extremely lengthy, which resulted in a lower response rate than expected. The survey sample is therefore more representative of an exploratory survey. For ease of carbon reduction and land use reduction calculations in the analysis chapter, Section 6, it was assumed the sample survey was representative of the larger population.

As a result of the survey respondents being representative of a pilot study to investigate whether it would be viable to take the research to the next level, in combination with scarcity of information provided by the Wits Parking Office, approximate carbon emission reduction targets have been allocated per capita by prorating the target according to the national population. The carbon load contribution is skewed across the population where 20% of people (car users mainly) consume 80% of all fuel and contributes to a similar percentage of carbon emissions. The per capita target of each car user would therefore be much higher. The carbon emission reduction target set for Wits student and staff is therefore a very low estimate of what is realistically required.

Incentive mechanisms in a form of a competition were used to entice students to answer the questionnaire. Lecturers of students studying the topic of environmental management were asked to notify their students of the survey. These students might have a slight bias as they would have already had an interest in the topic.

The survey provided many options for selection, resulting in a large number of variables, which required complex tracking of interdependencies and trends. There

were some technical difficulties with the survey responses, which lead to some ambiguity and double counting for some answers. These questions were disregarded and the partial results were omitted in the study.

Parking for students in residence was assumed to be beyond the scope of this study, due to distinct difference in resident student commuting patterns compared to daily commuting students.

Note that in section 6.4.3 which discusses the method for analysing monetary land savings association with the proposed carpooling model, the property value is that for land and buildings, the most relevant figure would have been land only, however this data was not easily available, and places a limitation on the results of the analysis in this section.

The literature review was conducted up to August 2012, and some of the statistical data represented in this study at the time of submission may have been superseded with more recent data, which could not be included.

4. LITERATURE SURVEY

In order to investigate the research question, it is pertinent to understand the case for change. The extent of future emission growth more specifically due to the transport sector will be more clearly defined in this study. The concept of a shared transport model and the triple bottom line benefits encapsulated in sustainable transport, in the context of corporate and individual sectors, must be defined.

The contribution of the transport sector towards the overall South African pollution burden and the influence of dense traffic will be analysed, and the implication on the environmental, economic and social-response elements further explored. Similarly, the land consumption associated with the transport sector will be analysed and the implication on the environmental, economic and social-response elements will be explored. These two themes have been selected as criteria which have the greatest impact on the corporate (Wits) and the individual (students and staff) sectors to be analysed in this study.

The literature survey reviews the sources and identifies relevant and authoritative literature that pertains to shared transport models. The survey investigates the case for change, how the change can be implemented and establishes the barriers for adoption to be aware of during the future implementation phase, as depicted in Figure 4.1 below.

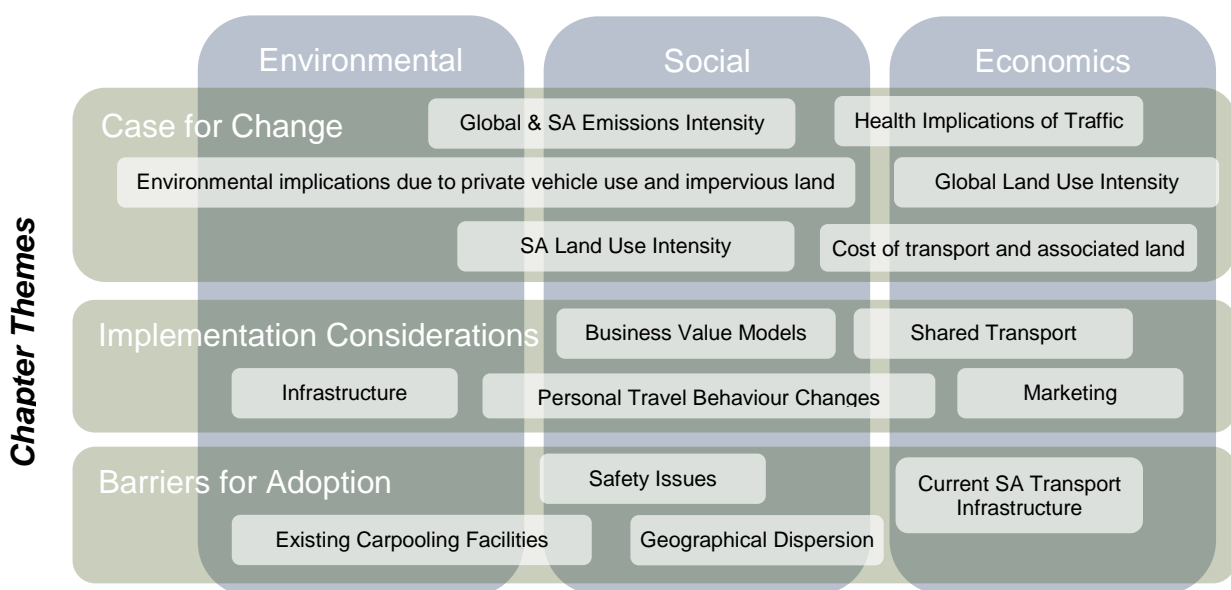


Figure 4.1: Literature survey structure

4.1 Case for Change

The greatest contributing factor or influencer on emissions growth, in accordance with the decomposition equation, is economic growth (GDP per capita), followed by population, energy intensity and fuel mix (Baumert et. al., 2005). This will assist in identifying the South African GHG emission projections and show understanding of the implication of setting ambitious emission reduction targets.

Urban sprawl induces increased travel distances, increases the number of vehicles on the road, encourages congestion and increases the amount of impervious land use for roads and parking. The associated costs and negative environmental impacts provide just cause for substantial change to the transport modes currently adopted (Litman, 2011).

The pollution contribution from the combustion of fossil fuels associated with passenger transport in South Africa is measured in Million ton Carbon Dioxide equivalent (MtCO₂ eq). Targets for reduction can further be identified and established for the South African Passenger Transport Industry, based as a percentage of GHG emission reduction targets (Litman, 2011).

Understanding the impact that traffic has on the release of MtCO₂ eq, strengthens the case for reducing the number of vehicles on the road in order to meet carbon reduction targets. Heavy traffic is associated with health issues in the surrounding environment as well as the danger it poses to pedestrians and passengers in vehicles as a cause of more accidents. There is also the associated economic loss as the time spent by its workforce in traffic cannot be recovered (Litman, 2011).

The cost of transportation varies according to the mix of public transportation used by commuters, in addition to which the type of transport varies across different metropolitan areas. Various indices have been established to gauge the maturity of a well-established and integrated public transport system, including the percentage of household's income spent on transport as well as the number of vehicles per thousand road passengers (Litman, 2011).

4.1.1 South African Emission Intensity

The International Energy Agency (IEA, 2011), which published data relating to CO₂ emissions from fuel combustion, continued its support for climate change negotiations at COP17/CMP7, Durban South Africa, which took place between November and December 2011. A publication titled *Navigating the Numbers*, released by the World Resources Institute (Baumert et. al., 2005) aimed to reveal the most recently recorded environmental performance of South Africa’s Transport sector in comparison with various trends from around the world.

The drivers of CO₂ emissions can be best described through decomposition analysis of the equation presented in the publication (Baumert et. al., 2005:14). The equation consists of “*Activity*” and “*Carbon Intensity*”

Activity refers to the relationship between the income per person and Greenhouse Gas (GHG) emission equated to million tons of CO₂, and is also a function of population growth.

The carbon intensity is the measure of GHG emissions per unit required for an economic activity which is impacted by both energy intensity and fuel mix. Therefore the carbon intensity depends largely on the amount of energy consumed per unit of GDP and indicates the level of energy efficiency and economic structure as well as the carbon content of the energy consumed in a country. Coal has the highest carbon content, followed by carbon fuels such as oil and then gas (Baumert et al., 2005).

The decomposition analysis of the equation is depicted below:

$$CO_2 = \frac{GDP}{per\ person} \times Population \times \frac{Energy}{GDP} \times \frac{CO_2}{Energy}$$

Activity
 ↙ ↘
 $\frac{GDP}{per\ person}$ $Population$

Carbon Intensity
 ┌───────────┐
Energy Intensity **Fuel Mix**
 ↓ ↓
 $\frac{Energy}{GDP}$ $\frac{CO_2}{Energy}$

Activity and Results

Figure 4.2 demonstrates the relationship between the income per person and Greenhouse Gas (GHG) emission equated to million tons of CO₂, this as measured in the year 2000. However, the results produced can be adopted in determining the future trends to be expected for future projections. In terms of South Africa's results, the per capita income illustrated in Figure 4.2 illustrates South Africa at \$11,000.00, which equates to approximately R110,000.00 per year (USD:ZAR = \$1:R10.00) and results in approximately 400 Mt of CO₂ eq being produced. The results are relatively high compared to that of other countries with a similar GDP per capita (Baumert et al., 2005).

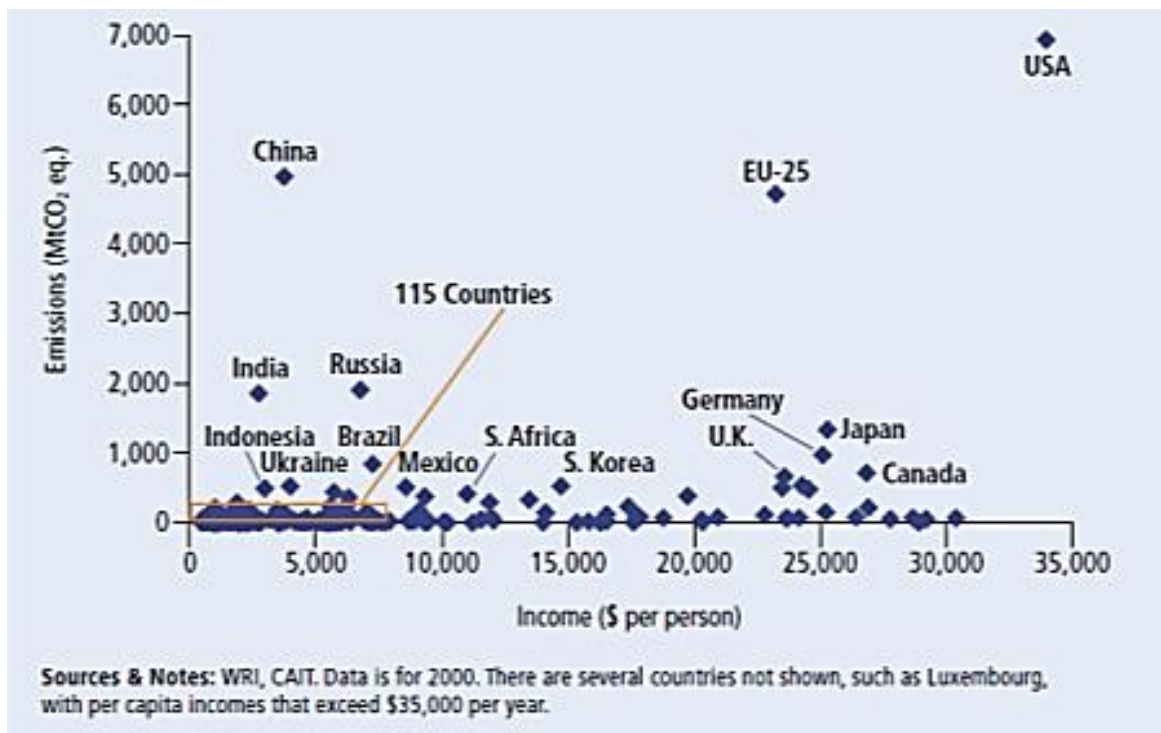


Figure 4.2: Income per capita and GHG emissions (Baumert et al., 2005:37)

Baumert et al. (2005) indicate the largest driver of emissions in South Africa can be attributed to population growth, where projections show an absolute growth of 3.4% reaching 52.2 million by 2030. This population growth has significantly slowed over the previous two decades. An increase in population can be translated directly into increased energy demand and use, resulting in continued increase in GHG emissions.

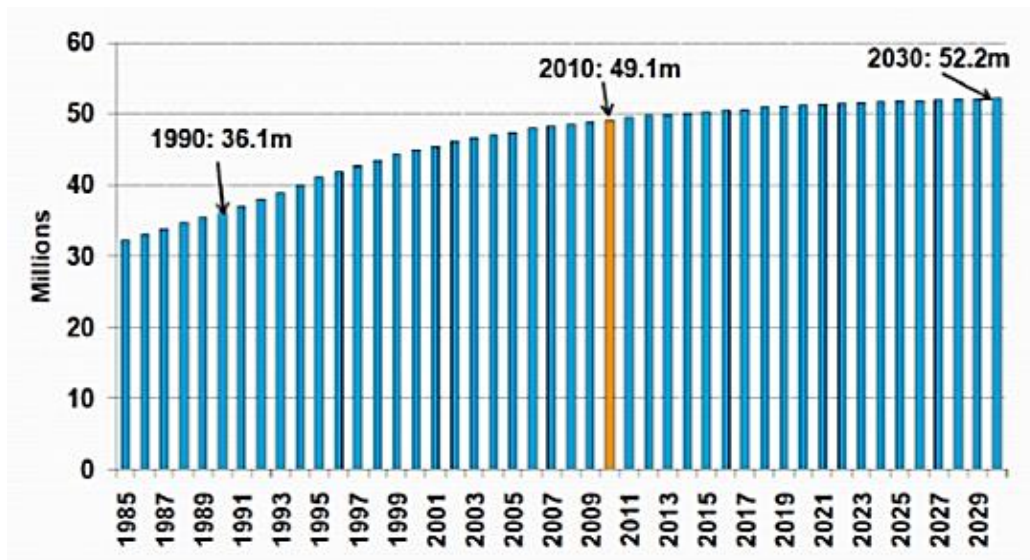


Figure 4.3: South Africa's estimated population growth, 1985-2030 (Wright, 2010)

Carbon Intensity (Energy Intensity and Fuel Mix)

In 2011, the United States Energy Information Agency (USEIA) reported that South Africa was the world's 12th most carbon-intensive country, although the pattern of CO₂ emissions is heavily skewed towards coal as this is the main natural resource used for generating energy within the country.

Between the years of 1990 and 2002 (12 years), South Africa's emission increased by 23%, which equates to an absolute value of 69 MtCO₂ eq (Baumert et al., 2005).

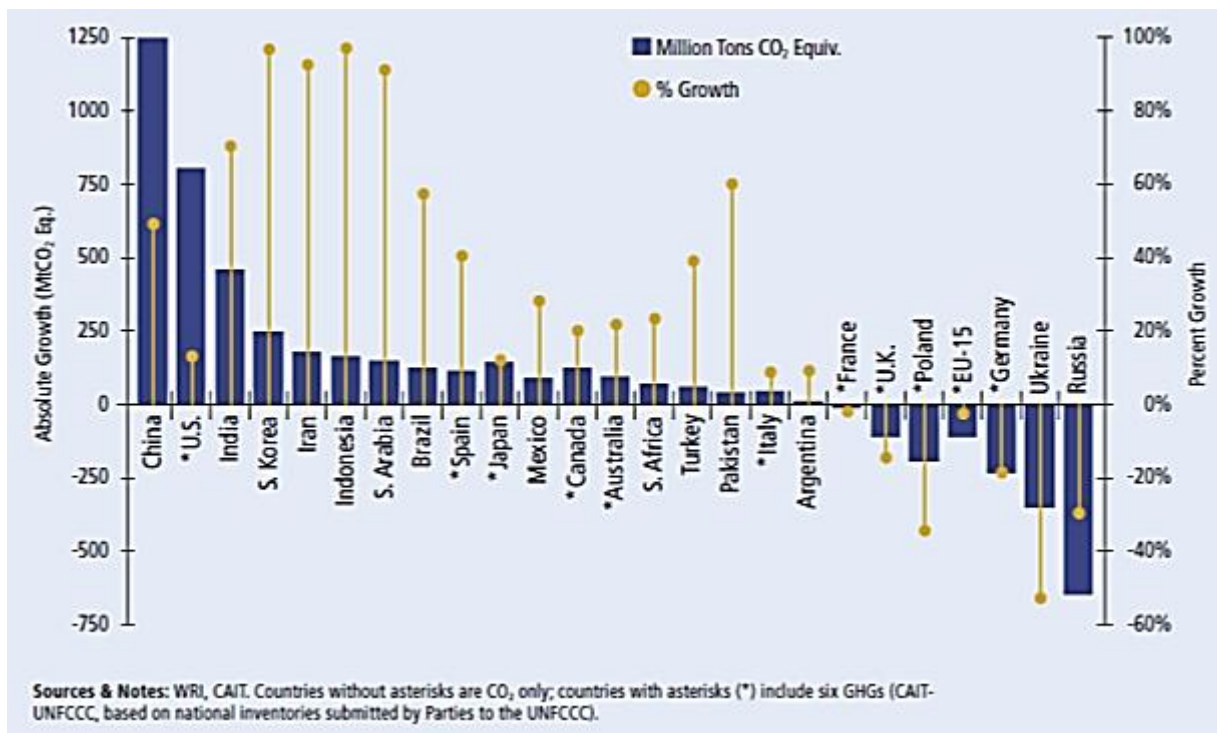


Figure 4.4: GHG emission growth, 1990- 2002 (Baumert et al., 2005)

It is projected that global GHG emissions are expected to rise by 57% between the years of 2000 and 2025, whereby Africa's projected emission growth is expected to reach 80% by 2025 (Baumert et al., 2005).

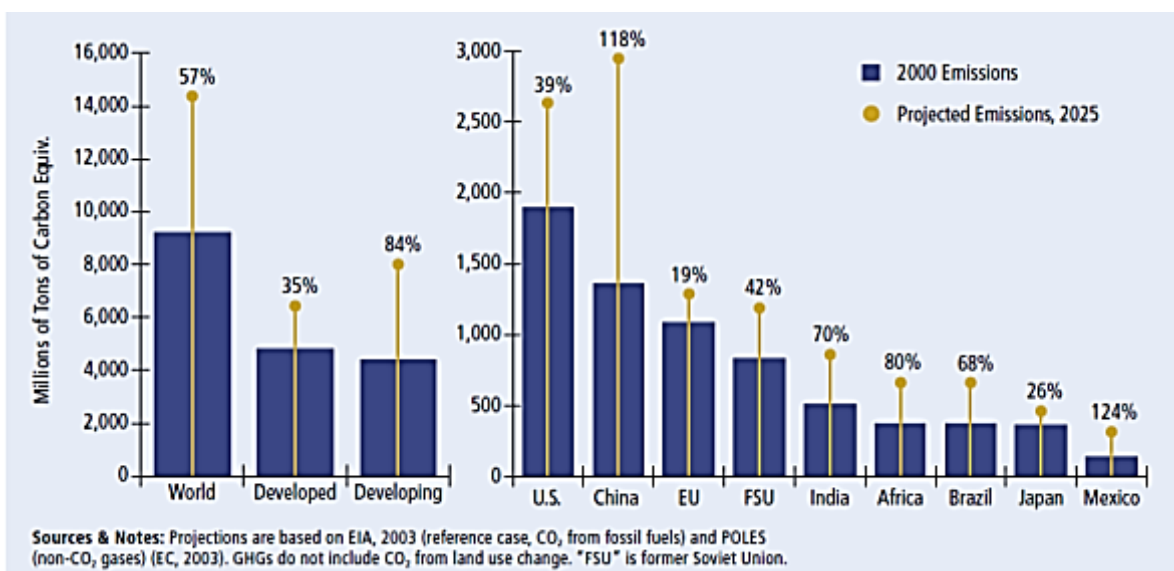


Figure 4.5: Projected emissions of GHGs in 2025 (Baumert et al., 2005)

A report published by Letete et al. (2008) highlighted that South Africa’s projected GHG emissions will equate to 850 MtCO₂ eq by 2025; this is based on Long-term Mitigation Scenarios (LTMS); and Growth Without Constraint (GWC) as depicted in Figure 4.6 below. GWC assumes “there is no damage to the economy resulting from climate change, no significant oil supply constraints, where choices to supply energy to the economy are made purely on least-cost grounds, without internalizing external costs” (Letete et al., 2008:10). GWC is used as the baseline cost model to the LTMS research. With reference to the graph illustrated in Figure 4.6 below, in 2002 GHG emissions measured roughly 430 MtCO₂ eq, GHG emissions were predicted to reach 600 MtCO₂ eq by 2014 resulting in an increase of 40% over a period of the next 12 years, which is almost double the rate of GHG emissions growth between 1990 and 2002.

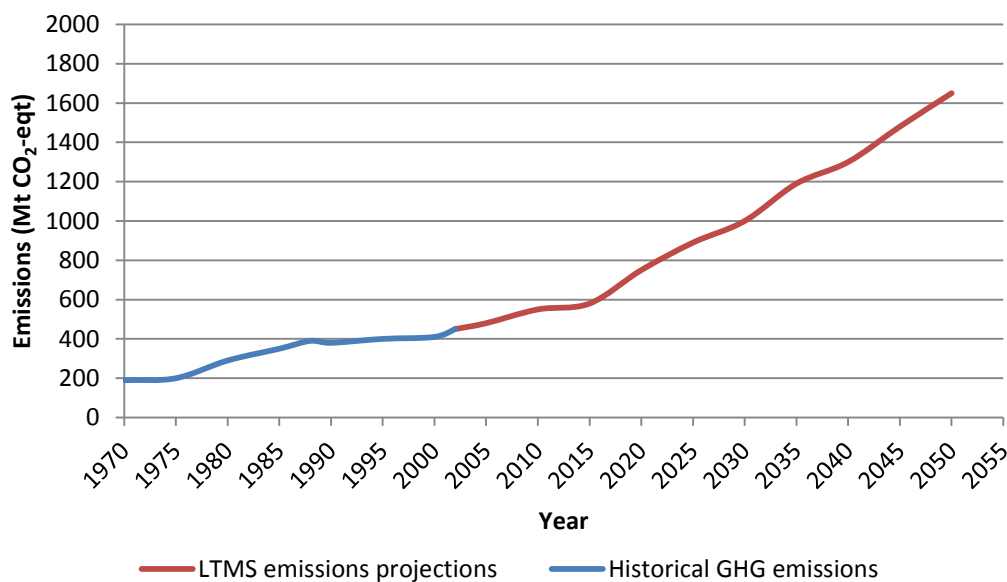


Figure 4.6: South Africa’s historical and projected GHG emissions (Letete et al. 2008)

It is important to note that even though current trends indicate income per capita of developed countries to have grown eight times more between 1980 and 2002 than developing countries, developed countries’ access to modern energy services is much greater than that of developing countries. The capability for a developing country such as South Africa to mitigate their emissions is a much greater challenge due to insufficient availability of funds. In general, developed countries have a higher emission per income

capita due to higher energy consumption and energy intensive lifestyles; however South Africa's largest driver of emissions is population growth (Letete et al, 2008).

The Copenhagen Accord that aimed to replace the Kyoto Protocol at the 2009 COP15 summit provided a way for many countries to announce new migration commitments and voluntary action in response to a call for binding GHG reduction targets. Declarations of voluntary Nationally Appropriate Mitigation Actions (NAMAs) by other parties to The United Nations Framework Convention on Climate Change (UNFCCC) have included transport sector emission reduction in their national targets.

The Intergovernmental Panel on Climate Change (IPCC) states that it is crucial for emissions to be reduced substantially against the 'base case' emission rate, by 2050. In 2009, the South African government committed to reducing the country's emissions by 34% below "base case" trajectory by 2020 and 42% below "base case" trajectory by 2025, based on the LTMS projections. The gap between base case carbon emissions and the commitment of 34% by 2020 is 253 Mt CO₂ eq. In order to meet the 2020 target, South Africa's emissions must decrease by 0.2% per year. These targets are based on what is 'Required by Science', to establish strategic options to get from 'Growth without Constraints' (GWC) to that of 'Required by Science' (RBS), which was determined by the DEA's (Letete et al, 2008) Long-term Mitigation Scenarios. 'Required by Science' is driven purely by a climate target, which tests what would happen if South Africa reduced its emissions by 30-40% from 2003 levels by 2050.

The projections indicate that in the years between 2035 and 2050, other options in the reduction of CO₂ emissions in South Africa will become available. These include but are not limited to: new future technology (investigating technologies in order reduce carbon emissions); resource identification (searching for lower carbon-emitting resources); people-oriented measures (incentivised behaviour models); and transition to a low-carbon economy (Letete et al, 2008). The last option, referring to people-oriented measures relates closely to the investigation in this study.

4.1.2 Urban Sprawl and Increased Private Vehicle Dependency

A common theme identified amongst the leading practitioners assisting world cities to adapt to increased urban population, is the understanding of well-planned, as well as smart, centralised urbanisation. Litman (2011) expands by stating that the full impact of sprawl versus smart growth of cities can be considered as two different scenarios. Urban sprawl is a phenomenon which occurs when urban development tends to disperse outward from the city centre towards the outer boundaries of the central business district, often termed as the urban fringe, which encourages the use of automobile-dependant modes of transport. The premise of smart growth assumes that multi-modal mobility infrastructure supporting walking, cycling and public transit encourages more compact urban development. A growing city however must be supported through high economic performance to ensure funding for infrastructure will be made available to assist the city to absorb its growing urban population.

The relationship between sprawl and private vehicle dependency, has led to the increase of GHG emissions and unsustainable land use that is best understood when considering the self-reinforcing relationship cycle depicted below:

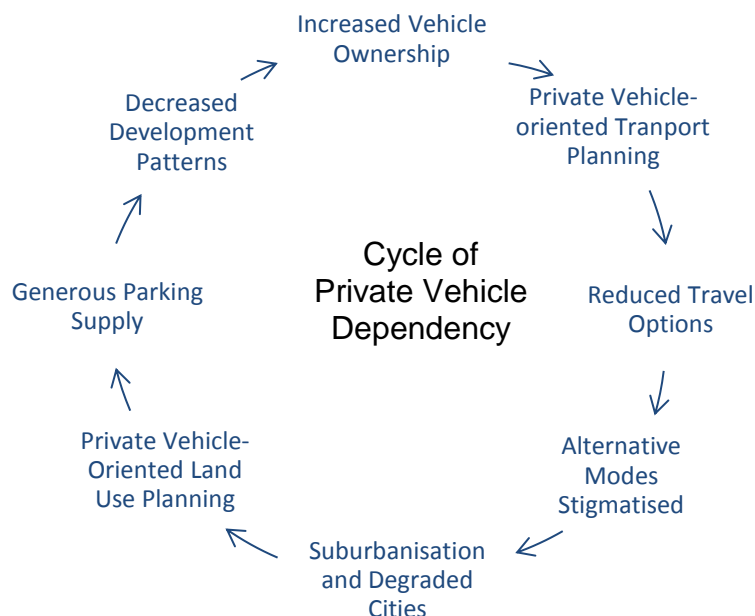


Figure 4.7: Cycle of automobile dependency and sprawl (Litman, 2011)

This cycle is further broken down into impacts on traffic engineering and land use planning in research conducted by Toth, (2006:132), depicted in Figure 4.8.

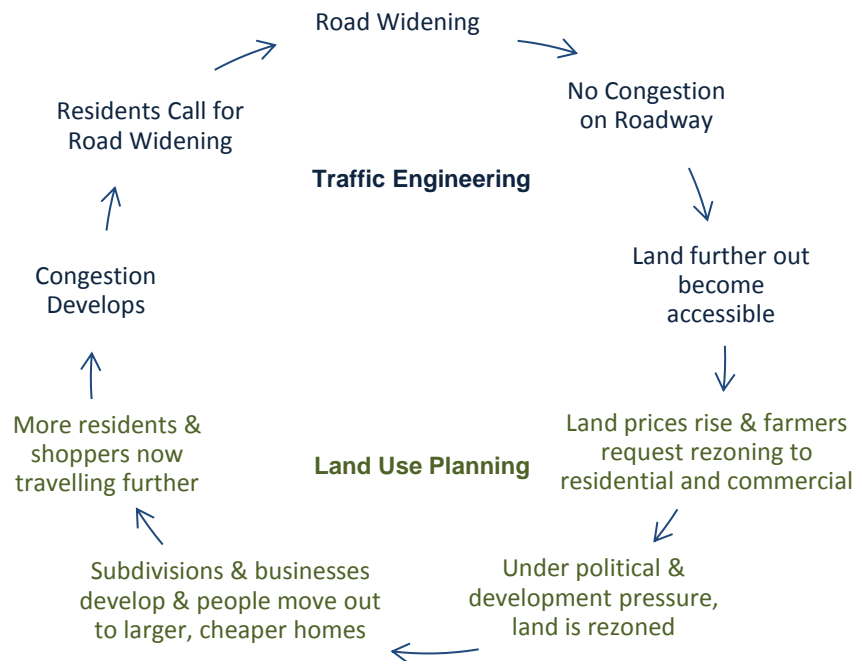


Figure 4.8: Cycle of Capacity and sprawl (Toth 2006:132),

Urban planning professor Angel (2010), based in New York, tracks how 120 cities changed in shape and population density between 1990 and 2000. Angel (2010) informs that even in developing countries, most cities are spreading out faster than people migrate into them. Angel (2010) then concludes that, on average, cities are 2% less dense each year; thus it is expected that by 2030 the area consumed by sprawl could triple.

The impact of sprawl can be linked to private vehicles, which ultimately translates to increased paved areas and dispersed development which results in:

1. Reduced open space such as parks, gardens, farmlands and wildlife habitat;
2. Longer travel distances per passenger;
3. Inequitable impacts on disadvantaged people due to reduced accessibility for non-drivers;
4. Increased vehicle traffic and resulting external costs related to management of congestion and adequate infrastructure, accident risk, higher energy consumption, pollution emissions management impacting overall public health;
5. Value of land reduced due to the land dedicated to transport facilities; and
6. Reduced economic productivity due to time spent travelling.

(Angel, 2010)

Barrett (2008) claims that in 2000, one in three Africans already lived in a metropolitan area or city, and by 2030 one in two will do so. In most cities, authorities have had difficulty meeting the service demands of new urban residents, particularly the poor. The absence of policies on land use and economic development leads to urban sprawl. The declining density associated with sprawl has increased travel distances and escalates the price of public transport. Meanwhile, the rising use of private cars obstructs roads, endangering the safety of pedestrians and the health of city residents who breathe in carbon emissions generated by vehicles.

McCaul (1990:219) explains that since the 1930s, bus companies and State-owned trains dominated the transport industry in South Africa, and passenger transport was designed with only “convenience” in mind. Suburbs were connected via transport linkages that met commuter needs to travel east-west along the gold reef, which extended in later years drawing on labour from the south western areas of Gauteng, now known as Soweto. Over the last few decades there has been significant expansion of all suburbs surrounding central Johannesburg, which has added a significant amount of additional traffic onto the existing transport infrastructure. Urban populations therefore commute long distances between work and home, unlike European cities where most inhabitants live and work in or near the city (McCaul, 1990).

More recently, “prestige leisure” enterprises such as restaurants, cinemas and other recreation venues have relocated to outlying suburbs such as Rosebank, Sandton, Randburg, Fourways and Bryanston. This urban decentralisation is typical of urban sprawl and Johannesburg is now a focally organised structure, parallel to residential movement. This is contradictory to recent efforts for inner-city regeneration to re-establish the CBD as a traditional city centre on a cross-ethnic and cross-class basis, by attracting wealthier residents and businesses to fuel this inner-city regeneration (McCaul, 1990).

Inequitable impacts on disadvantaged people as mentioned by Angel (2010) above has specific reference to the South African context, where McCaul (1990) explains that the legacy of Apartheid planning has placed lower income groups on the periphery and affects the poor disproportionately, excluding them from work opportunities and social services. More recently, informal settlements have sprung up on land which was previously used as agricultural land, which was on the urban edge. Examples include

Honeydew, Diepsloot and Orange Farm, which have led to longer journeys ultimately making it more expensive for new urban dwellers seeking work (McCaul, 1990).

The City of Johannesburg’s Integrated Development Plan (2010) provides an illustration of how the physical spatial patterns of urban sprawl and transport corridors affect lower-income dwellers more significantly. Figure 4.9 depicts the predominantly black townships in relation to the main transport corridors in Johannesburg.

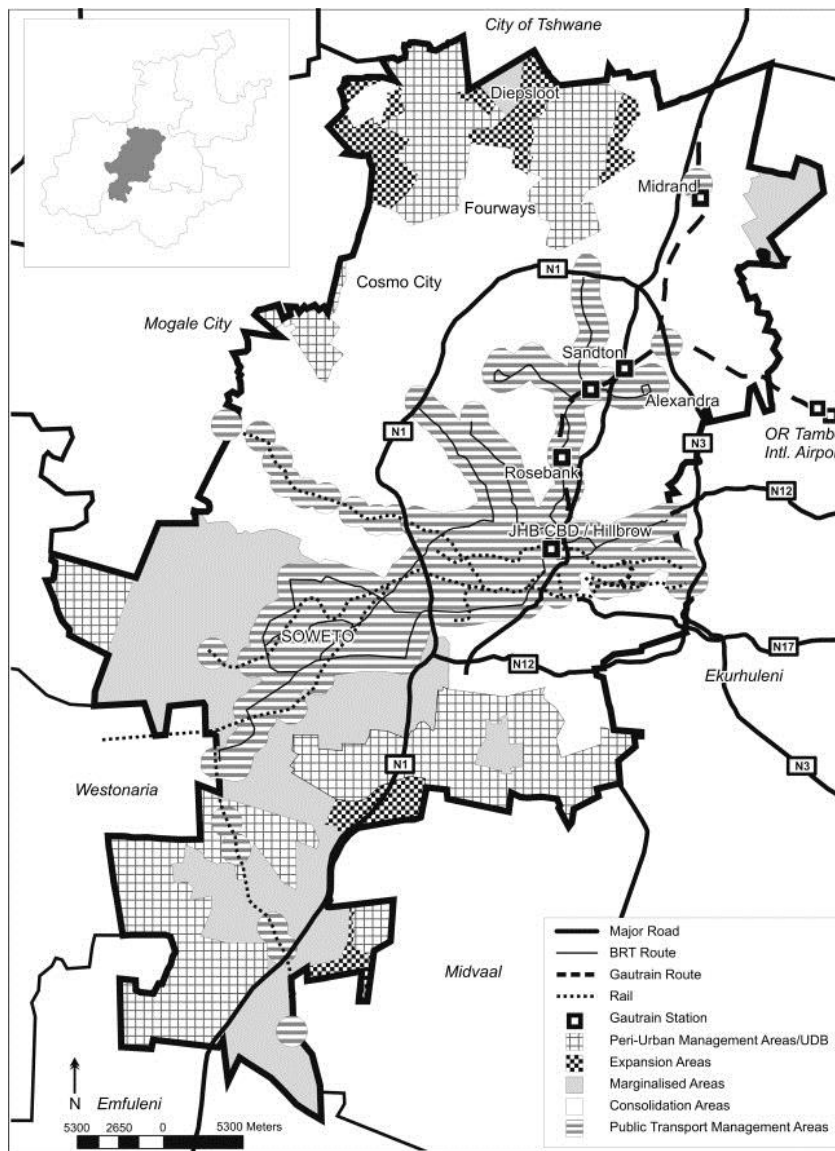


Figure 4.9: Densification township trends (COJ, 2010)

A useful indicator to gauge the opportunities of the reduction of carbon emissions related to private vehicle use is the tracking of passenger vehicles for every 1 000 people in the

populace: if there are 80 vehicles per 1 000 people as opposed to 90 vehicles per 1 000, the former results in fewer passenger vehicles.

Statistics presented by the World Bank (2009) indicate that there has been a rapid increase in the number of passenger vehicles per 1 000 vehicles in South Africa, this is an increase from 93 passenger vehicles per 1 000 people in 2005, to 108 passenger vehicles per 1 000 people in 2009, equating to 16% growth during the period. In a global context, this is relatively high compared to the top emitting countries investigated in the year 2000, as illustrated in Figure 4.10.

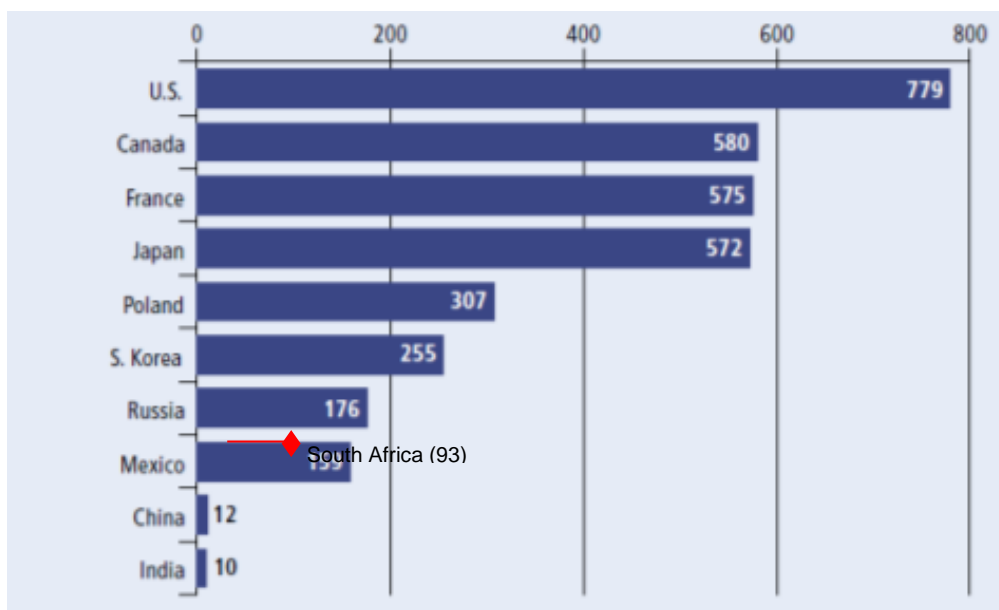


Figure 4.10: Passenger Vehicles per 1 000 people, from 1997-2000 (Baumert et al., 2005)

Figure 4.11 (Department of Transport, 2007) illustrates that between the years of 1991 and 2004 there was a significant growth in the amount of traffic on public roads, and in certain areas within Johannesburg, the increase was as high as 129% times that measured in 1991. This can be attributed largely to the 120 000 additional households that gained access to cars by 2003, compared to that of 1995. The total number of registered vehicles in Gauteng in 2003 was 2.55 million. The demand for privately-owned vehicles has evidently increased, however this has increased the amount of traffic on South African public roads. This has placed a major burden on public roads and created a significant challenge to town planning and council budgets.

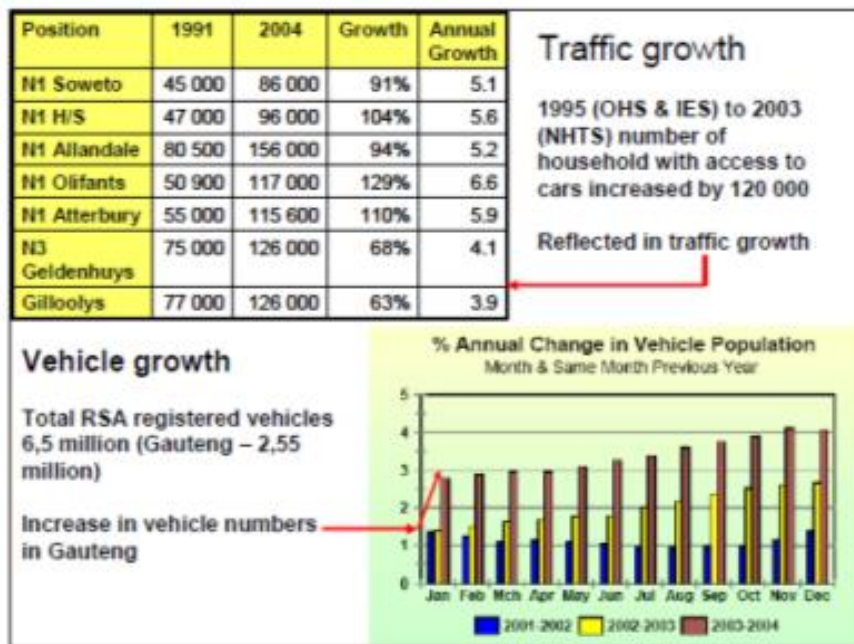


Figure 4.11: Gauteng traffic growth due to increase in vehicle growth (Department of Transport, 2007)

Even though there has been a significant increase in car use in Gauteng, there is still a large portion of South Africans who use public transport and walking as their main forms of mobility. The mix of public transport used, as opposed to private vehicles, is shown in Table 4.1.

Table 4.1: Number of people that used mode at least once in the past 7 days (Department of Transport, 2007)

| Transit mode | <i>Train</i> | <i>Bus</i> | <i>Minibus-taxi</i> | <i>Car</i> |
|-------------------------------------|-------------------|------------|---------------------|------------------|
| Number of users | 1 083 000 | 2 566 000 | 10 080 000 | 7 088 000 |
| Total public transport users | 13 729 000 | | | 7 088 000 |

Therefore 1.9 times more people use public transport than private vehicles on South African roads, however seven million car users is a significant proportion of South Africa’s population, with much room for improvement and pragmatic management considering the significant expected growth in South Africa’s population.

Based on these trends of the significant percentage of the Johannesburg commuters increased dependency on private vehicles coupled with projected increase in urban sprawl, the emission related to private vehicles will continue to affect the Johannesburg

city commuters and inhabitants. The city leaders need to consider alternative strategies that have been adopted abroad. Leading practitioners in urban planning have repeatedly mentioned a shift from urban sprawl to smart growth.

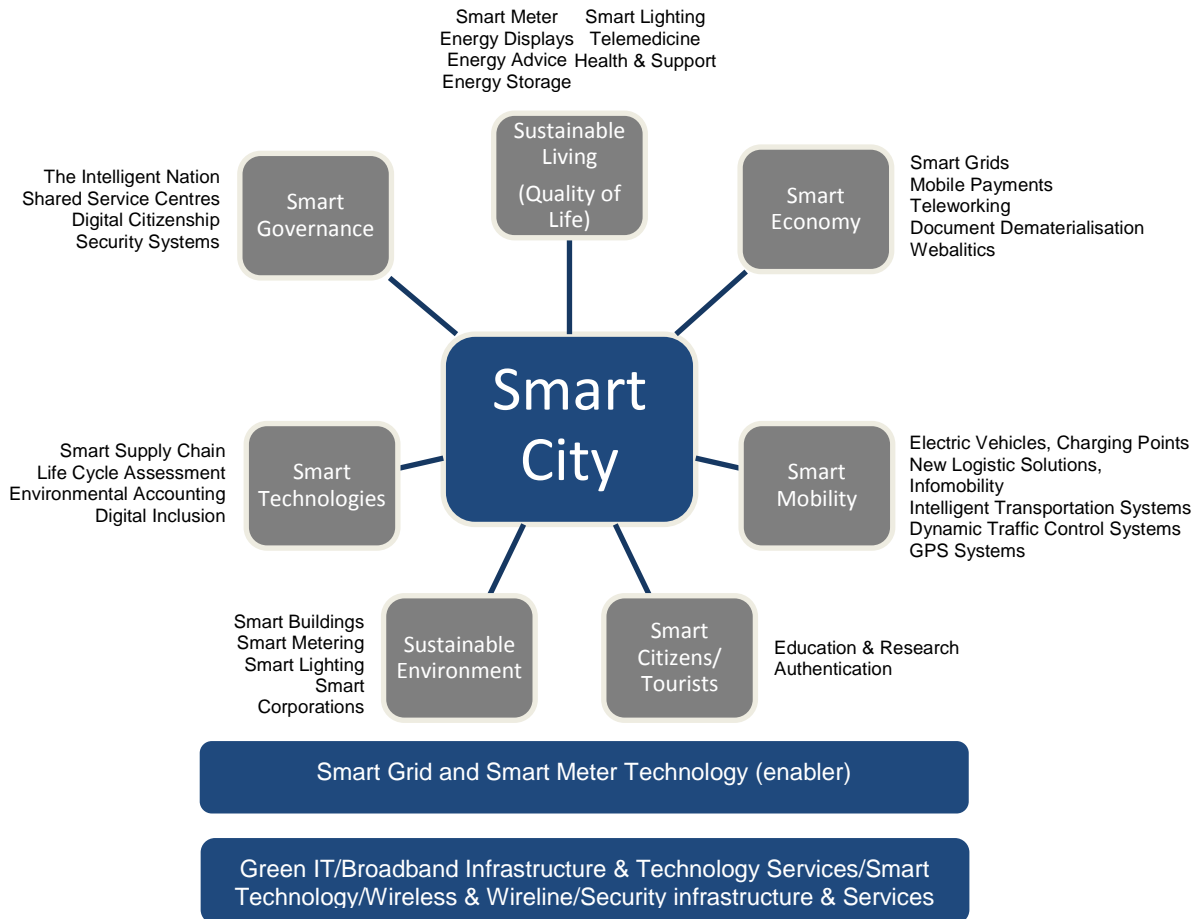


Figure 4.12: Smart City Conceptual Framework (World Smart City Forum, 2012)

Smart Growth requires multi-modal transport systems to ensure ease of access to services and destinations and to ensure emphasis on the public realm where all city dwellers are encouraged to share streetscapes, sidewalks, public parks, public facilities and where the streets are designed to support numerous activities and not solely dedicated to carrying maximum volumes of automobile traffic (Angel, 2010).

The structure of dense, smart cities enables the use of fewer resources required in buildings that will use less energy to be heated, cooled and illuminated, where the required services are within walking distance and in close proximity to public transport,

resulting in reduced reliance on vehicles. The dynamic concept of smart cities has been encapsulated in Figure 4.12, reproduced from the World Smart City Forum (2012). There are elements within this framework that need to be considered for a holistic sustainable transport solution within smart cities, enabled through dynamic technology interfaces, appropriate infrastructure, governance and sustainability-oriented citizens and tourists.

4.1.3 Environmental Implication as a result of Private Vehicle Oriented Systems

Emissions as a result of Combustion of Fossil Fuels from Private Vehicles

In 2011, the International Energy Agency (IEA) reported that the total CO₂ emissions due to the combustion of fossil fuel in South Africa amounted to 369.4 Mt CO₂, which equates to each individual South African being responsible for 7.5 Mt CO₂, which is 1.75 times the global emission rate of 4.29 Mt CO₂ per capita. If the road transport industry emitted 12.6% of the total CO₂ emissions in 2009, absolute CO₂ emissions come to 46.7 Mt CO₂. If South Africa’s population is estimated at 49 million people in 2009, each South African would have been responsible for 0.95 tonnes of CO₂ in that year, which is determined from the manufacturing and use of road transportation. The percentage of CO₂ emissions contributed by industry in South Africa for 2009 is represented in Figure 4.13.

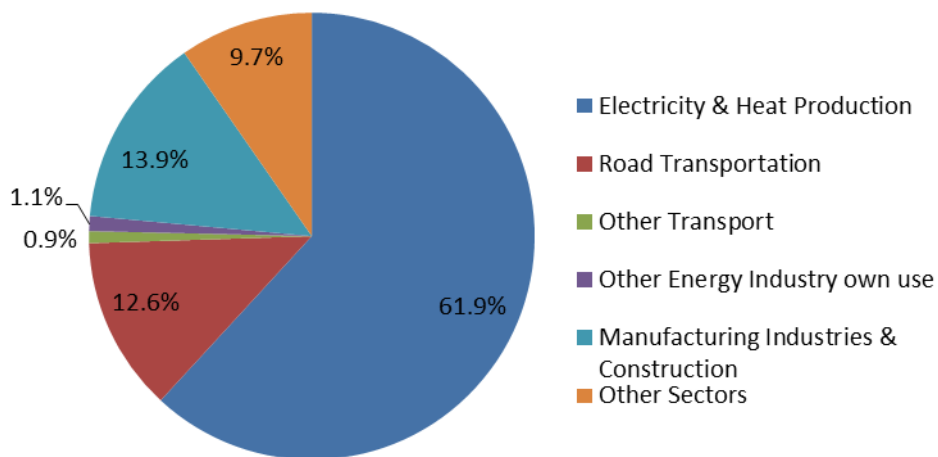


Figure 4.13: Percentage CO₂ emissions generating from the various contributors within the South African economy (IEA, 2011)

Assumptions regarding transportation have been derived from RAC Motoring Services (2012) in order to determine the contribution of CO₂ emissions eqt, based on the private vehicle engine size:

- A small petrol engine is up to 1.2 litres (below 150 grams CO₂ per kilometre),
- A medium petrol engine is up to 1.8 litres (150 - 185 grams CO₂ per kilometre); and
- A large petrol engine is up to 3 litres (185 - 250 or more grams CO₂ per kilometre).

Land Consumption Associated with Private Vehicle-oriented Transport Systems

The land use associated with private vehicle transport systems has a significant impact on the environment as compared to multi-modal transport systems (Behrens & Venter, 2005). Table 4.2 below compares the typical land consumption per capita in square metres, based on multi-modal versus auto-oriented communities.

Table 4.2: Typical land consumption per capita (Litman, 2011)

| Land Use | Multi-modal | Auto-oriented |
|---|-------------|---------------|
| Housing (111.5m ² interior space per capita) | 37 | 111 |
| Parking (28m ² per space) | 56 | 167 |
| Roads (1.4m right of way width per lane) | 42 | 139 |
| Impervious surface per capita (m ²) | 135 | 418 |

*NOTE: data given in ft and the equivalent metric units have been use for ease of reference

Private-oriented transport systems therefore consume 3.1 times more impervious surface infrastructure than multi-modal transport systems, which could alternatively be made available for productive uses such as agriculture, communal parks, or densification, in line with compact city principles.

An extremely useful index reported by Litman (2011:38) is that for each additional urban motorist an extra 80 m² to 140 m² of land is required for the additional road and parking space to ensure that there is no increased traffic and congestion. Compared to other land uses such as the land required for a small family home with four residents of 400m² 10m² of office space required per employee and 30m² for retail, a vehicle requires the same

land that is required for a typical urban resident for dwelling, job space requirements as well as their commercial activities.

However in South Africa a typical small family house, such as a RDP house is roughly 36m² while a typical middle income house in South Africa would be around 300 m² to 500 m² (COJ, 2010). The additional space required for a motorist will be assumed to be in the range of 80m² to 140 m² (Litman, 2011:38) although South African's urban planning guidelines and regulations would be different. It is still evident that the amount of space required for a motorist is 2 to 3.8 more that of an RDP house.

It is therefore critical to start changing the transport behavioural patterns of South Africans to ensure that these are embedded for future generations to follow as well as to ensure that fair and sustainable transport solutions are accessible for South African's mobility and urban space.

Environmental Impacts Associated with Impervious Land required for Private Vehicle-oriented Transport Systems

Further to the discussion above, private vehicle-oriented transport systems consume 3.1 times more land for the construction of roads and other transport roads of impervious surfaces than that required for multi-modal transport systems. This results in less land being available for agricultural or other economic purposes. There are also negative environmental impacts associated with such large areas of impervious surfaces whereby the depletion of natural sub-surface ground water occurs because of rapid stormwater runoff, as well as the increase of the Urban Heat Island (UHI) phenomenon in cities (Litman, 2011). UHI is the microclimatic phenomenon that occurs within metropolitan areas with large amounts of impervious surfaces such as buildings and roads, the significance of the phenomenon is the increase in the ambient temperature within the metropolitan area as opposed to that experienced in the surrounding suburban areas and rural regions (Országos Meteorológiai Szolgálat, 2013).

Table 4.3 further summarises the negative environmental impacts associated with impervious land consumption as mentioned by both Litman (2011) and Országos Meteorológiai Szolgálat (2013).

Table 4.3: Negative environmental impacts associated with impervious surfaces (Litman, 2011).

| Environmental Impact | Description |
|----------------------|---|
| Hydrological Impacts | Permanently changes surface and ground-water flows and increases storm-water runoff, raising the risk of flooding, scouring and siltation |
| Heat Islands | Paved surfaces cause increased ambient summer temperatures to rise higher than normal, which in turn increases energy demand due to required air-conditioning |
| Health Impacts | Heat island causing higher incidents of injuries and deaths from dehydration, worsened by smog induces and impacts health problems |

4.1.4 Health and Associated Economic Implications as a result of Emissions caused by Private Vehicles

In terms of public health costs due to traffic congestion, Levy et al. (2010) determine that the main component of a motor vehicle’s emissions that contributes to outdoor air pollution is referred to as fine particulate matter (referred to as PM_{2.5}). In urban areas, vehicles can contribute up to one third of observed PM_{2.5}. This fine particulate matter has been associated with premature deaths, in which health impact assessments that were conducted have been able to detect the social impacts and costs associated with premature death, particularly from heart attacks and strokes, asthma attacks and other respiratory illnesses. Although fine particulate matter is associated with a myriad of health impacts and premature death can result from the many negative health impacts of breathing in PM_{2.5}, one could argue that this is an extreme case. Ratings of city-specific emissions were created based on the miles travelled by each vehicle in a year, temperature profile, and average vehicle speed. The study incorporated several inter-linked models to predict the amount of pollution (particulate matter) that people breathe in due to the emissions from traffic congestion. The study which is still underway seeks to determine the number of people who die prematurely as a result of exposure between the years of 2000 and 2030. The predicted deaths are assigned a dollar value using “value of a statistical life”.

Based on the combined results of Figure 4.14 and Figure 4.15, the mortality and public health costs of congestion are expected to diminish slightly over time in the majority of the

85 urban regional areas in the United States included in Levy et.al's (2010) study, although the trend is predicted to rise again towards the end of the modelling period, which is in the year 2030. The initial reduction is assumed from the continual turnover of the motor vehicle fleet to lower emission vehicles and the increased use of cleaner motor fuels. This contradicts the expected continued annual growth in cost associated with fuel and time loss over the next 20 years. In 2005, the congestion-related premature mortality was estimated at 3 000 lives across the United States, with an associated value of \$24 billion (exchange rate of 2007).

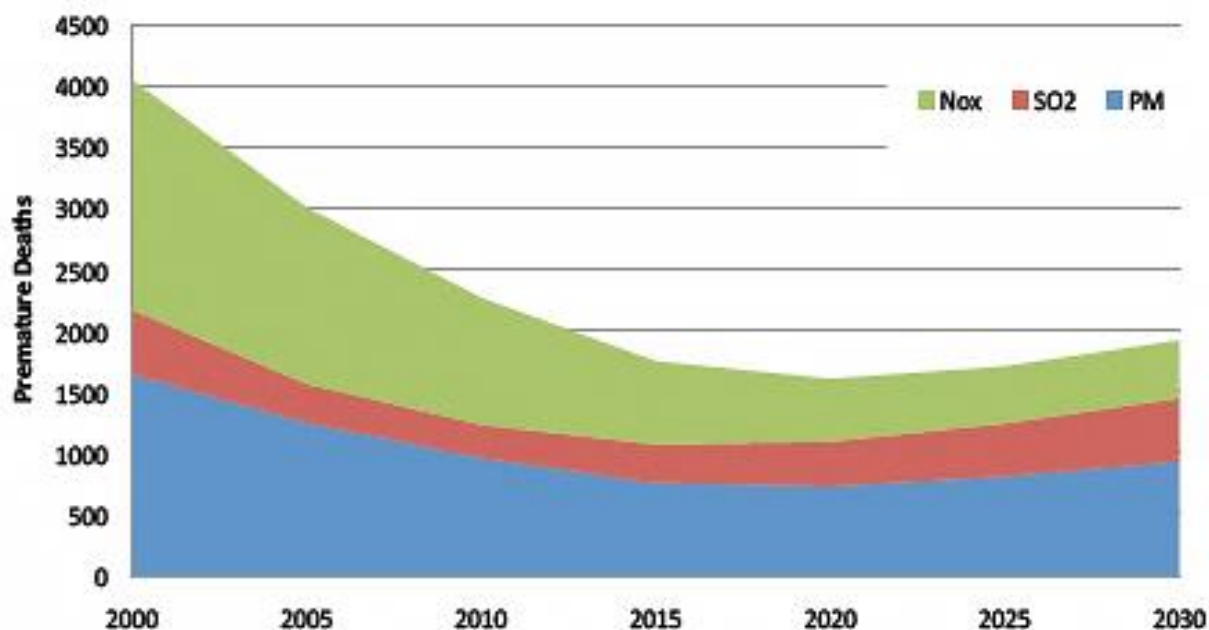


Figure 4.14: Projected nationwide (which country?) premature deaths attributable to traffic congestion, 2000 – 2030 (Levy et al., 2010)

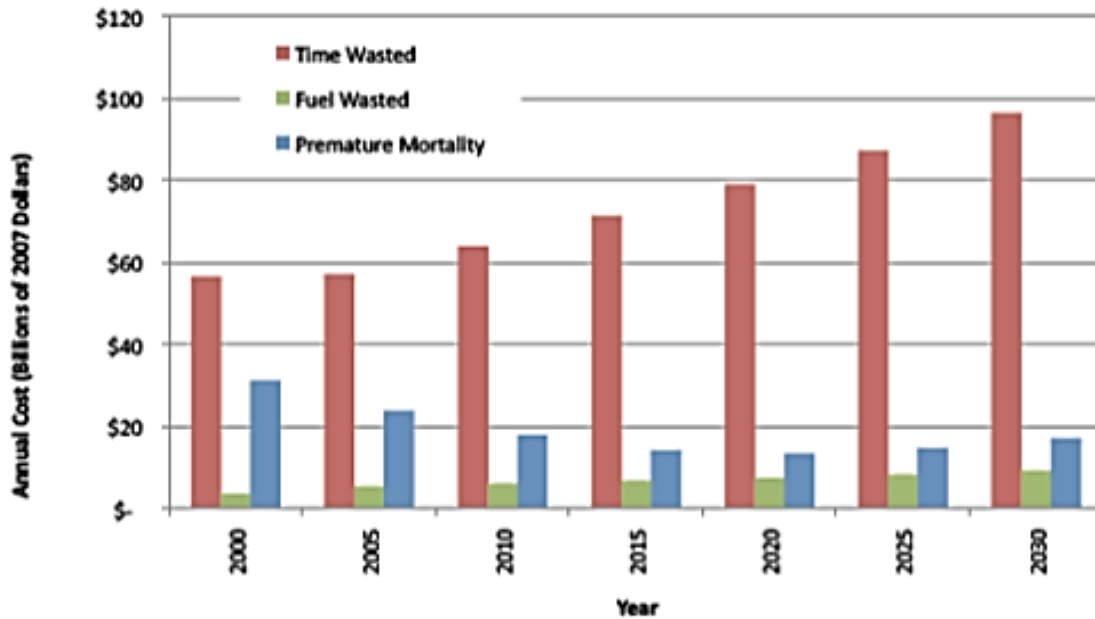


Figure 4.15: Monetised premature mortality as compared to projected time and fuel dollars wasted attributable to traffic congestion (Levy et al., 2010)

Litman (2011) also investigates multiple indices for valuing the active transportation benefits of reduced private vehicle use, and reported extensive savings from avoided driving, increased happiness and overall quality of life, and reductions in coronary heart disease, diabetes risk, congestion, pollution and crash risk which ultimately leads to reduced economic implications of absenteeism from school and work, which is tabled below:

Table 4.4: Health benefits of increased walking and cycling for economic analysis (Litman, 2011)

| Country | Walking | Cycling | Tool |
|-------------|--|----------------------|---|
| New Zealand | \$ NZ 2.70 per mile | \$ NZ 1.40 per mile | New Zealand Transport Agency's Economic Evaluation Manual |
| USA | \$ USD 3.70 per mile | \$ USD 1.92 per mile | New Zealand Transport Agency's Economic Evaluation Manual |
| Britain | For every £1.00 spent on a programme that encourages walking results in benefits worth £2.59 | - | Active Transport Quantification Tool |

The social benefits are reported similarly in numerous countries including Fez, Morocco, where reduced private vehicle dependence have inspired cycling, exercise and healthy leisure activities. Improved downtown traffic flow has been reported in New York, pedestrian injuries have been reduced from 63 % to 35%, as well as a significant reduction in emission-related respiratory diseases.

In conclusion, a variety of studies reveal the social and cost benefits associated with improved public transport and reduced dependence on private vehicles.

4.1.5 Economic Implications associated with Private Vehicles

Percentage of South African Household Income spent on Transport

Employment has become more concentrated in the northern suburbs of Johannesburg, fast closing the physical gap between Johannesburg and Pretoria. This has led to increased travel time and costs, affecting those who can least afford it (Department of Transport, 2007). According to Statistics South Africa (2005/2006), in preparation for the Integration Transport Plans, the lowest income populace spends more than 10% of their personal income on travelling to work. The graphs constructed from Stats South Africa below strongly indicate that the demand for transport has increased (Pillay et al., 2006).

Figure 4.16 illustrates that 19.9% of South African households' income was spent on transport during the years of 2005 and 2006, as reported by Statistics South Africa, Income & expenditure of households 2005/2006- P0100.

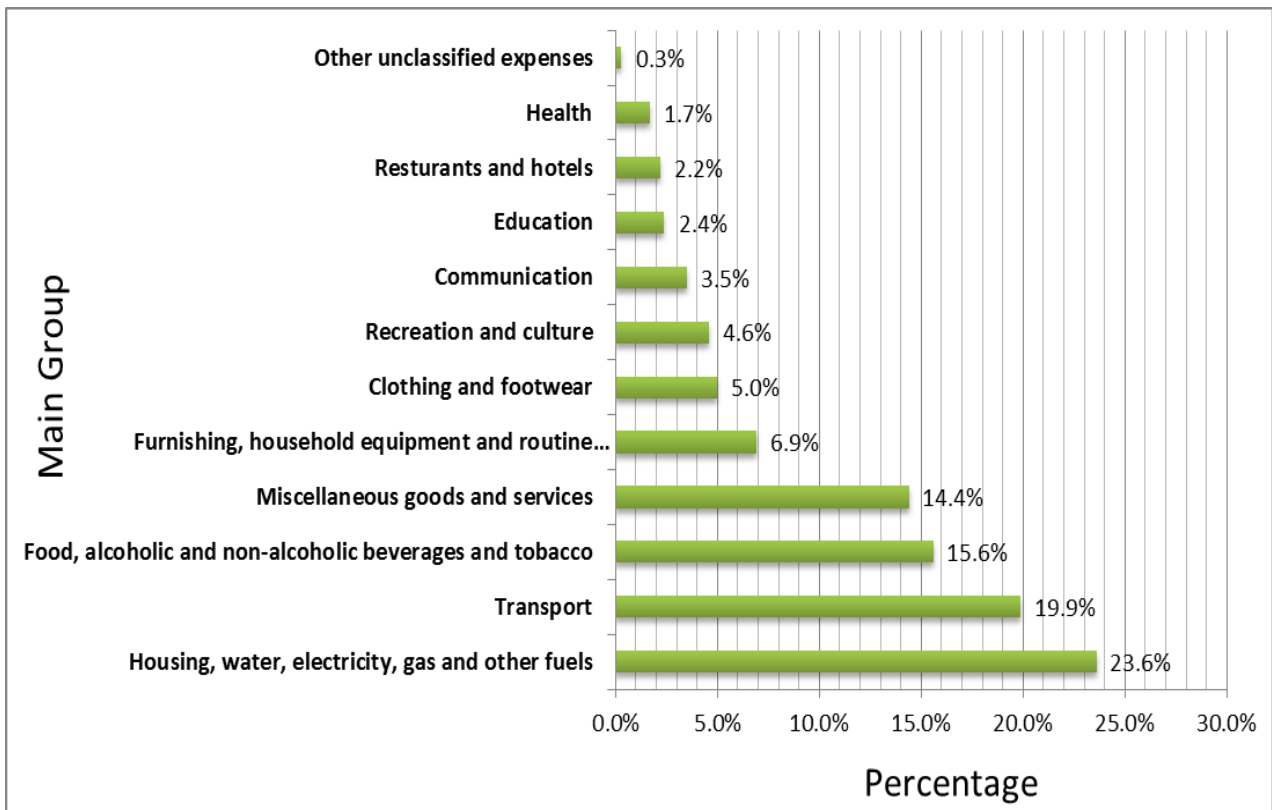


Figure 4.16: Percentage distribution of total annual household consumption expenditure in South Africa by main expenditure group (Statistics South Africa, 2005/2006)

Figure 4.17 reveals that in the period of 2005 to 2006, the proportion of income spent on transport increased with the increase in household income. Households in the lower income ranges spent approximately one tenth of their consumption expenditure on transport while households in the upper income ranges allocated up to one quarter of their total household budget to transport.

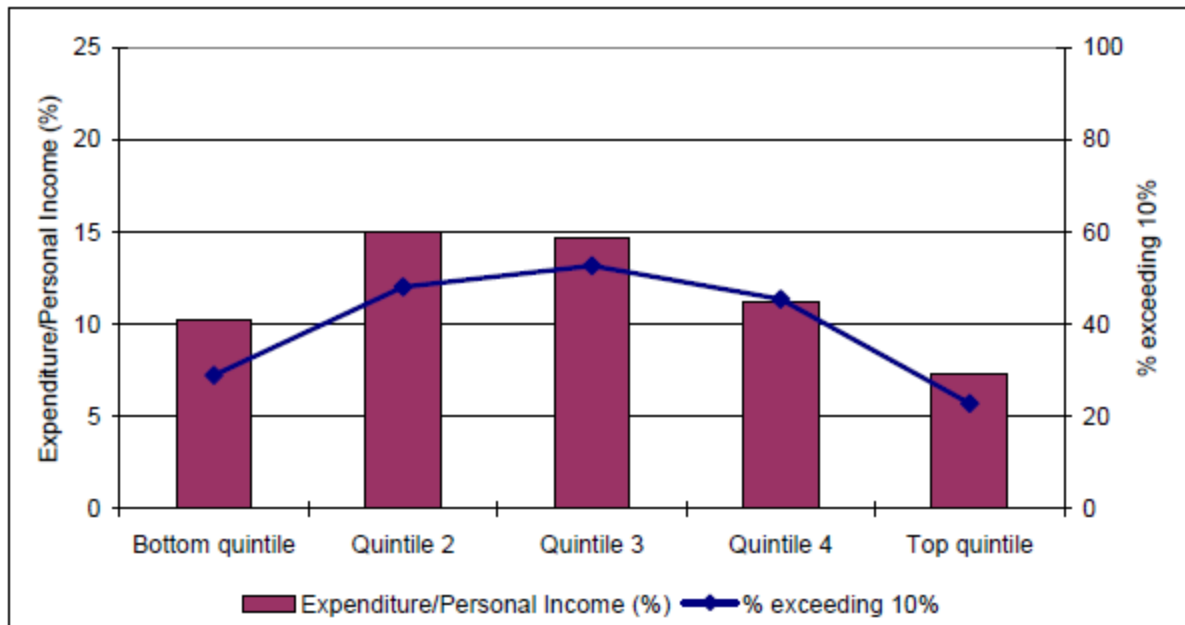


Figure 4.17: Proportional expenditure vs. income for car modes to work (n=3942 individuals) (Behrens & Venter 2005)

When reviewing the results provided by Behrens & Venter (2005), it is evident that there are unfair pressures placed on the lower income population with the second and third quintile spending at least 14-15% of their personal income on transport. This further influences the fact that the poor are disproportionately affected by the high expenses associated with transport, resulting in the poor's mobility being limited by their lack of income. The 3rd and 4th quintiles most likely represent target market at Wits, where these groups are probably in a financial position where they are able to seek alternative transport solutions, where the top quintile's transport choice would most likely only be reconsidered due to ethical considerations.

Additional Cost due to an Inactive Workforce as a Result of Traffic Congestion

Although the focus of this investigation looks at the savings opportunities based on shared travel costs due to carpooling, if shared transport were to be adopted by larger working commuters, economies of scale would play part. The time lost in productivity due to traffic congestions could result in significant savings.

Survey results collected by Litman (2011) through the use of Travel Time Index (TTI) revealed per capita congestion delay in the United States of America in 2007, as depicted in Table 4.5 below.

Table 4.5: Congestion delay for Cities in the USA (Litman, 2011)

| | New York | Los Angeles | Philadelphia | Miami | Boston | Dallas |
|---|------------|-------------|--------------|-----------|-----------|-----------|
| Population | 17 799 861 | 11 789 487 | 5 149 079 | 4 919 036 | 4 032 484 | 4 145 659 |
| Per Capita Annual Congestion Delay | 46 hrs | 72 hrs | 38 hrs | 50 hrs | 46 hrs | 58 hrs |

The quality of transport available to South Africans is further dependent on the available road infrastructure, which in turn impacts on the journey length. Bogetic et al. (2005) indicate that South Africans' travel time to commute to work from home, in major cities such as Johannesburg takes up to an average of 35 minutes. In the OECD countries, travel time is estimated at 32 minutes over the same distance and Sub-Saharan African countries record 34 minutes, whereas the world average is 31 minutes.

Studies in preparation for the implementation of the BRT project as projected by the National Road Agency (2009) give the following indices for Gauteng.

Table 4.6: Indices for Gauteng, South African public transport modes (National Road Agency, 2009)

| Description | Index |
|--|---|
| Average travel cost to work by public transport | R186 per month |
| Public Transport users' income | R1 600 per month |
| Percentage of households not owning private vehicles | 63% |
| Average travel time to work (Average: 48 min) | By Car: 37 min Minibus Taxi: 51 minutes Inner City taxi- 78 minutes |
| Public/Private Modal Split (am peak hour) | 47:53 |
| Public Transport Modal Share | By train:14% By minibus:72% by bus 9% |

Sacci (2010) developed a cost estimate of R15 per hour per person due to traffic congestion. The estimate was based on 90 000 vehicles travelling between Pretoria and

Johannesburg between 6:30am and 8:30am on weekdays, with one person per vehicle and an average income of R170 an hour. The cost estimate did not take into account fuel and vehicle maintenance costs, the cost of late freight deliveries, other associated transport and business opportunity costs or the cost of additional collisions.

Land Consumption and Cost Considerations associated with Private Vehicle-Oriented Transport Systems

The direct and indirect cost of parking lots has been constructed in Table 4.7 below using resources made available from the US Environmental Protection Agency (USEPA, 2008).

Table 4.7: Cost of parking lots (USEPA 2008)

| Cost Type | Description |
|---|---|
| On-site direct costs absorbed by developers and local governments | <ul style="list-style-type: none"> • Construction, operation, maintenance and disposal of materials to develop and maintain parking lot costs • Paving material and the cost of supporting infrastructure such as gutter and storm drainage • Additional landscaping costs |
| On-site indirect costs transposed to parking lot users | <ul style="list-style-type: none"> • Decreasing the automobile value quicker through accelerating the deterioration of the vehicles tyres, paint and plastics. • Increased energy cost of surrounding building to overcompensate through increased air-conditioning use |
| Infrastructure costs - indirect cost | <ul style="list-style-type: none"> • Due to water quality deteriorating and increased volume of storm-water runoff caused by impervious surfaces, municipalities need to upgrade their storm=water management systems |
| Opportunity costs - indirect cost | <ul style="list-style-type: none"> • Less land is available for more profitable use such as office parks, recreation and agriculture |
| Distributional issues | <ul style="list-style-type: none"> • The land used for parking only services the commuting consumers, whereas the surrounding community would be better served if the land was used for alternative purposes. The surrounding property value would also increase due to reduced amount of adjacent paved areas |
| Community development costs | <ul style="list-style-type: none"> • Reduced appeal and liveability leading to discouragement of pedestrian-friendly communities and alternative, sustainable public transport solutions |

The monetary value associated with purchasing land, and the construction and operation of parking bays in North American urban areas has been well documented by Litman (2011). The costs will however vary, depending on factors such as local land values. Litman (2011) estimates that the cost of shifting from automobile to non-motorised travel in the form of parking savings would be in the region of \$2 to \$4 per urban-peak trip (a typical commute has \$4 to \$8 per day parking costs, \$1 to \$3 per urban off-peak trip, and about \$1 per rural trip).

4.2 Shift in Paradigm: Motivating People to Use Alternative Transport Modes

Shared Transport, as reported in a recent World Share Transport forum (Britton, 2011), consists of four principle components: Shared transport space and information, Business value-driven models, shared transport modes and personal travel behaviour and, where:

1. Shared space and knowledge: Shared space aims to improve the sharing and use of limited public space within cities to facilitate the process through land-use policies, access control and restrictions, modal separation (Bus Rapid Transit or BRT, cycle lanes), parking, time zoning of activities, shared surfaces and limiting of speed in certain areas. Where shared knowledge encompasses the use of: integrated technology systems (ITS); maps; schedules; interactive media; behaviour change communication mechanisms in support of educating commuters; and providing real-time integration with shared space and shared modes;
2. Sustainable business value-driven models, which shift private and public initiatives from a product economy focus to a service economy focus, which further motivates shared transport concepts;
3. Shared transport modes aim to improve the efficiency of transport through taxi sharing, small bus sharing, bicycle sharing, car-sharing, ride sharing and integrating existing transport systems to increase overall flexibility and service levels of those existing modes; and
4. Changing personal travel behaviour identifies elements which influence the actual behaviour in modal choices and how to influence a paradigm shift towards shared transport options.

4.2.1 Shared Space and Knowledge

The concept of shared space is particularly interesting in that it embodies the concept of intelligent urban design.

The World Share Transport Forum (Britton, 2011) noted the following concepts and practices for consideration: shared parking; street-sharing with other transport modes; street-sharing with non-transport activities; public space sharing; workplace sharing (neighbourhood telework centres, virtual offices, co-workplace) and team sharing, leading to cost and time sharing. The concept of shared space ultimately leads to the consideration of smart urban design and a focus on car-free city zones that best support a sustainable system where space is utilised for both work and living. These powerful concepts have been recently reported in the national geographic (2011) *energy series – car-free city zones*, which could be applied to increase the adoption rate of shared transport modes.

Lerner (2011) further emphasises that different sectors of the cities should take on different roles during 24 hours of the day so as to better utilise space. Space should never be empty, therefore multipurpose planning for space and buildings needs to be adopted to ensure the forward moment of greener cities and eradicating the need for cars. The leading views developed across designers and developers of car-free cities, is that there needs to be shift in focus from the movement of cars to the movement of people, simply an extension of the concept of a service-oriented economy rather than a product-oriented economy.

From the literature review it is evident that for bicycle-sharing, ride-sharing and fleet-sharing to work effectively, the investor or its partners as well as the users need to be well informed of the system operations. This is essential to ensure that the maximum benefit from the programme is achieved as well as educating the users as to the full environmental and cost benefits through transparent costing systems and effective marketing mechanisms.

To date, there is no central repository for obtaining statistical information regarding bicycle-sharing. Although the most recent and relevant guideline information that is

specific to bicycle-sharing schemes is available from the Canadian Environmental Authorities, bicycle-sharing schemes are being increasingly implemented in cities around the world (Midgley, 2011). This will lead to the need for developing reliable, exhaustive, easily located information on the cost, benefits, design guidelines, implementation and operation guidelines for bicycle-sharing. The benefits of this central repository would ensure that countries, especially developing countries, will have access to tried-and-tested information, which would eliminate the need to conduct their own case studies and re-invent approaches, cost estimating tools and associated expected benefits as reported by Midgley (2011). These benefits would also hold true for establishing car and fleet-sharing systems.

The most up-to-date repository of relevant publications and advancements related to global ride and car-sharing, fleet-sharing, and other shared public transport has been listed in Table 4.8. A brief description of the networks, the estimated date the network commenced and the extent of social media mechanisms/forums is also listed (Midgley, 2011).

Table 4.8: List of Global Sustainable Transport Publications available to South Africa

| <i>Organisation</i> | <i>Web URL</i> | <i>Description</i> | <i>Formalisation date</i> | <i>Social Network Mechanisms</i> |
|--|---|--|---------------------------|----------------------------------|
| African Centre of Excellence for Studies in Public and Non-motorised Transport | www.acet-uct.org | Provides current projects and academic publications relating to South African public and non-motorised transport | June 2011 | None |
| Green Car Congress | http://www.greencarcongress.com/ | Provides publications related to energy options, technologies, products, issues and policies related to sustainable mobility | April 2004 | Twitter |
| International Association of Public Transport | http://www.uitp.org/advocacy/public_transport.cfm | International network for public transport authorities and provides a way for worldwide cooperation, business development and the sharing of know-how between its members | August 1885 | None |
| World Streets | http://worldstreets.wordpress.com/ | Built on two decades of collaborative problem solving and International networking from the New Mobility Agenda; www.newmobility.org and is a published weekly newspaper dedicated to addressing sustainable transport issues | 1988 | Facebook Twitter LinkedIn |
| Carsharing Net | http://www.carsharing.net | This has been a definite resource for shared information on car-sharing and how to implement the service within your own community. It draws from lessons learnt in implementing the system in North America | 1990 | Twitter |
| Mobility | http://emag.mobilitymagazine.co.za | An online southern African magazine for policy and decision makers related to transport solutions | 2009 | None |

4.2.2 Sustainable Business Value-Driven Models

The most appropriate definition of business sustainability was articulated by the Institute for Sustainable Development as: “Adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future,” (International Institute for Sustainable Development et al., 1992).

With the growing awareness and adoption of sustainable performance by business, MBDC (2010) suggests that there is increased demand by the public for companies to incorporate the following criteria in order to grow awareness and adoption of sustainable performance, an organization:

- Include sustainability measures in their success metrics and annual reporting;
- Address socially responsible investing (SRI) concerns;
- Attract and retain their employees (staff) through ensuring socially responsible workplaces; and
- Support and facilitate a shift from regulation as imposed by government to partnering for sustainability, where opportunities are identified.

The stakeholders who are affected by the selection and implementation of these business strategies have been depicted by MBDC (2010) in Figure 4.18, where public institution roles have been noted in brackets.

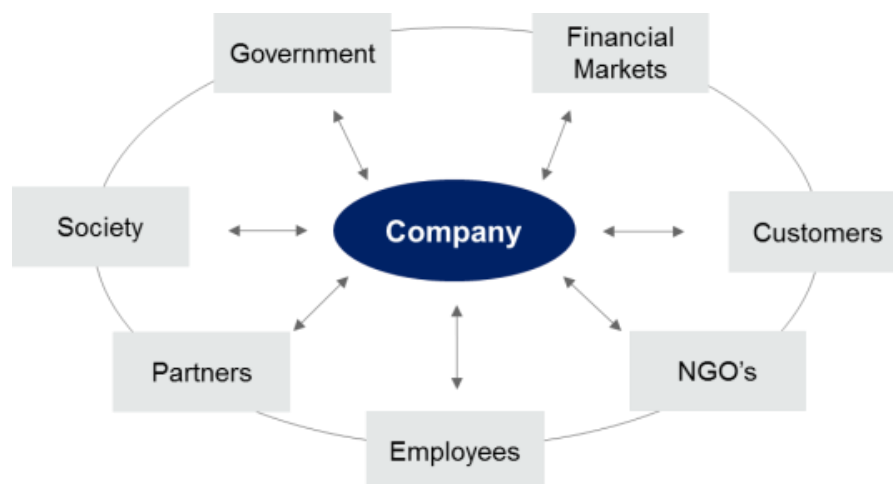


Figure 4.18: A company's stakeholders whether traditionally perceived or not (MBDC, 2010)

Research conducted by MBDC (2010) shows that positive stakeholder engagement and reputational enhancement could facilitate operational economical optimisation. With focus placed on multiple stakeholders, the company moves beyond individual self-interest through creating increased value through increased quality of life, which in turn secures self-interested achievements (International Institute for Sustainable Development et al, 1992). Therefore by a business ensuring it reduces environmental impacts while incorporating socially responsible business strategies, it will increase saving on investment.

Wits Vision 2022 Strategic Framework (Wits, 2010:6) resulted in numerous round table discussions and debates; a key theme which is relevant to this report, was “Autonomy and accountability: How will Wits respond to the pressure of becoming an active global citizen concerned about forging, embedding and contributing to a consciousness of sustainability?”.

Similarly a public institution such as Wits could adopt sustainable performance and influence its students to drive behavioural change as future business leaders. The criteria listed by MBDC(2010), are as applicable to public institutions like Wits as they are to a business.

4.2.3 Shared Transport Models

Shared transport in the automotive industry challenges the mind-sets of sellers and consumers by offering an alternative mode of transport to private car ownership. This concept emerged from Stahel’s school of thought , since the 1970’s which is embodied in MBDC shared business value-driven model, where ultimately environmental benefits can be realised through transforming product-oriented economies into service economies. The premise is based on product life extension which implies that companies should be in the business of selling the utilisation of products and not the product itself. The product is maintained better and more importantly, the reusing and remanufacturing of parts to extend product life becomes an intrinsic focus. This supports industrial ecological transport sector ideals, where integrated transportation systems move people with the highest efficiency while resulting in the lowest possible pollution (Lowe, 2005).

Shared transport concepts emerged in Switzerland and Germany in the late 1980s, and have since spread to other countries across Europe. In the 1990s the concept was adopted in North

America and Asia. Most recently Australia launched three car-sharing initiatives in 2003. In total, car-sharing operates in 600 cities worldwide. It has been suggested that these concepts will soon be adopted in South Africa to address the demand for personal vehicle access in developing countries, while fulfilling the need to reduce personal transportation costs as well as address negative impacts such as congestion, inefficient land use, energy consumption and CO₂ emissions. These concepts have been established to improve car-sharing knowledge and advanced technology further supports the operations of car-sharing (Shaheen & Cohen, 2006).

Britton (2011) argues that the solution to de-emphasising the vehicle is not to ban cars and force commuters to take public transport, but rather explore a third way of motivating commuters to use alternative low-carbon modes of transport; where disincentives include limiting space through conditions of access to cars when in use and parked, such as restrictions and imposed penalties. Incentives would be through mechanisms which entice commuters to use efficient mobility solutions made available to all level of income commuters.

However it is evident that despite the many known benefits and successful improvements across numerous cities, it is unclear why policymakers and transport planners have not adopted this form of new mobility paradigm more aggressively.

Types of Share Use Transport

The appropriate use of shared transport as compared to existing public transport and non-motorised transit is depicted in Figure 4.19, which indicates that over a certain distance, specific transport modes become the preferred choice of mobility due to their level of flexibility. This indirectly illustrates the potential available market, where it is evident that shared transport fulfils a significant proportion of market potential.

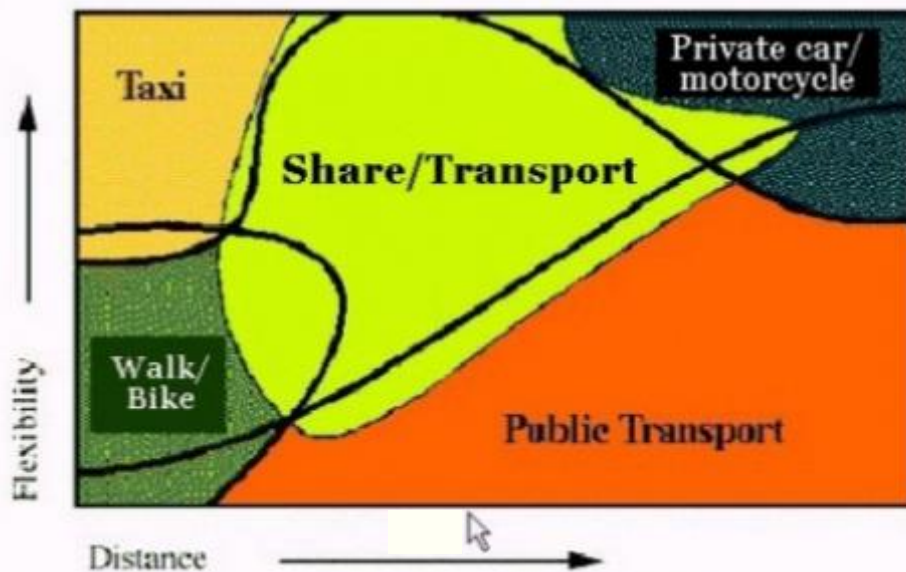


Figure 4.19: Transport Mode Concept Diagram (Britton, 2011)

The World Share Transport Forum lists numerous areas of innovation and practice associated with shared transport modes; public transport, bicycle sharing, car-sharing (includes both formal and informal arrangements, including P2P car-sharing), fleet-sharing, ride-sharing (carpools, van pools etc.), taxi-sharing, demand responsive transport systems, paratransit and social service transport, truck or van sharing (combined delivery or other), sharing SVS (small vehicle systems: BRT, shuttles, community buses, etc.) and finally successful integration of public transport within a shared transport city leading to cost and time sharing (Britton, 2011).

This investigation focuses on a selection of the above list, namely: bicycle sharing, car-sharing, fleet-sharing, ride-sharing, sharing SVS and the integration of these systems with the current public transport modes available in the City of Johannesburg.

Bicycle Sharing

Bicycle sharing has been well established across the world. It has been successfully deployed in 33 different countries. Midgley (2011) reports on the components required for successful bicycle-sharing schemes to be implemented, and analyses the benefits and impacts of bicycle sharing as well as some of the opportunities and challenges experienced thus far.

The components that make for a successful bicycle-sharing scheme implementation rely on the availability of a bicycle that meets the average user's needs. This relates to the individual's

size and weight, as well as being fit for purpose. To enable automated management of the system, the bicycle is fitted with a global positioning system (GPS) and Radio Frequency Identification (RFID). This enables fleet transport demand management and tracking of lost or stolen bicycles. Docking stations for the bicycles are self-contained. These docking stations are therefore easy to erect and disassemble in response to demand or special events. Access is allowed to members of the scheme through the provision of a smartcard or magnetic stripe card, which releases the bicycle from the stand.

For security reasons, an entry code is presented to the registered user via mobile or pay phone to unlock the automated lock on the bike. It has been noted that pre-registration discourages use of the bicycle and it is therefore critical that docking stations have technological interfaces (kiosks) as displayed in Figure 4.20 where registration can be carried out immediately. These kiosks must have advertising space to provide information required by the user, touch screen user interface to view ticket purchase options, information on how to use the docks, bicycle and parking facilities. Key card readers must be made available for already-registered users to top-up fares such as a credit card/debit card terminal which will enable easy payment, as for security reasons cash collection slots are undesirable. The ideal dispenser should provide an option for once-off, daily or weekly passes for the individual to utilise the system.

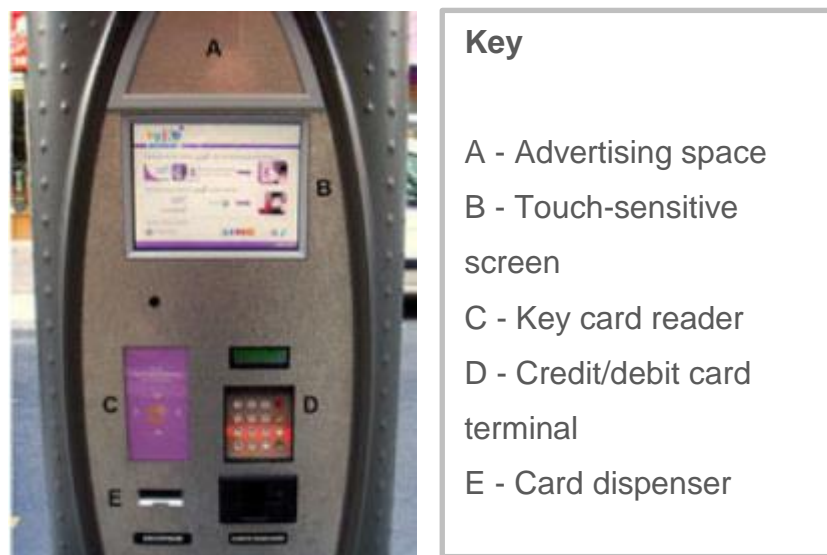


Figure 4.20: Kiosk components (Midgley, 2011)

To ensure that users have accessibility to the bicycle-sharing schemes and are easily able to locate the systems, it is critical to have a user-friendly status information system to provide

real-time information on websites of bicycle availability and where to find and return the bicycle to the closest station to the individual’s position. “AllBikesNow” is a smart phone application which has enabled this function for bicycle-sharing schemes in 23 countries.

To optimise and ensure balanced availability of bicycles around the city, the scheme employs dedicated sweeper units which collect bicycles in popular final destinations and return and distribute bicycles to areas located at the top of hills where users are less likely to travel.

The operation and investment into bicycle-sharing schemes are supported by local government, public transport agencies, advertising companies and NGOs in order to enable funding mechanisms such as user fees, municipal budgets and public/private partnership agreement resources (Midgley, 2011).

The opportunities and challenges reported in the use of bicycle-sharing schemes thus far could be applied to any other shared transport modes, as summarised in Table 4.9 below.

Table 4.9: Opportunities and challenges experienced in bicycle-sharing schemes (Midgley, 2011 and Wittink, 2010)

| Opportunities | Challenges |
|--|--|
| <ul style="list-style-type: none"> • Annual subscription or registration promotes “ownership” and ease of charging • The strategic pricing structure must consider free period of use, scale of pricing increase • Station location choice is critical in promoting use of the bike-sharing scheme • Maintenance of the fleet and docking stations must be easy • Project governance and sponsorship is critical to ensure the system is deployed correctly and operates efficiently • Public perception of transport mode and willingness to share the road is critical for success • Integrated information systems are encouraged, leading to improved smart city adaptation • Fair and equitable access to mobility to increase service efficiency of the disadvantaged leading to increased economic activity • Critical mass and raising awareness will lead to political support and momentum regarding sustainable mobility options | <ul style="list-style-type: none"> • Theft and vandalism of the bikes despite user ID technology • Safety laws and enforcing users to follow the safety laws to minimise injury of riders • Misrepresentation of CO₂ reduction rates if the potential benefits and reduced car use are misconstrued, leading to reduced appeal of the system due to reduced user confidence • Barriers to entry presented by current planning policies and design practice transformation may require significant time and effort to enhance the transport demand management solutions • Large costs associated with transport interventions leading to increased barriers of adoption of sustainable public transport solutions |

Ride & Car-Sharing

The collaborators of the Transit Cooperative Research Program (TCRP, 2005:23) define *Ride & Car-sharing* as “privately-owned vehicles shared for a particular trip.” A carpooling facility can be established by independent commuters offering the use of private vehicles and governed by mutually agreed, informal established rules of etiquette defined by the members of the carpool or lift club.

The research conducted in the study by the TCRP (2005) revealed that there are levels of automation for the *Ride & Car-sharing* schemes. The informal *Ride & Car-sharing* schemes tend to rely on manual processes to physically get together with people in a community and agree on terms which the group will follow. The more formal schemes are supported by webhosts who act as mediators to store information which the member can browse through; the more advanced systems provide suggested matches based on a set of criteria entered by the member; while the most sophisticated and formalised *Ride & Car Share Schemes* are automated and enabled through real-time dynamic passenger/driver route matching and cost-sharing technology. These schemes are assisted through GPS and live data streaming. The interface usually requires smart phone applications which can be accessed by a member at any time and can organise lifts with 30 minute prior demand logging and automatic cost-sharing, based on entry and distance travelled in the vehicle (TCRP, 2005).

There have been various levels of formally established carpools. A successful example of a lift-share initiative was established in 1997, and has since developed spinoffs for students as supported by studentcarshare.com as well as attempts to provide flexible, convenient transport in more rural areas, villagecarshare.com. The site search engine has been adapted over time to sustain the members’ needs to coordinate departure and destination points, travelling time and gender. *Lift share* reports that in the UK there is only a 36% success rate for matching sharers and success is largely crippled by reliability factors as well as lack of members offering their private vehicles for lifts (Bannister, 2005).

Figure 4.21 depicts the exponential growth of lift-sharing schemes in the UK between January 2003 and December 2005.

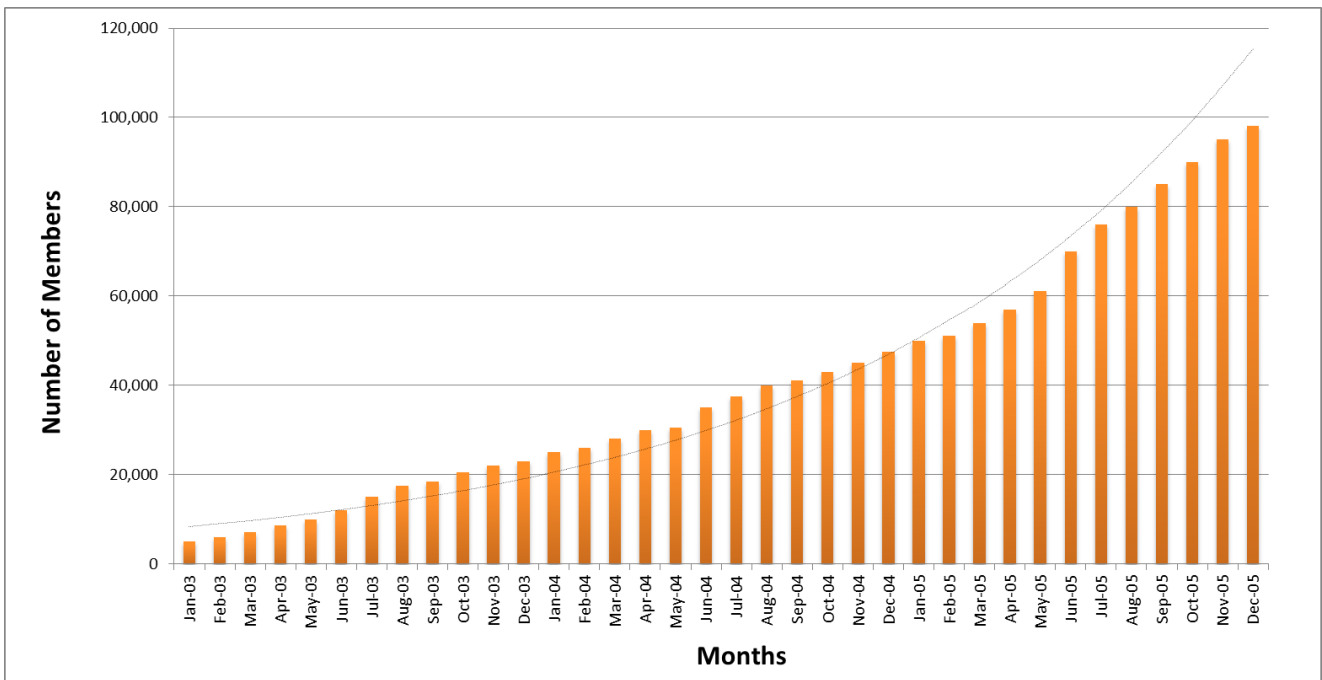


Figure 4.21: Lift-sharing membership growth (Bannister, 2005)

In the attempt of urban planners to address the growing concern of urbanisation in India, strategies have been developed to reduce the emissions per kilometre travelled and the total distance travelled (Dewan et al., 2007). The planners investigated the viability of formalising a carpooling system in Delhi, India. If the planners could successfully implement carpooling, it was estimated that the cost related to purchasing petrol would reduce by 31%. For carpooling to be successful in Delhi, Dewan et al. (2007) argue that the following elements need to be incorporated into a carpooling scheme:

- Government should encourage the use of carpools in urban areas by means of programmes, which include funding of carpool demonstration projects, and the encouragement of local authorities to establish schemes by various means including distribution of information;
- The ride-sharing will only increase significantly if clear incentives to the participants exist. The most important incentives to ride-sharing appear, in practice, to be reserved road space and parking space, and the absence of a convenient alternative mode e.g. where there are no other adequate public transport services. The reservation of road space for high occupancy vehicles is therefore essential. The ride-sharing programme would reduce the vehicle miles travelled by single occupant vehicles. To make carpooling attractive:

- An interface tool provided that encapsulates a more personal touch is an important element in any car-sharing matching service, as this provides the users with access to car-sharing member information and personalising their online profiles;
- Efforts for ride-sharing should be concentrated within recognised groups, rather than spread across the community. New pools can be largely formed with participants who have clear similarities;
- The employer of an organisation plays an important role in promoting and making the carpool a success;
- A pool may be formed by one or more employer in a particular commercial complex which is as important as the official matching service;
- If the schemes are to succeed, efficient and dynamic leadership is required; and
- To make carpooling an attractive proposition: there must be a substantial increase instead of gradual increase in the price of petrol.

In addition, the advantages as a result of adopting carpooling in Delhi, India as reported by Dewan et.al. (2007) include:

- Reduced parking demand directly related to reduced private vehicle use;
- Reduced travel demand as a result of reduced road congestion through maximising the movement of people and not vehicles, leading to fewer vehicle trips on existing road networks;
- Benefits to communities through providing cost-effective and fair access transport;
- Facilitating the integration between public and private transport;
- Reduction in the likelihood of accidents by 50%; and
- The arrangement of carpooling facilities can maximise the available employee parking, encourages sociability between employees, reduces stress in driving to work and improves the companies' corporate social image.

The study conducted for Delhi, India also aimed to estimate the number of cars reduced due to commuters' willingness to carpool, using indicative percentages from an appropriate sample. Dewan et al. (2007) sourced the total number of private passenger cars in Delhi. Surveys were conducted to understand the total percentage of people willing to carpool with one, two and three people. This represents 50%, 67% and 75% less cars on the road respectively. However because only a certain percentage of passengers are willing to carpool, only a percentage of

the full complement would actually help to reduce vehicles on the road. The study reported that the vehicle owner spent Rs5 392 (approximately R875 at the 2007 exchange rate)² including fuel and maintenance and parking, while traveling an average of 40km per day. By carpooling with three other people it was found that each person saved Rs4 044 per month (R656.90 at the 2007 exchange rate). 500 respondents were interviewed, of which only 15.2% currently carpool while 84.8% do not carpool. The analysis of the data also revealed that 28.2% of people want to carpool with one person, 8.2% of people want to carpool with two people, and 15.4% would carpool with three people, while a significant number of respondents at 48.2% were not willing to carpool. This serves as a useful benchmark for the analysis of the Wits survey responses in later chapters.

The most formalised and dynamic car-sharing scheme is the system devised by the American Company, Avego. Integrated data management systems and application as developed by Avego (2011), offer a non-commercial dynamic carpooling service established since 2008 that provides software to enable flexible car-sharing arrangements, including the provision of secured, equitable and predetermined methods of billing car-sharing members.

Registered members are required to submit verified billing and insurance details before Avego's application can be loaded onto their phones. Members, who offer their vehicles to the service, log their common routes and activate them every time they take one of those trips. The prospective passenger must log demand at least 30 minutes prior to required departure. The driver must accept the logged demand; whereupon the driver is directed to the confirmed passenger via GPS. The members who are registered users of the Avego drive application service share the cost incurred by the driver for the distance that the driver has driven the member. As soon as the member is collected by the driver, he or she is provided with an access code. On receiving that access code the route distance entered by the passenger is used to calculate a fee which is charged to the passenger's credit card and 15% of this fee is retained by Avego for services rendered and 85% of the fee transferred to the driver's credit card.

² Exchange rates calculated as an average over 2007, values accessed from <http://www.x-rates.com/average/?from=INR&to=ZAR&amount=1&year=2007>, accessed January 2012)

Fleet-Sharing

Fleet-sharing is based on the concept that a group of organised participants, formally or informally, provide access to one or more shared vehicles based at numerous decentralised parking locations within close range of home, work and shops. It requires that the use of these vehicles is booked in advance via real-time-enabled technology and rentals are charged for short periods of time, self-accessed by members. The formal definition of fleet-sharing provided by the Transit Cooperative Research Program (2005:23) is: “Vehicles owned by a separate organisation and shared between a numbers of different users, who may use them at different times.”

In 2005, fleet-sharing accounted for only 0.03% of transport use by the urban population in the USA. The graph below shows that although fleet-sharing is still a niche form of transport, there is an exponential growth of fleet-sharing.

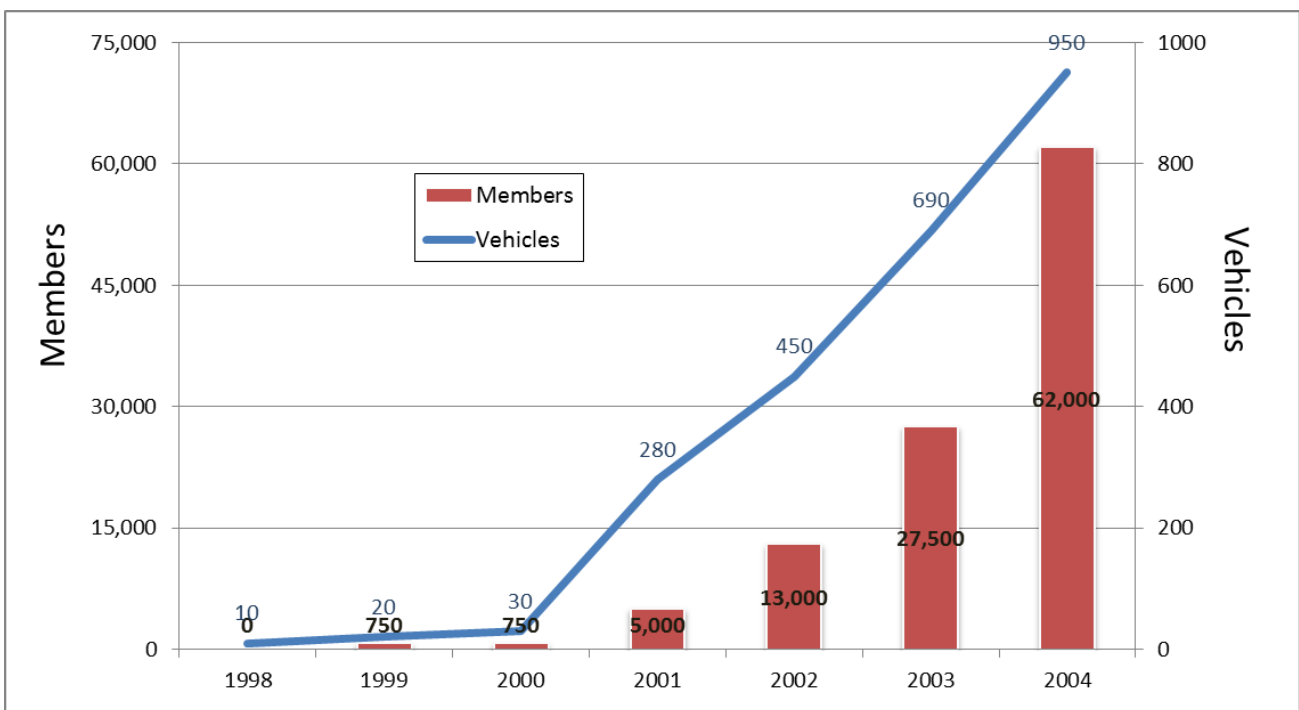


Figure 4.22: US fleet-sharing growth (TCRP, 2005)

Research into the success of fleet-sharing (TCRP, 2005) reveals that the users have high levels of education, with 35% of current members being in possession of bachelor's degrees and 48% having completed postgraduate studies. The users are between the ages of 30 to 40

years who are middle-income earners. Most members join due their concern for environmental issues and are less concerned about the vehicle looks and brand.

Most of the members use this form of transport system for personal errands and rarely use this system to commute as depicted in the graph below.

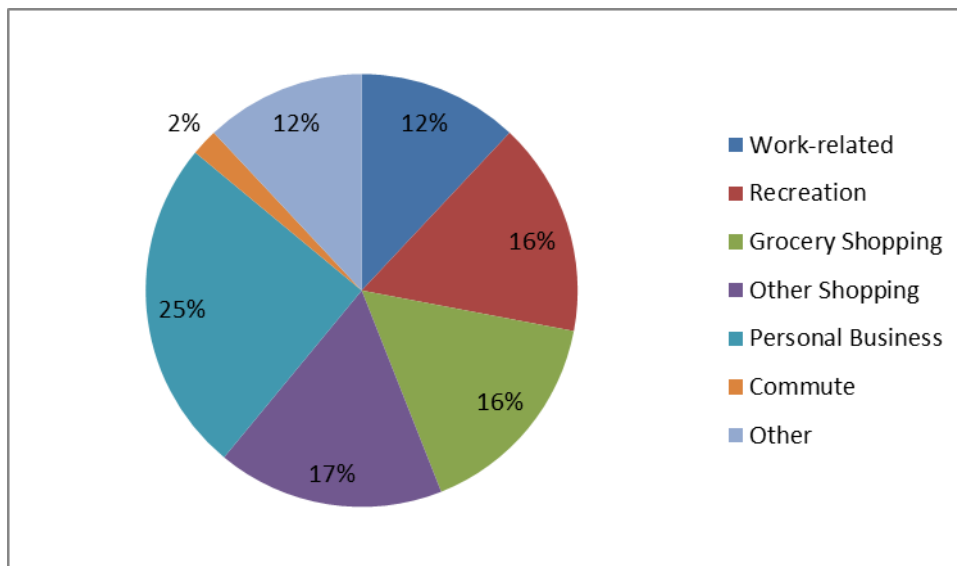


Figure 4.23: Trip purpose (TCRP, 2005)

Extensive literature incorporating international views from across the United States of America (USA), Canada and Europe were consulted by the collaborators of the TCRP (2005). It revealed that fleet-sharing only works successfully in highly concentrated metropolitan areas (95% of the USA members are situated in these areas), and complemented with access to effective public transport. The areas are therefore pedestrian-friendly, have a mix of uses of shared space and there is severe pressure on the availability of parking. The systems seem most adopted by those that are able to live without a car or have access to only one vehicle; therefore low vehicle ownership is a key predictor of fleet-sharing. Universities have proven to be a niche market for fleet-sharing. Generally the use of fleet-sharing will result in 20-66 users per vehicle, with the members using the fleet vehicles on average only twice a month (TCRP, 2005). The empirical data revealed that 40% of the fleet-share members reported cost-saving while 16% reported that students spent more money when using fleet-sharing systems. On average, the fleet-sharing systems resulted in savings of between \$154 and \$435, while monthly fleet-sharing costs averaged \$40.50.

The number of members whose transport use changed to non-motorised or public transport systems is depicted in Figure 4.24. It is important to note the 77% of members who owned a vehicle on joining and reduced their total driving, which in turn would result in reduced emissions and increased health benefits through increased walking are evident in the figure below.

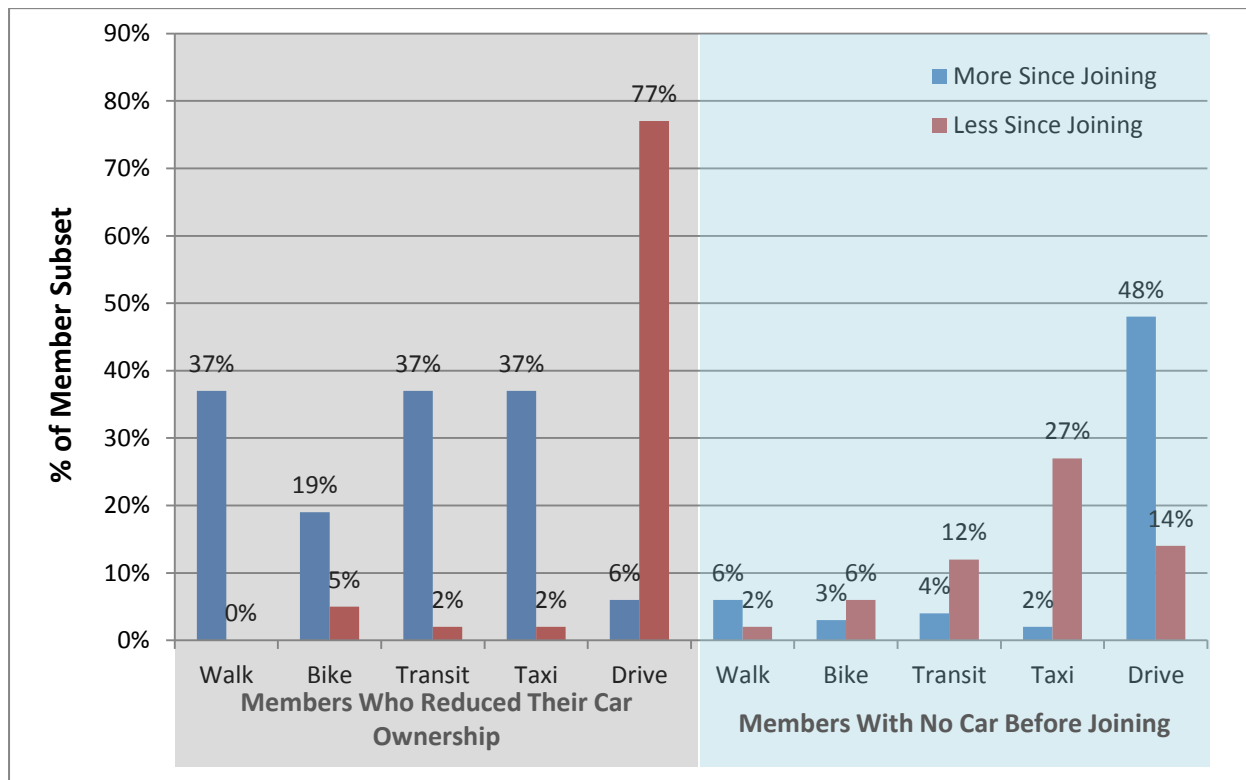


Figure 4.24: Self-reported Changes in Travel Behaviour of fleet-sharing members - Philadelphia (TCRP, 2005)

The International Transport Forum (ITF, 2009) attempted to quantify the fleet-sharing benefits in a summarised fact sheet which included results from existing schemes, showing that:

- Vehicles provided in the schemes are appropriate for the purpose of particular journeys as the fleets comprise small fuel efficient vehicles that are appropriate for short commutes;
- There are benefits to lower income communities, who may require access to vehicles in order to travel to their various work locations;
- There are environmentally-friendly benefits of the scheme's vehicles with regard to pollutants as the fleet vehicles are newer and better maintained than older private vehicles;

- A fleet of shared vehicles replaces between four to eight private vehicles, this results in reduced parking requirements. Each bay requires an area of 36m² to 84m². The reduction in private vehicles also results in reduced CO₂ emissions and resource consumption;
- The schemes provides an ideal environment for the pilot testing of new technology vehicles such as hybrid and electrical cars;
- The benefit of cost transparency that translates into reduced distances travelled;
- The behaviour of the community changed gradually after the realisation of both financial and environmental benefits; this has been defined as the “learning curve of car-sharing participation”, which usually takes effect in the first year of participation; and
- There are voluntary spinoffs that relate to some of the CO₂ off-setting programmes made available by the fleet-sharing organisations where members are given the option of contributing some of the fees generated to climate protection programmes

(ITF, 2009)

The technological capability required to enable fleet-sharing depends on the level of systems that are available. The types of technology that would assist in the integration of the car-sharing system are summarised in Table 4.10.

Table 4.10: Fleet-sharing technology advancement requirements (TCRP, 2005)

| Technology Advancement | Reservation | Access | Billing |
|------------------------|--|---|---|
| Less Advanced | Telephonic live operator retrieves calls and accesses fleet manual log | Early fleet-sharing systems used lock boxes located close to the vehicle. A universal key or ID pin to allow each member access to the vehicle key's lock box | Honour systems through capturing membership use on trip log book kept in the vehicle |
| More Advanced | Automated online reservation systems | Access vehicles through members-only smart card (electronic card) and entering a lock pin on the car itself | Time and mileage recorded automatically through systems incorporated on the car dashboard capturing and sending real-time information to the fleet company database |

In addition, the real-time logged membership use can track members’ travel patterns and enable effective travel demand management suited to the available parking and fleet

requirements. Most cars are also fitted with GPS systems to locate fleet vehicles in the case of theft or incorrect parking location.

The effective implementation of a fleet-sharing system depends on an appropriate and flexible price structure, as well as a rating system that with the appropriate technology and support from business partnerships with local governments, transit agencies, developers, employers and universities, all may be able to provide financial assistance to cover start-up costs, subsidies for low income communities, marketing, administrative activities and management of the user base. This includes provision of currently available parking sponsored through the partners, collaboration between partners to waiver joining fees to fleet-sharing programmes for frequent public transit users, as well as being the custodians of fleet-sharing through demonstrating their commitment through membership to the fleet-sharing programmes (TCRP, 2005).

Some difficulties and key factors of success have been identified in the context of USA, Canada and European fleet-sharing companies and are summarised in Table 4.11.

Table 4.11: Barriers to and factors for success (TCRP, 2005)

| Barriers to Adoption | Success Factors |
|---|--|
| Finding investment partners | Appointing a fleet-sharing champion who understands the true benefits |
| Failure of effective knowledge sharing which creates unrealistic expectations of fleet-sharing and under-appreciation of the true cost -saving related to fleet-sharing | Adopting supportive policies and regulations through provision of zoning incentives and encouraging fleet-sharing in corporate sustainability plans |
| Lack of start-up funds | Selecting the right pilot markets, i.e. neighbourhoods which support the requirements of successfully implementing and displaying true benefit realisation |
| Regulatory issues related to zoning and business licensing | Provision of required enablement, i.e. parking, marketing and administrative support |
| Land use patterns that more easily accommodate private vehicle ownership | Best implemented through business ventures, public private partnerships, municipality run, or private social investment |

The goals and benefits of introducing a fleet-sharing or carpooling scheme within universities is therefore established in the literature, which shows that such a strategy would meet the requirements for transport demand management in reducing the amount of pressure on parking facilities, as well as the broader environmental impact posed by private vehicle ownership. Universities also provide ideal locations for this transport facility due to the pedestrian friendly environment, constrained parking, and scarcity of capital funds which requires universities to incorporate innovative parking management systems. Knowledge sharing is also supported through ease of access to the target audience through appropriate marketing mechanisms (TCRP, 2005).

4.2.5 Changing Personal Travel Behaviour

The theory of planned behaviour is an extension of the theory of reasoned behaviour (Ajzen, 1991). There are four elements that influence the actual behaviour which is being performed by an individual in changing personal travel behaviour namely:

- “The *intention* of the individual to perform a particular behaviour which means that the more motivation a person has to change their behaviour, the greater the chance that the change will take place.
- “The ability of an individual successfully being able to perform a particular behaviour.” The more easily available the opportunities and resources are, the higher probability that the person will be able to achieve the intended behaviour.
- The *attitude* of a person towards certain behaviour refers to “the degree to which a person has a favourable or unfavourable perception of the behaviour in question”. This relates to the types of associations the intended behaviour creates for the person and whether it is perceived to be beneficial or detrimental to change.
- The *subjective* norm refers to “the perceived social pressure of an individual to perform or not to perform certain behaviour”; therefore expectations are rated in terms of their importance to a certain group or individuals.

(Ajzen, 1991: 4-8)

The attitude of a person could also be associated with personal norms aligned to personal values. It is believed by Heath et al. (2002) that this only leads to actualisation of the behaviour if the person is also aware of the extent of the consequences of their behaviour and a sense of

associated responsibility; this is referred as a model of the norm activation model. The more favourable the attitude, the greater and more favourable the subjective norm and the greater the perceived behavioural control, the more probable that the person will perform the behaviour being considered. The schematic diagram below depicts the influences leading to the actualisation of the behaviour being performed:

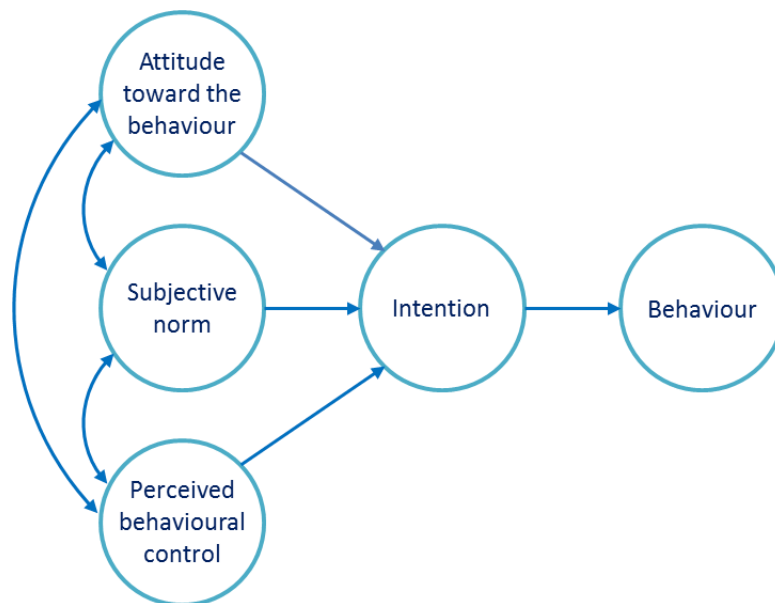


Figure 4.25: Theory of planned behaviour (Ajzen, 1991:182)

Research conducted by Heath et al. (2002) examines psychological aspects influencing modal choices which is underpinned by the Theory of Planned Behaviour (TPB). Theory of planned behaviour was tested at the University of Victoria, Canada to understand university students' current and planned modes of choice as influenced by interventions such as carpool priority lanes or reduced bus fares. Supporting research reveals that reduction in vehicle use is difficult to achieve as even drivers with a high awareness of the risks and problems associated with vehicle use still feel that the personal benefits of vehicle use outweigh the environmental problems.

In the Netherlands, it was found that vehicle users were aware of the problems associated with private vehicle ownership, and had a greater sense of guilt linked to private vehicle use compared to public transport use. The research further reveals that beliefs, moral norms and awareness about the state of the environmental conditions influence vehicle users' willingness to take positive environmental actions, such as reducing their vehicle use by taking the bus.

There was also a significant correlation in descriptive norms where bus use increased due to the perception that their friends were taking the bus. However there was also increased bus use by those who were less concerned by the problems caused by private vehicle ownership or less morally obligated, however the reduced fare or incentive was strong enough to motivate for reduced vehicle use. An interesting finding was that the community's opinion became more positive when barriers such as bus fares became less significant; factors such as the bus schedule knowledge now became more important due to more frequent bus use. Where the frequent bus commuters' perceptions became more objective, the attitude towards using public transport become more positive. In conclusion, there is a strong correlation between behavioural intention and changes in psychological variables (Heath et al. 2002).

Some of the interventions to influence behaviour in Germany for habitual vehicle users were investigated to demonstrate that strong association with habit hinders conversion from private to public transportation modes (Ajzen, 1991). The main premise is that activating moral norms should result in action; however this must be balanced with other motivations such as saving time and money as well as comfort. However in cases where people do not behave in accordance with their norms, defence mechanisms such as "denial of responsibility or redefinition of the situation," (Ajzen, 1991:203) materialise. A third concept which impacts the model is associated with "habit or habitual concepts," (Ajzen, 1991:203). This helps researchers to identify a starting point for interventions. However it is recognised that when personal vehicle use is a strong habit, the situational cues usually impacted by moral arguments or motivation will not take the intended effect and habitual choice of travel mode will be selected.

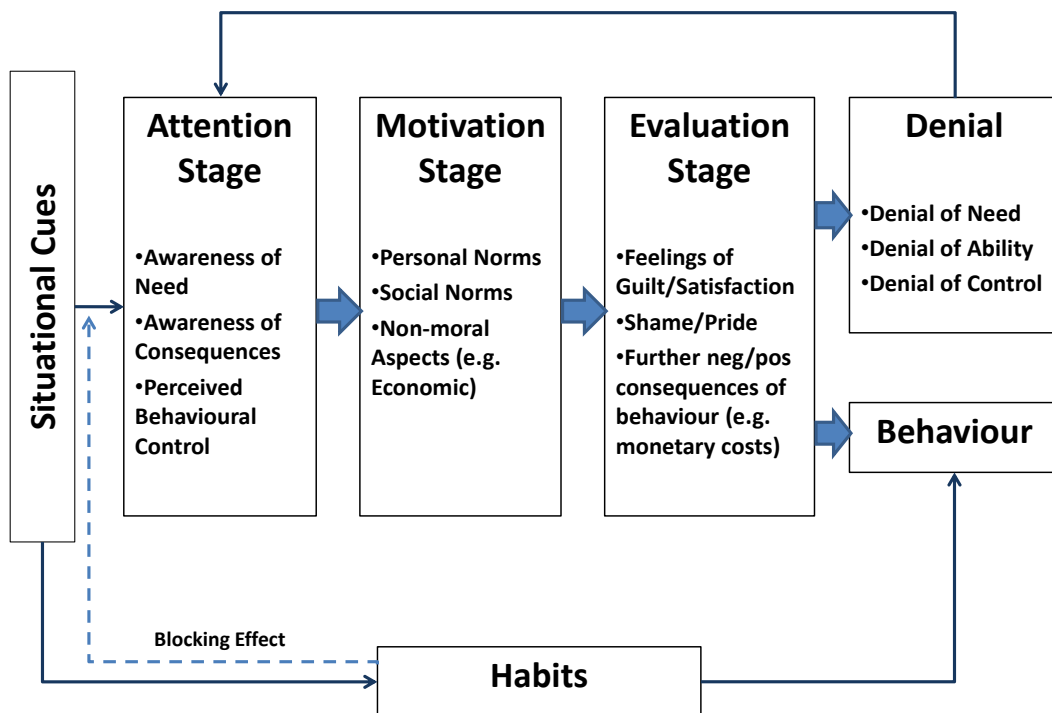


Figure 4.26: Modification of the model of moral decision making including habits (Matthies et al., 2006:93)

Matthies et al. (2006) ultimately concluded that interventions should result in voluntary commitment, where these commitment strategies must appeal to self-satisfaction aligned to personal values which raises the cost of not acting. These strategies can be strengthened when paired with strategies to change habitual behaviour such as providing reduced travelling fares or free tickets to alter the situation temporarily. In order for habitual vehicle users to change their behaviour, providing a temporary base case to test new transport use is critical for ultimate success. Usually in studies of environmental behaviour, subjective norms play an important part, however, when it comes to the mode of transport, the social pressures and awareness of the particular mode may be influenced by the individual's expectations and hence impact the individual's decision to use the particular mode of transport continuously. Interventions are stronger than commitment pledges in motivating behavioural change. These temporary interventions only translate into long-term change if the temporary experience is positive.

A common theme observed across studies regarding shared transport, is that the main task is to raise awareness of the alternative to private vehicle ownership (Matthies. et al, 2006). The vehicle can no longer be seen as a status symbol, which causes people to justify the high expense associate with owning a personal valued possession. Private vehicle ownership

seems more convenient and flexible when less people own them. Due to the current high ownership rate,, this mode of transport causes high congestion and actually results in the reverse, it is costly, time-consuming and inefficient. Shared transport, whether it be bicycle sharing, *Ride & Car-sharing* or fleet-sharing, provides an alternative, cheaper and more convenient mode of mobility. Section 4.3 illustrates that if people are given the correct incentive enabled by effective mechanisms, behaviour and association with private vehicles can change, resulting in the reduction of the number of vehicles or passenger distance travelled by urban commuters (Matthies. et al, 2006).

Research conducted in the UK by Mann et al. (2006) on behavioural paradigms for commuters' travel mode choices based on "affect" provides both opportunities and obstacles for carpooling. "Affect" refers to the incentives or penalties perceived by an individual. The research demonstrates that utility considerations such as time, cost and reliability are not the only influencers on modal choices; affect also plays an important role. The two behavioural paradigms are inter-related, referred to as affect-utility integration as the decision making process relies on both aspects simultaneously. Four themes exist where affect is influenced:

- Journey-based affect (JBA) decisions (which are positive or negative feelings experienced during a journey);
- Personal space and autonomy (freedom to live by one's own rules);
- Car ownership; and
- Identity.

The behavioural paradigms between modal choices from the research conducted by Mann et al. (2006) are presented in Table 4.12.

Table 4.12: Behavioural paradigms for commuters' travel mode choices (Mann et al., 2006)

| Theme | Affect Element | Private Motorised Transport | Negative Influencer | Public Transport | Opportunity for Improvement |
|--|--|--|---|--|--|
| <i>Affect-Utility integration</i> | Stress related to length of travel. Availability, Safety , Affordability | Hidden costs, leads to inaccurate comparison to public transport costs | Congestion leads to longer travelling times | Stressful, unpleasant, increased travelling time due to waiting times and trunk routes | If quality of transport is presented as better than PMT, higher rate of conversion. Increased transparency and comparison of cost savings |
| <i>Journey-based Affect (JBA)</i> | Time, stress and comfort | More positive feelings | Inability to use time productively as opposed to Public Transport | More negative feelings | Maintain a comfortable and stress-free journey to entice change of transport mode |
| <i>Personal Space</i> | Time alone, ownership of space | High importance and decision criteria | Results in isolation | Negative JBA aspect that discourages public transport | Protection from intrusion through allocating designated areas for noisy communication tools |
| <i>Autonomy</i> | Reliability & accessibility | Resulted in driver valuing being in control of their journey and journey specifics | Unavailable parking and congestion reduces autonomy with PMT | Commuters felt less in control | Removing the unknown by providing real-time bus schedules Improved reliability leads to trade-off of the car ownership responsibility Influence on the person in control |
| <i>Car Ownership & Identity</i> | Essential use traded over financial burden | Sign of adulthood and financial status | Guilt associated with environmental impacts caused | Lacks the expected high standard of quality | Campaign the environmental impact of driving PMTs |

The research indicates that driving a personal vehicle results in affective benefits that are unachievable by public transport. There is also a clear level of importance associated with psychological factors such as safe, dry, clean, comfortable, stress-free and convenient travelling modes (Matthies et al, 2006).

Time efficiency is identified as having a critical impact and should be a key mechanism for discouraging private vehicles and making public transport more attractive. The study reveals the opportunity for the trade-off of time efficiency and more pleasant public transport journey. Mann et al. (2006) indicates that developing quality public transport services and successfully marketing these to commuters depends on having a comprehensive understanding of the perceptions and concerns related to commuters' driving decisions.

Restrictions and Imposed Penalties to Reduce Private Vehicle use

Since the 1970s, policymakers have attempted to have control mechanisms implemented to reduce or eliminate the use of private vehicles from either high volume pedestrian areas, such as Times Square in New York, to the entire inner city, such as in Bogotá, Columbia where the Mayor of this city “declared a war on cars” (Lerner, 2011). These mechanisms include the restriction in the number of cars permitted during rush-hour traffic, imposing fuel taxes and ring-fencing revenue made from this tax to subsidise bus systems in order to service a larger number of commuters.

Due to the increased number of challenges cities have experienced in encouraging commuters to change from private vehicles to public transport, some of these international cities have either tried to incentivise or penalise commuters using private vehicles. The City of London introduced a congestion charge in order to alleviate traffic congestion (Monaghan, 2004). Clarke (2011) advocates for a more effective mechanism such as pay-as-you-go road pricing structure, which would be implemented in order to maintain a congestion-free zone as well as reduce the amount of air pollution. In addition, Clarke (2011) suggests that public transport should be given a dedicated route that is congestion-free to encourage commuters to use this mode of transport.

Social Pressure and Incentive Mechanisms to Reduce Private Vehicle use

An example where voluntary public behaviour and pressure has changed the mobility modes for cities is that of Freiburg, Germany, where protests against the building of a new nuclear power station led to the residents opting for strict energy-efficiency standards for new homes, combined heat and power, and solar systems in order to support their cry for conservation of energy and reduction in demand from the electric grid. This led to 5 000 people pledging that their neighbourhood, Vauban, would remain a car-free zone. Residents certify every year either that they do not own a car, or that they keep their vehicle in a reserved parking space on the district's periphery. Streets that do allow cars have a strict 30km/h speed limit to ensure safety of pedestrians and reduce the amount of carbon emission through more efficient driving practice (Buehler et al, 2011).

In the United Kingdom, Bannister (2005) reports that the incentive for alternative solutions other than fuel efficient cars has been a focused agenda. This includes high city centre congestion fees, while reducing bus fare rates to encourage public transport.

The EPA (2008) discusses promotion and acceleration for the adoption of green parking lots, and details planning aspects, which include various strategies. Most pertinent to this investigation, where these strategies could be applied to promote carpooling at Wits university include; reducing minimum parking requirements in locations close to public transport reducing the allowable parking spaces; and linking parking to smart growth by encouraging alternative public transport by making more bicycle-docking stations available in the parking lots, allocating prime parking to public or shared car users and creating more accessible drop-off zones while subsidising portions of their travel cost.

These types of strategies must be considered to promote the use of carpooling facilities at Wits, however they need to be tailored for the Wits environment. To further investigate the likely adoption of carpooling at Wits, one can review other carpooling systems or public transport systems that exist in the South African context and report the lessons learnt that could facilitate improved uptake of carpooling at Wits

4.3 Shared Transport in the Context of South Africa

There are limited car-sharing initiatives to investigate within the South African context. The international car-sharing growth comparisons conducted by Cohen et al. (2006) show that car-sharing start-ups have been planned in eight additional countries, namely Malaysia, China, Ireland, Israel, Kenya, New Zealand, Portugal, and Zambia. Four experts from these start-up countries, including South Africa, completed a survey exploring the car-sharing operations, providing input to a high-level summary (Cohen et al., 2006). This did not list contributions to detailed topics including member vehicle ratios, market segments, vehicles and fuels, parking, insurance and technology.

4.3.1 *Examples of Shared Transport in South Africa*

In South Africa, there are limited examples of how ride sharing or lift clubs have historically been established within the South African metropolitan environment. Search results provide information via webhosts such as eRideShare.com, carpoolworld.com, gumtree.co.za, and carpoolmates.co.za. Members look for similar commuters and contact the offering party to establish predetermined collection points, shared cost schemes, commuter rules and travel routes. These webhosts only provide a technological interface to connect and manual search for an available carpool that meets the member requirements.

A recent development with a formally established free carpooling service, Ridelink, has been made available to students and staff members of the University of Cape Town (Pallet, 2011). Ridelink was established in 2007 and went live in September 2010. It is hosted on the integrated student information management system, Vula, which provides secure data management for students and registered users. This system has proven to be most dynamic due to the fact that once the participant's requirements have been captured, the system automatically matches those requirements with that of existing carpools (Pallet 2011).

The development and management of the site was absorbed by the facilities and properties department of the University, in an effort to alleviate parking requirements, reduce the need for future development, as well as reduce the costs associated with parking facilities. The site allows students to match their needs with other students offering the use of their private

vehicle. The service however provides added flexibility, in that if one can no longer depart with the original lift club one is able to log onto the site during the course of the day and arrange alternative lift clubs to match the new departure time (Pallet, 2011).

Benefits to date have been evident in that Ridelink students are provided with preferred parking close to university amenities. The cost of travel is shared amongst the users and the Ridelink site provides possible shared cost schemes to guide users in best practice. By reducing the number of single occupancy vehicles on the road, the amount of carbon loading per person reduces significantly. Members are recognised as socially and environmentally responsible and encouraged to change travel behaviour through dissemination of sustainable transport information, services and products (Pallett, 2011).

A similar student carpooling portal has been established in Grahamstown, however this service was extended to the wider local community and has not been limited to students and staff of Rhodes University (Rhodes University, 2012). Members organise their travel by logging a request, which becomes listed as either “arriving in Grahamstown” or “departing Grahamstown”. The member then searches through the listings filtered by departure date, departure and arrival location and cost.

A study conducted in Cape Town (Wilkinson, 2010) reveals that the percentage modal share between private, public and non-motorised transport for the metropolitan area in Cape Town is 46:42:12 respectively. Although this study focused on the Metropolitan Cape Town environment, it is the most accurate indicator of the likely modal share for Johannesburg. In 2007, the Department of Transport (DoT) initiated a large driving force to institutionalise travel demand measures that would discourage private motorised transport in all major South African Cities. Up to now, this initiative by the DoT has been limited to the implementation of Integrated Rapid Transit, which focuses on integrating buses, minibus-taxis and trains (Wilkinson, 2010).

4.3.2 Barriers to Adoption of Shared Transport in South Africa

McCaul (1990: 219) explain that the highly regulated bus companies and State-owned train companies have restricted competition. Furthermore the outlying areas such as Soweto, Randburg and Cosmo City remain largely unconnected by public transport to the rest of city.

The legacy of the gold reef development resulted in a patchwork service network with few transport channels adjacent to urban areas. This type of network limits urban movement that largely affects the lower income population, who are unable to afford a personal vehicle. Decentralisation also compromises efforts to integrate urban transportation and reach targets such as being named Africa's "world-class city," (McCaul, 1990:222).

Obstacles reported by Shaheen et al. (2003) that would apply to a South African context include: High capital investment limitations (start up costs); insurance rates; and scarcity of cost-effective technologies. The ability of an emerging sector to actualise its total environmental, economic and social goals is limited. It has also been suggested by the International Institute for Sustainable Development (1992) that in developed and mature markets, sustainable development and environmental stewardship are synonymous. It is therefore suggested that sound environmental performance is an expected objective for business in those markets. However in developing countries, focus is placed on rapid and sustainable development and lacks focus on environmental management.

Czegledy (2004) explains that in the past, vehicles carried a symbolic meaning of wealth in South Africa, second to the home as symbol of success. More specifically, the accessibility of the country's wilderness and nature reserves has increased the popularity of four-wheel drive vehicles. Private car ownership has been a status symbol in South African culture, and due to lack of alternative modes of transport a large percentage of the population uses private vehicles to commute (Czegledy, 2004). It is therefore important to investigate the individual's attitude to traditional vehicle usage, assuming that high value is placed on flexibility and mobility given by vehicle ownership as reported by Shaheen et al. (2004).

Johannesburg residents, in particular more affluent residents of the Northern Suburbs, indicate that the poor condition of public transport is only one of many reasons for their preference for private vehicles. It has also been reported in studies conducted by Wilkinson (2010) that there is a rise in crime on buses, which extends to drivers' accepting less than stipulated fares from bus passengers in return for not issuing a ticket and pocketing the fare themselves. More importantly the fear of violent crime is a major factor, which is not confined to these more affluent residents and is an on-going public concern that crosses all boundaries of race, gender and economic status. Crime has profoundly affected all aspects of South African lives to the extent that it undermines sociability, with personal caution

increasingly dominating all forms of interaction. As a consequence, even routine social courtesies such as greeting, eye contact, and even pedestrian proximity are discouraged through increasingly unconscious practices of social avoidance and non-response. These concerns have become embedded due to prominently reported armed hijacking and car theft (Wilkinson, 2010). Jennings (2010) explains that high crime rates are reported to be the main reason as to why bicycle-sharing schemes which were piloted and approved in Cape Town, had to be postponed at business plan phase mainly due to fear of theft and vandalism of the bicycles, resulting in costs to the investors. Jennings (2010) also highlights increasing safety concerns and lack of reliable, adaptable public transport infrastructure and policy in Johannesburg renders itself as an ideal location for the ease and security of shared car use.

Jennings (2010) explains that the bicycle scheme was further hindered by the lack of bicycle infrastructure, safety regulations requiring helmets to be worn, as well as lack of data on potential users, creating obstacles for effective demand planning and projected costing. Furthermore to ensure that the service meets government socio-economic objectives, the systems developed for South African cities must create jobs (limiting self service docks and kiosks), have low-technology requirements such as locks, keys and physical guards, and must require no pre-registration (Jennings, 2010). Although informal bicycle taxi and hiring schemes exist in northern Africa, this system has not been adopted in South Africa due to the lack of dedicated bicycle lane infrastructure, with the additional risk of aggressive driving, all of which pose the risk of accidents occurring.

To break down these barriers requires creative solutions, for example car depots and adequate plans developed to address the security concerns that would need to be put in place to ensure that the community trust car-sharing services. House-to-depot couriers for surrounding markets would need to be established to facilitate safe transit to the vehicle. More conventional opportunities for adopting shared transport have been captured in the following section.

4.3.3 Opportunities to Promote Shared Transport in South Africa

Cape Town has been able to successfully introduce numerous public transportation initiatives that have assisted in alleviating and restricting the total number of private vehicles used in the inner city (Wilkinson, 2010). The historical development of Cape Town as a linear

horseshoe shape facilitated the Victorian railway system, which was an important stimulus to the next generation of growth. The present 'radial' format developed slowly enough to allow various other public transport modes to develop in tandem with the city's growth, example of the rail and bus system into the Cape Flats (Wilkinson, 2010).

Behrens & Schalekamp (2010) test the feasibility of incorporating informal operation in the public transport system in Cape Town after experiencing the obstacles listed above. The research reveals the likelihood of hybrid outcomes in order to implement a BRT system more successfully in future. Their survey conducted in Cape Town in August 2010 investigated the modes of public transport (rail, bus and mini bus-taxis) that the passenger were satisfied or dissatisfied with, as well as the level of importance of each mode.

Table 4.13 details the items with which users of the train, bus and mini-bus services were dissatisfied. Several of these items, as marked red in should be explored to reduce barriers to the adoption of car-sharing at Wits.

Table 4.13: Train, bus and minibus-taxi user service attribute mean satisfaction rating vs. mean importance rating (Behrens & Schalekamp, 2010)

| | | | |
|--|-----------------------------------|-----------------------------------|-----------------------------------|
| Train opportunities for improvement | | | |
| 1 seat availability | 10 seat comfort | 19 ticket purchase | 28 train bunching |
| 2 in-vehicle overcrowding | 11 station weather protection | 20 station staff customer care | 29 station pax. Information |
| 3 in-vehicle security personnel | 12 service frequency | 21 vehicle cleanliness | 30 station security |
| 4 graffiti | 13 station toilets | 22 in-vehicle security | 31 in-vehicle reading |
| 5 seating density | 14 vehicle reliability | 23 boarding and alighting | 32 driver behaviour |
| 6 open doors | 15 station security personnel | 24 fare affordability | |
| 7 service transfers | 16 vehicle and station livery | 25 travel speed | |
| 8 station seating | 17 passenger politeness | 26 in-vehicle temperatures | |
| 9 service punctuality | 18 in-vehicle staff customer care | 27 station cleanliness | |
| Bus opportunities for improvement | | | |
| 1 travel speed | 10 service transfers | 19 bus stop security | 28 passenger politeness |
| 2 bus stop weather protection | 11 PTX weather protection | 20 in-vehicle temperatures | 29 in-vehicle reading |
| 3 bus stop seating | 12 seat availability | 21 PTX staff customer care | 30 in-vehicle staff customer care |
| 4 seating density | 13 fare affordability | 22 vehicle reliability | 31 interchange cleanliness |
| 5 service punctuality | 14 PTX security personnel | 23 vehicle and stop livery | 32 interchange security |
| 6 service frequency | 15 interchanging seating | 24 ticket purchase | 33 boarding and alighting |
| 7 driver behaviour | 16 bus bunching | 25 seat comfort | 34 in-vehicle security |
| 8 bus stop pax. Information | 17 bus stop cleanliness | 26 interchange pax. Information | |
| 9 in-vehicle overcrowding | 18 interchange toilets | 27 vehicle cleanliness | |
| Minibus opportunities for improvement | | | |
| 1 driver behaviour | 10 rank toilets | 19 in-vehicle reading | 28 service availability |
| 2 in-vehicle overcrowding | 11 seat comfort | 20 rank staff customer care | 29 travel speed |
| 3 vehicle reliability | 12 in-vehicle waiting | 21 rank security | 30 passenger politeness |
| 4 ranking seating | 13 fare affordability | 22 in-vehicle staff customer care | 31 boarding and alighting |
| 5 rank security personnel | 14 vehicle and rank livery | 23 rank passenger information | 32 |
| 6 seating density | 15 rank weather protection | 24 cash-based fares | |
| 7 service transfers | 16 taxi bunching | 25 vehicle cleanliness | |
| 8 in-vehicle music | 17 law compliance | 26 in-vehicle security | |
| 9 rank cleanliness | 18 journey time reliability | 27 in-vehicle temperatures | |

In summary, if alternative public transport system that could address those attributes that are ranked as dissatisfactory for both the minibus-taxi and bus users, could service a large target market (Behrens & Schalekamp, 2010). Common service attributes such as weather protection, seating, information, customer care, security and cleanliness could be improved across all three modes of transport that were investigated (Behrens & Schalekamp, 2010). The constraint is that these improvements could only be implemented with the required invested capital and intensive human resources for the improvements to be achieved.

Recently, there has been increased activity in upgrading the South African roads to facilitate private car ownership (Behrens & Schalekamp, 2010). A new e-tolling system is to be implemented according to the South African Road Agency in order to assist with the maintenance of the freeway system in and around Gauteng Province. This could result in higher cost for single passenger trips and result in students at Wits being more receptive to the idea of carpooling.

The report supports the reduction on environmental impacts, in addition to which it supports alternative transport methods that can be addressed through shared car usage between commuters who have to commute to the same destination.

4.3.4 Potential Shared Transport Users in South Africa

Surveys conducted by Litman (1999) indicate that potential users are predominantly identified as households that avoid owning a second or third vehicle. Shared transport is suitable for higher density urban neighbourhoods with established alternative public transit services. These areas are traditionally those which have successfully introduced and developed a form of car-sharing already within the community. This can be attributed to having a sufficient number of users that are within convenient walking and cycling distances. In line with these findings, in order for any introduction of car-sharing scheme to be successfully implemented, the ratio between the number of vehicles and the number of users required for an efficient scheme to survive is one vehicle to ten users. This is the ideal ratio whereby the ten members per vehicle relates to approximately thirty family members living within a radius of one square mile (approximates to 2.56km²).

Litman (1999) explains that due to the high levels of crime experienced within South Africa, the market criteria would need to be adapted to accommodate high density business areas where vehicles are parked on the roads or basements that are within close walking distances. Litman's (1999) survey revealed that potential users are willing to walk distances in the region of 400 metres in order to access a vehicle, although the service is only practical should the mileage travelled by the shared vehicle be less than 10 000km per year.

Possible markets as defined by Shaheen and Cohen (2006) include both the individual and corporates, both of which hold true within the South African context. These include:

- i. "Individual" markets, which can be established by identifying the number of commuters or residents residing within cities that have multi-modal neighbourhoods; this can then be multiplied by the percentage of drivers who travel in vehicles with low annual mileages. Cohen (2006) notes that an ideal market is represented by residents living in urban neighbourhoods that have on-street parking and lower income households. However, cities such as Bologna or Barcelona, which have a large variance of residents in different income brackets, tend to use their cars only for weekend trips into the countryside, and neighbourhoods with a large ratio of people willing to reduce their individual car use are a prime target market.
- ii. "Corporate" markets are represented by businesses or universities requiring station vehicles that can be accessed from parking lots; these are generally required for short frequent trips in and around the city or close enough to be returned to the same station at the close of business.

4.4 Literature Review Summary

There is large base of evidence that suggests that CO₂ emission will continue to rise as a result of combustion of fossil fuels for private vehicle oriented transport. South Africa was rated the 12th most carbon intensive country by the USEIA in 2011. The decomposition equation provided by Baumert et al., (2005) provides a breakdown of these factors contribution to carbon emissions; which includes activity (which is influenced through population growth rates), energy intensity and fuel mix. South Africa's population is expected to reach 58.1million people by 2030 (Euromonitor, 2013). South Africa's largest energy

resource supply is made up of 75% carbon for electric use. It has also been predicted that South Africa's GHG emissions will reach 850 MtCO₂ by 2025.

The South African Government, through its commitment to the Kyoto Protocol, has recognized the need to reduce the countries emissions by 34% by 2040 and 42% by 2025. This results in 253MtCO₂ by 2020. Work completed on the LTMS has identified scenarios to help achieve these targets. The channel most appropriate to this study includes establishing people-oriented measure which can apply to Wits in support of the South African Government in meeting its ambitious target and transition to a low-carbon economy.

It has been identified that a large driver behind private vehicle oriented systems is urban sprawl. This relationship between sprawl and private vehicle dependency has led to the increase of GHG emission and unsustainable land use. South Africa's legacy of state-owned trains which dominated the transport industry in 1930s and the legacy of Apartheid planning have resulted in lower income groups developing on the periphery of Johannesburg disproportionately affecting the poor through excluding them from work opportunities and access to reliable social services.

IEA report that in 2011 South Africa's emissions per capita, due to the combustion of fossil fuel, was 1.7 times larger than the global emission rate per capita. The transport industry was said to contribute 12.6% of the total CO₂ in 2009. RAC motoring service (2012) indicate a medium petrol engine up to 1.8 litres results in 150-185 CO₂ eqt. per kilometre. The World Bank, (2009) reported that South Africa's index of passenger vehicles to 1000 people increased by 16% between 2005 and 2009, leading to significant growth in the amount of traffic on public roads. In 2007 the DoT reported that 7.1million commuters in South Africa use a vehicle, and although 1.9 times more people used public transport there is much room for improvement.

Private vehicle oriented transport systems are also proven to consume 3.1 times more impervious surface infrastructure than multi-modal transport systems. The environmental impacts associated with this impervious land consumption includes hydrological changes to both surface and grown-water flows, heat islands as a result of lower heat absorption by this type of artificial surface, further leading to incidents of injuries or death from dehydration, often resulting in higher energy use for air conditioning.

In the USA on average traffic congestion leads to 46 hours of wasted productive time per person, which serves as an international benchmark for comparison. It has been reported that the average travel time to work from home in major cities is between 35 to 37 min, while the associated cost due to traffic congestion is estimated at R15 per hour per person. This results in a large proportion of the population being unproductive and further hindering the economic growth in South Africa. Furthermore results from Statistics South Africa (2010) reveal that that 19.9% of the total annual household income is spent on transport, while the middle quintile population, which most closely represents the Wits commuter, spend at least 12% to 14% of their personal income on transport, which is a disturbing pattern as it demonstrates the poor's mobility is severely limited by their lack of income. The literature also reveals that air pollution due to traffic congestion has been associated with premature deaths from heart attacks, strokes, asthma attacks and other respiratory illnesses.

Leaders in urban planning emphasize the adoption of smart growth in cities to reduce reliance on private vehicles, while encouraging shared city space to support multiple activities, by reducing parking supply, increasing parking prices through mechanisms like congestion charges, improving alternative transit modes, reducing traffic speed and improving the streetscape to encourage increased pedestrian traffic.

The concept of smart growth can further be supported by service oriented economies as opposed to product oriented economies resulting in sustainable business value-driven models and embodies concepts like shared space, shared knowledge and shared transport modes. This paradigm shift is evident in the body of literature and insights such as success factors, barriers experienced and future recommendations, which could facilitate a higher rate of adoption of carpooling at Wits University, are listed below:

- City areas that have adopted the concept of shared space with specific focus on traffic alleviation have been successful in doing so where there is a shift in focus from the movement of cars to movement of people.
- Sustainable business value-driven models are centred around a service economy where business places focus on multiple stakeholder and moves beyond self-interest by creating shared value by increasing the quality of life of those impacted by its activities, which in turn secures self-interested achievements. In this regard Wits has the opportunity to put in place a carpooling model which serves both its self-interest as

well as enhancing the students' experience at Wits, enhancing the Wits brand as being cutting edge in addressing carbon emission proactively, while reducing the need for costly parking structures.

- Numerous case studies were reviewed to assess the successful implementation of shared transport models. The literature reveals that there is a large target market for shared transport as a function of distance and flexibility.
- Bicycle sharing has been a great success internationally where advanced GPS, real time booking and pay stations are made available to the users. The bicycle sharing scheme did not excel in South Africa, due to the lack of access to this technology, as well as high rates of bicycle theft. These barriers should also be considered and planned for before implementing more formal fleet-sharing schemes at Wits.
- *Ride & Car-sharing* is well developed worldwide, however it exists at different maturity levels, from being an informal lift club to being smart phone application where lifts are organized quickly and flexibly on real time dynamic route matching software. South African car-sharing systems are quite informal with the exception of the University carpooling programmes that have been well established and are functioning at UCT and Rhodes. Carpooling has been proven to be a realistic solution to traffic congestion alleviation as well as a more affordable transport system, in Delhi which could be likened to South African transport issues. The Delhi case study reports the number of users likely to carpool with one, two or three passengers, which is a useful benchmark for this study. The Delhi carpooling survey responses indicate that 28.2% of people want to carpool with one person, 8.2% of people want to carpool with two people, and 15.4% would carpool with three people, while a 48.2% people were not willing to carpool. Shaheen et al. (2003) highlight the largest barriers for adoption in South Africa being lack of funding for high capital investment, high insurance rates and lack of cost-effective technologies.
- Fleet-sharing needs to be considered for the next phase of implementing shared transport solutions at Wits. Carpooling will plateau in the future, where timing is based on the rate of adoption. The next phase of vehicle use reduction could be the fleet-sharing concept. If this is first piloted at the University, the users at Wits are likely to be the next business leaders and will more readily incorporate fleet-sharing schemes at private companies. The rate of adoption in the US has been significant where over a four year period between 2000 and 2004, fleet-sharing membership increased by

820%. In a well-established fleet-sharing scheme one vehicle services 20-66 members. Again there are various level of maturing of fleet-sharing schemes from live operator bookings, manual security systems like lock boxes and an honour system of billing with manual completion of member log books. Compared to more advanced systems which are supported online and through real-time smart application technology.

The theory of planned behaviour (TPB) is the basis of the survey developed by Shaheen et al, and has been adapted for this study. Various other sources refer to TPB as well as journey based affect (JBA) decisions specifically when testing commuter's attitudes to private and public transport modes. It is evident from the various studies that a person's belief, social and moral norms and awareness about the state of environmental conditions did influence the car users' willingness to take positive action and reduce their car use by using alternative transport modes. However it was clear that unless these moral arguments were presented to the users the commuter would revert back to personal vehicles due to deeply-entrenched habits.

In order to drive behavioural change based on the insights provided by urban planning through leaders tested through TPB or JBA has led to either implementing penalty mechanisms or incentives namely, congestions charges, increased fuel or carbon taxes, limiting private vehicle parking bays, shared transport preferred parking, shared vehicle dedicated lanes, traffic reduction and leading to reduced cost and time wastage.

Wits University is an ideal entity to implement an advanced carpooling scheme, where a conceptual model first needs to be introduced to possible users, while highlighting the benefits and then testing the likelihood of adoption. The target market at Wits includes both individuals; students and staff members, who are those commuters who reside within Johannesburg and frequently travel to Wits with relatively repetitive travelling patterns; as well as the institutional dimension of the University, which represents the "business" entity. The benefits of carpooling must be clearly derived for this stakeholder who will be the driving force behind the success of carpooling at Wits, and possibly fleet-sharing in the near future.

5 RESEARCH METHOD

The research method includes quantitative and qualitative methods. The data was collected through a literature survey, case study interviews, conducting of questionnaires and drawing out summary statistics of data sets, and mathematical modelling as described in more detail below:

- 1 Conducting a literature review to identify inputs and methods that could be used to calculate the likely reduction in the number of cars on campus as a result of adoption of carpooling, in order to measure the carbon emission reduced and the value of land that could be converted for more beneficial uses at Wits University. The value of the study is to show what 'savings' in emissions and land are likely at present (2012) levels and values.
- 2 Interviewing a representative involved in the Case Study: University of Cape Town – Ridelink.
- 3 Registering and testing existing carpool webhost systems like Ridelink, Greenwheels, Carpooling SA to explore concepts that could be included in the proposed WITSIT Carpooling model as detailed in Section 5. It was necessary to develop a detailed conceptual carpooling model, with a proposed governance structure and roles on the basis of the literature review and interviews, to provide background content for the staff/student questionnaire. A conventional research report would purely investigate the attitudes of the survey participants and would not normally require a conceptual model at this level of detail. The conceptual model would usually come as a result of testing the target audience's requirements and developing a model in response to those requirements.
- 4 Conducting an online questionnaire with the University's staff and students to establish the current modes of travel, the preferences and lifestyles that affect the perception of alternative shared transport modes and likely adoption of the proposed carpooling model at the University. The questionnaire utilised in this study was developed by Shaheen (2004) and was adapted as little as possible to reflect the South African context. This replication of Shaheen's survey could therefore permit direct comparison, allowing for more generalizable conclusions. The survey is widely adopted in Shaheen's (2004) car-sharing studies. The original survey was adapted for the use of the Metric system to ensure improved comprehension from the target audience. An application was submitted

to the Human Research Ethics Committee (HREC Non-Medical) who approved the use of the survey with the University's student and staff participants.

- 5 The data sets were evaluated through the use of frequency counts, percentage weightings and descriptive statistics to identify any patterns and graphically present represent the patterns.
- 6 The results were then mathematically modelled by evaluating variables like; likely percentage of carpoolers, carbon emissions released per vehicle, targets for carbon emission reduction, total emission reduced if one, two, three or four people were to carpool. Modelling techniques have been expanded on section 5.4.

5.1 Literature Review Indices Used in the Analysis

The following measurements were identified through the case studies reviewed in the literature survey, in order to capture the economic and environmental benefits associated with car-sharing and carpooling models. The measures listed below require both quantitative and qualitative analysis supported by the literature survey, as well as analytical and mathematical adaption. As detailed in the limitations, data up to 2012 is used throughout this study for consistency.

Economical improvements are measured through:

- Savings realised through the use of the proposed integrated shared transport model as compared to conventional car ownership. This is achieved by assuming that the survey respondents' current practice and attitudes to carpooling applies *pro rata* to the larger Wits population;
- Using the reduction in parking bays and the current market value of the University's property to calculate opportunity savings associated with this reduction in land use; and
- Calculating both the running and fixed cost per vehicle in terms of distance travelled. This required establishing purchase cost of the vehicle, operating cost as well as the cost of maintenance over a predetermined life-cycle period (AA, 2012), which is determined by the ratio of distance travelled over the life-cycle period. Only the running cost of the vehicle would be shared by carpooling and was therefore analysed in more detail, while fixed costs were ignored.

Possible respondents' attitudes and willingness to change could be measured through establishing:

- The participants' attitude towards private vehicle use and awareness of environmental impacts of private vehicle use.
- The likely involvement in the programme to foster environmental stewardship and the spinoff of behavioural initiatives.

Possible environmental improvements could be measured through establishing:

- The reduction in travel distance of the number of vehicles that can be achieved through car-sharing, which in turn is converted to the reduction in CO₂ emissions;
- The reduction in the number of parking bays that can be attributed to car-sharing, as well as the environmental opportunity costs associated with the area of University property that could be used for alternative purposes; and
- The contribution to the target as outlined in Section 4.1.1, where South Africa is expected to mitigate 253 Mt CO₂ eqt from 2010 to 2020. A target of 12.6% of total CO₂ emissions in South Africa will be assumed for the transport industry. These targets can then be interpolated for Wits University based on the population of the University in proportion to South Africa's population in 2011, as per data sourced from the South African Census (2011) and Facts and Figures, University of the Witwatersrand (2011).

South Africa's population was tabulated based on actual data from the SA Census in 1996, 2001 and 2011.

In order to investigate the questionnaire participants' attitudes towards their current transit modes, their attitudes to the conceptual WITSIT Carpooling model and their likely involvement in the programme in the future, a conceptual WITSIT Carpooling model was developed, as presented below.

5.2 Conceptual Wits Inter Transit (WITSIT) Carpooling Model

The survey developed by Shaheen et. al. (2004) that was used in this study required that the survey participants would pilot the proposed system prior to the survey. Due to the limitations of this study, the same approach was not possible. The survey participants therefore first

needed to be given the context of the proposed alternative transport system that would be appropriate for Wits and then only could their likelihood of participating in this type of programme be tested.

The model was developed by first examining the current existing transport facilities and associated infrastructure, as well as existing physical, IT and management structures which could be leveraged to create the WITSIT Shared Transport service. These observations have been further detailed in Appendix B: Wits University's Current Transport Facilities and Infrastructure. Some of these opportunities identified with the existing transport infrastructure include:

- Parking availability is becoming an increasing issue;
- The Wits public transport sites do not provide sufficient information for the student to pursue the alternatives independently;
- The application still being largely paper-based, with limited automation in capturing the data;
- Students who do currently carpool are not rewarded for alleviating traffic through any form of incentive or preferred parking allocation;
- Existing multi-car permits could be leveraged to encourage carpooling systems however the additional cost would need to be waived; and
- MyWits is the official communication between the University and students, and currently hosts no forums, blogs or portals which provide the bases for forming carpooling organisations.

A conceptual WITSIT Shared Transport service was described online to explain to the questionnaire participants how the model would realistically evolve at Wits, while also exposing the participants to the possible roles that would need to be fulfilled to ensure the successful implementation of the model. The conceptual model also details a proposed governance structure, strategy and policy planning that the future WITSIT management team have to consider, as per good practice. This has been briefly explained in Appendix C: Conceptual WITSIT Shared Transport Model . This appendix also provides process maps to guide the future volunteers and established committees on practical implementation of the WITSIT Shared Transport model.

5.2.1 WITSIT Conceptual Carpooling Operating Model

Various university websites were reviewed and tested to gain insight into the extent of carpooling that is currently taking place at South African universities. Two universities had well-developed carpooling systems, University of Cape Town (UCT, 2010) and Rhodes University (Rhodes, 2012) in Grahamstown. UCT, like the rest of Cape Town, has limited land space available. There is little or no option for expansion of the parking facilities, and the layout of the University requires that many students park at the lower levels of the University and either have to walk quite far to the lecture halls or ride in the Jammie Shuttle service (Wits Student Services, 2013). The issues with parking led to the implementation of the Ridelink, part of the Green Campus Initiative that provides a free service to the students of the University and is supported by VULA, the integrated information student management system. VULA provides real-time data for matching users, based on their travel schedules and routes. A similar, but less advanced system was established in Grahamstown and is used by the Rhodes University commuters. The method for connecting with other students had been described in more detail in Section 4.3.1. Screenshots for the university carpooling systems as well as some other informal carpooling webhosts such as eRideShare.com and carpoolworld.com have been depicted in Appendix A: South African Carpooling Webhost Examples.

The WITSIT Carpooling Model has been developed through adopting or adapting parts of these existing carpooling systems in South Africa discussed in Section 4.3 and enhanced through adopting the insights documented throughout the Literature Review, specifically relating to bicycle-sharing and *Ride & Car-sharing* schemes discussed in Section 4.2.3 and applying concepts from a Service Economy business model discussed in Section 4.2.2. The model also aims to address some key contextual issues listed in these previous sections.

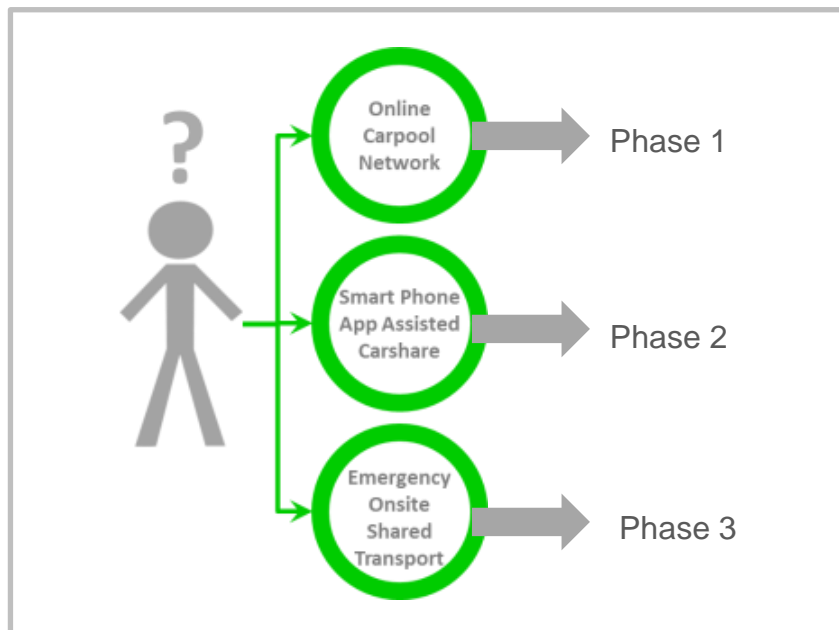


Figure 5.1: High-level WITSIT operating model

The design of the WITSIT service depends on a web hosted interface for an improved Integrated Shared Transport system. The system is planned to provide users with flexible options as demonstrated in Figure 5.1; realistically these will only be able to be implemented in phases due to responding to request via a feedback loop as part of continual improvements and establishes and adaptive co-management framework in line with best practice in environmental engineering and project management:

- Phase 1: WITSIT members join a carpool group as facilitated by an existing Wits social online network. This allows members to find commuters that travel from similar areas and have similar schedules. The shared costs can either be maintained interpersonally or managed through an automated smart phone and online application which can facilitate a real-time payment system;
- Phase 2: Once the WITSIT online matching system is well established, improved flexibility is offered. If a member's schedule is unpredictable and he/she is not able to commit to a regular carpool group, the member would join the smart phone application group and in real-time would be able to find a driver who passes by their home en-route. Members are able to log demand 30 minutes before the driver passes their location. The driver is directed via GPS coordinates to the passenger's location, where both receive a verification code upon meeting. Once the verification code is accepted, the passenger will automatically share the cost of the ride for only the distance travelled with that driver; and

- Phase 3: It is assumed that once phase 2 is well established, it is easy to organize a lift going to University as most student's start times are similar and if not the student would not mind going into Wits earlier if they are relying on carpooling. However often the students' end time would not correlate. As an emergency option, if the member is unable to organise a carpool or share a lift, the member could use one of the emergency vehicles in the fleet, already parked at the University. The member will only be charged for the time and distance the vehicle was actually used to travel back home and back to the University the next day (if the member is unable to return the car to the University, a sweeper unit could be contacted to collect the vehicle at a reasonable fee). This type of set-up would also be more easily managed from the university campus and would be difficult to establish in an around student home locations, hence the service could only be offered for trips from the university to the student's home location.

These options have been adapted from existing service providers. Initially, the Wits Inter Transit (WITSIT) Carpooling system will be managed very similarly to the current UCT Ridelink Carpooling Model, after which, an online and smart phone application similar to that provided by Avego (2011) could be developed. Finally, the fleet-sharing system similar to that provided by Drive Now could be adapted for the University environment.

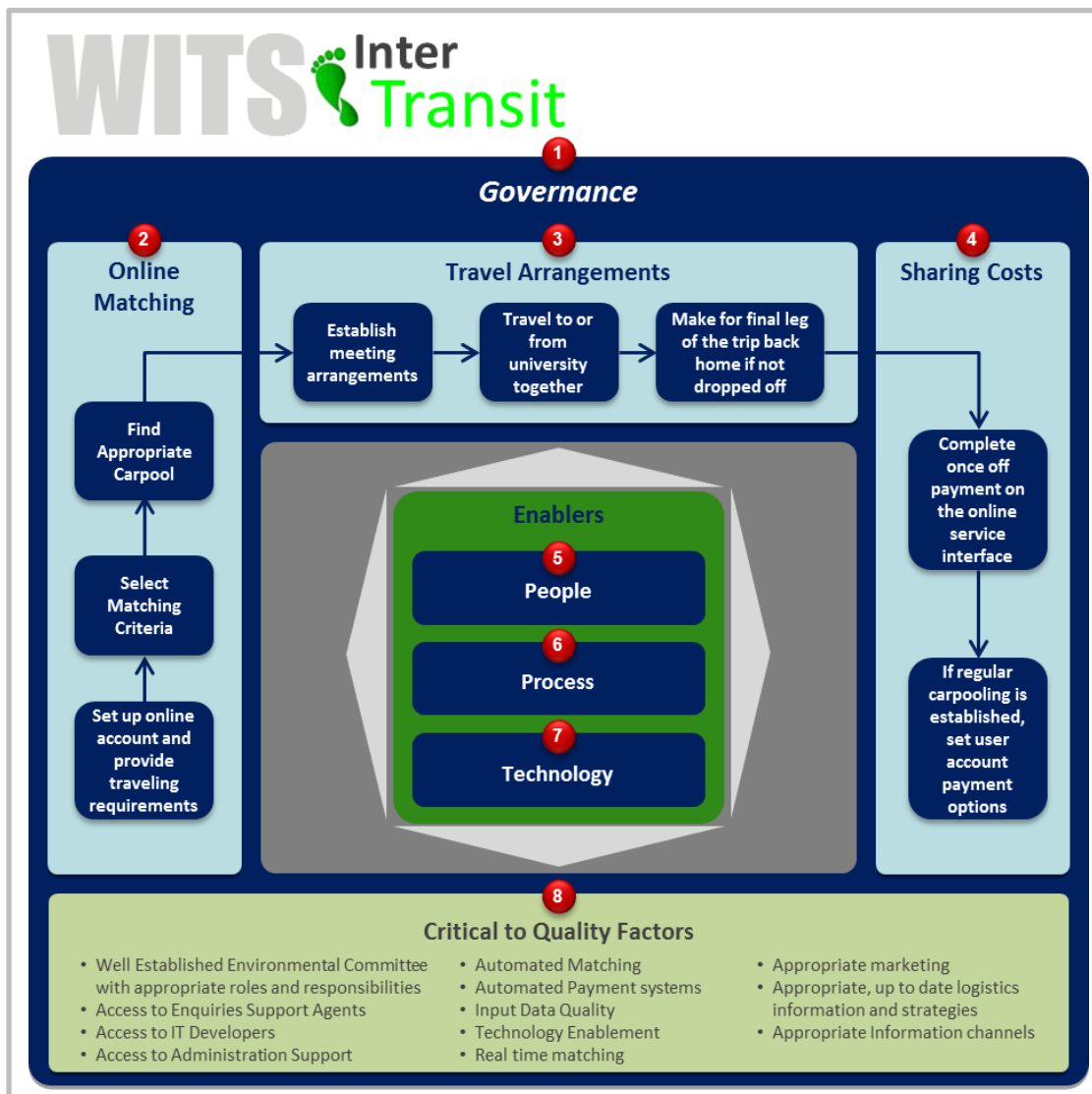


Figure 5.2: WITSIT Carpooling Operating Model

From Figure 5.2 the key components of the operating model are described below:

1. The governance framework aims to provide oversight through establishing appropriate roles with specific functions and responsibilities which will serve as a committee to govern the WITSIT Carpooling service. The committee should include representatives from strategy and planning, facilities management, environmental student & staff management committees, the system support staff (administration, logistics and it staff) and the end users, the Wits University commuters. Wherever possible, existing forums will be utilised as long as the five key governance elements are upheld, namely authority, communication; policy; responsibility; and measurement;
2. The service is provided through an online matching application that is linked to the Wits-e account:

- a. The Service is initiated through the online registration of the existing Wits-e Student Account and any additional personal data is provided to link the Wits-e account and the WITSIT account;
 - b. Additional Carpool Matching Criteria must be provided. This includes the commuter's travelling routes and carpooling preferences (gender, age, academic programme), which can be updated at any time; and
 - c. Automatically, the system will pair the commuter with the best-fit criteria.
3. Once paired with an ideal carpooling group, the driver will authorise details to be distributed. The Passenger can choose to communicate with the driver through Wits-e mail or mobile phone:
 - a. The carpool members can make arrangement to either meet at a central place where passengers can leave their cars safely or be dropped off and collected en route;
 - b. The passengers can travel to the University and back with the same carpool, or select a different return carpool; and
 - c. The passengers must ensure they can get back to the original meeting place, in order to collect their vehicle or be dropped off en route.
4. The carpoolers can arrange for once-off payments for the use of the driver's vehicle by:
 - a. Once-off cash payment to share the costs of traveling that day; and
 - b. Alternatively, if a routine carpool is established, the users' online Wits fees accounts can be linked to transfer the shared cost owed to the driver, or a PayPal application can be made available for online, real-time secured payments between the carpool members' bank accounts. (Something that could be adopted is mobile money transfers in order to make payments as easy as possible).
5. Strategic, tactical and operational roles, supported by an existing management structure, must be established to ensure the growth and sustainability of the carpooling service;
6. Processes for system management, administration, logistics and IT roles, the environmental management committee and the commuters must be established and updated to enable continuous improvement;

7. Appropriate technology must be selected and adapted to ensure the success of the carpooling service. It must also be automated as far as possible to ensure flexibility and agility; and
8. The pre- and co-requisites are crucial to the success of the carpooling service. Without addressing these dependencies, only partial benefit realisation can be achieved.

For the process to be successfully implemented it was suggested by Patell (2011), that a formal *Environmental Management Team* be put in place to govern the implementation and the continual improvement of the carpooling model in order to guide its evolution through to next phases of maturity of providing car- sharing services and ultimately inter transit solutions to provide opportunity for ideal efficiencies.

More information regarding the proposed governance structure can be found in Appendix A: South African Carpooling Webhost Examples The roles that the questionnaire participants could volunteer for included:

- Volunteer themselves as a carpooling driver;
- Agree to become a carpooling member and actively participate in the programme;
- Be a member of the future environmental committee;
- Be a marketer of the future WITS Inter Transit Programme;
- Assist in developing the smart software for smart phones to be implemented in future system; and
- Would not be involved at all in the programme.

The *Environmental Management Team* would then also be responsible to pilot adoption mechanisms as detailed in the literature review, to ensure the Wits commuters adopt carpooling. Some of these policies that could be applied have been further described in Appendix C: Conceptual WITSIT Shared Transport Model. In order to pilot the WITSIT Shared Transport system in the future, the environmental management team could approach a group of students travelling from the same area and provide them with support to execute shared transport more easily. These commuters could become champions for the programme, by sharing their experiences and preparing the technical team with likely issues that could be dealt with before fully launching the programme to the larger Wits population.

The process maps to demonstrate the processes followed to plan, maintain and execute carpool matching up to the point where the passenger and driver meet physically have been captured in Appendix C: Conceptual WITSIT Shared Transport Model. The etiquette of carpooling could be made available to the commuters online as a guideline for optimising the use of carpooling. Shared payment options and instructions are detailed for the convenience and critical success of the WITSIT Carpooling service. These processes were developed by integrating other South African carpooling systems personal tested and have been captured in Appendix A: South African Carpooling Webhost Examples. The process maps aim to provide cyclical feedback loops to enable continuous improvement and transparency for all involved in managing the service.

5.3 Questionnaire Modification, Distribution and Data Collection

5.3.1 Survey Sample

The following methodology for calculating sample size is used by IFAD (1998), Kennedy (2010) and IEEE (1997). The appropriate sample size for the larger population-based survey is determined by three factors:

1. The estimated prevalence of the variable of interest, in this study, daily Wits commuters.
2. The desired level of confidence and the associated critical value (Z-values), which is a component of confidence intervals, which measure the number of standard errors to be added and subtracted in order to achieve a desired confidence level; and
3. The acceptable margin of error.

Generally, for a survey based on a random sample, the sample size can be calculated as follows:

$$n = \frac{t^2 \times p(1 - p)}{m^2}$$

Where:

n = required sample size

t = confidence level at 90% (standard value of 1.645)

p = estimated prevalence of the carpooling (which was noted in various university transportation mode studies as being between 30 and 60%)

m = margin of error at 10% (standard value of 0.1)

However, due to the extent of reach and slow response rate, external intervention was applied to improve the response rates, therefore resulting in the selection of university student respondents not truly representing a random sample but rather that of cluster sampling. To compensate for this difference in design, Kennedy (2010), suggests the sample size must be adjusted with the use of a design effect, which represents the ratio of the standard deviation that would be obtained from a simple random sample of that size, to the standard deviation of the clustered sample (D=2).

Hence the sample size is multiplied by this factor:

$$n_p \times D = Dn_p$$

IFAD (1998) states that a sample needs to be further corrected by a contingency factor (CF) of 5%, to account for non-response or recording error.

$$n_p \times D \times (1 - 0.05) = 0.95Dn_p$$

5.3.2 Questionnaire Selection and Modification

The questionnaire detailed in Appendix B: Survey Questions and Distribution Systems Utilised was distributed to both staff and students of the University.

The survey consisted of “closed questions”, whereby the participants could choose from a limited number of responses to each question. The survey also incorporated “open-ended questions” whereby the participants were given the opportunity to provide a written response to the questions. The survey captured demographic and attitudinal data.

In order to identify any patterns in the responses, the rating scale was based on the Rensis Likert (1930) method providing an option to answer Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree, which has widely been adopted in other literature for multiple choice surveys. Ordinal methods were also utilised for some questions where respondents rank the responses to assign a level of importance to a specific object of interest.

The survey also incorporated features developed by Shaheen et al. (2004) based on Social Learning Theories, Social Marketing Theories and Activity Analysis Theory and Methods, traditionally known as the Travel Behavioural Methodology. All three techniques incorporated by Shaheen et al. (2004) aim to understand behavioural dynamics that importantly highlight possible behavioural adoption processes. Shaheen’s model was able to show that these social learning theories could be applied in written material, video and visual demonstrations. Different media such as videos, posters, labels and brochures were used in the supporting material attached to the survey to increase social learning. This was then used to obtain feedback and examines the attitudinal response to the concept.

Social marketing theory aims to understand market segmentation and competitor strategies and the influence they have on respondents’ behaviour. Most importantly, this theory assumes that individuals will alter their behaviour if they are educated on what needs to be done and how to implement it (Andreasen, 1995). In response to this body of theory, respondents were encouraged to explore a range of informational material prior to completing the survey.

Shaheen’s (2004) study was adapted for the sample surveyed at the University by converting American units of measurement to South African units. The survey was distributed through an online, media interactive website as prescribed by Social Marketing Theory to ensure a positive first time exposure to the proposed transportation service.

5.3.3 Questionnaire Distribution and Data Collection

A website was developed using Google document, form and website tools. This technological interface was chosen due to the compatibility with Excel and unlimited question allowance. The website was developed on the premise that it provided a more interactive system for the participants to be provided with context of the survey and to allow for completion of the survey from desktops or cell phones. The system also allowed for dynamic graphs that updated on completion of the form, which would demonstrate the extent of environmental benefits through visual means.

The following tangible and intangible factors were included to test the feasibility of the model:

- Demographic profile: student or staff respondent, proxy of income, age composition and race. These demographics were captured to determine whether any categories showed pronounced trends or patterns which could be useful to future researchers in shaping a marketing programme should the idea be adopted by the University;
- Wits University commuters' current travelling trends, distance travelled likes and concerns of their current transport mode choices, specifically the number participants using personal vehicles and carpooling;
- Respondents' attitude profile toward the WITSIT Carpooling service;
- Current travel behavioural influences;
- Economical sustainability of the model measured by the perceived importance of the WITISIT car-sharing service in providing an alternative form of car ownership;
- Whether the model influences social sustainability by encouraging participation in the programme to foster environmental stewardship, as well as measuring the perceived importance of impacts on community health; and
- Environmental sustainability based on consideration of alternative modes of transit, which can be related to reduced CO₂ emission reductions achieved through the reduction in number of vehicles due to car-sharing, as well as the likelihood of a private vehicle being sold after joining car-sharing.

The second part of the survey aimed to establish the following qualitative information, which was used to demonstrate the likely adoption rate of the car-sharing model:

- The value placed on instant flexibility and mobility;

- The cost at which individuals are willing to share a vehicle;
- Willingness to trade convenience for an environmentally and socially viable transport mode, measured by attitudes toward the environment, new ways of doing things and private vehicle enjoyment; and
- Features that would increase the attractiveness of the car-sharing service such as cost savings, convenience (location and use), guaranteed parking, vehicle variety and extra benefits such as roadside assistance, emergency taxi service, and customer assistance for problems experienced during the use of the shared transport services.

5.4 Questionnaire, Data Analysis and Mathematical Modelling

The analysis aims to evaluate the 'per capita' contribution in reductions that the University community needs to make to meet the targets set out by the South African government. Staff and student responses were analysed separately due to noticeably different number of weeks per year of commuting for each group.

In order to conduct the analysis three assumptions have been establish below:

- a) This measure of resident students at Wits will be excluded in calculations of the carbon emissions and parking bay calculations as their travelling patterns are very different to commuting students and would most likely not utilize the same transport facilities and routes as commuting students, as the resident students live on the university premises, however their attitudes to alternative transport modes are still to be considered;
- b) The 'saved bays' are proxy for saved trips If number of parking bays served as the most realistic proxy for the number of trips, staff bays being occupied during weekdays at 100% for 48 weeks of the year. While student bays are being occupied during weekdays at 100% for 26 weeks of the year. Although students and staff may commute to wits during exam time and holiday times, it will only be during these stipulated weeks of the year where students and staff follow more regular schedules and are likely to carpool;
- c) The potential carpoolers would be the first user per day in a bay even though it may have more than one car using it per day. This closely represent those commuter who have regular schedules and are most likely to carpool; and

- d) From personal experience over the last 8 years of attending Wits University, parking bays are 100% occupied in term time between 8:00am and 5:00pm. After 5:00pm, approximately 30% of the parking bays are occupied due to events or postgraduate night classes that take place at the University, however carpooling would not easily be adopted by these commuters.

The analysis involved several steps described below:

1. Calculating the current per capita carbon emission contribution by Wits commuters (excluding students in Residences as they would not form part of the potential Wits commuters likely to carpool);
2. The base case was developed by calculating the number of commuter trips in private vehicles if only one passenger occupied the vehicle per trip. This provided the worst case scenario; Scenario 0;
3. The number of bays was estimated from a Google earth satellite image of Wits, and counting the number of bays on the property. The basement parking that could not be counted from an aerial view was counted in situ.
4. The questionnaire data was evaluated to estimate the average travel distance per staff and student respondent, in order to estimate the transport emissions for each group;
5. The method used to calculate the potential number of cars that can be reduced at the University is based on the Dewan (2007) survey. The following equation was derived from the literature review where A, B, C, D... represent the percentage of people willing to carpool with a specific number of passengers:

The total reduction in vehicles on the road as a result of carpooling =

$$\sum_{x=1}^{n=\text{Number of people willing to carpool}} \text{Total number single occupied vehicles} \times \frac{x}{x+n} \times$$

Percentage of people willing to carpool

$$\text{The total reduction in vehicles on the road as a result of carpooling} = (Y \times 50\% \times A) + (Y \times 66.66\% \times B) + (Y \times 75\% \times C) \dots$$

6. The Delhi survey was used to calculate the percentage in reduction in trips, in terms of “willingness of drivers to share with 1, 2, 3 or 4” passengers; representing Scenario 1, 2, 3, and 4;
7. For Scenario 5, the results from the questionnaire were used to determine the current percentage of drivers who are willing to carry 0, 1, 2, 3 or 4 passengers. Scenario 5

assumes that the entire Wits population would follow similar ratios from which to calculate the “potential” number of people to carpool.

8. The outputs from steps 6 and 7 are used to calculate the savings in parking bays;
9. The outputs from step 8 are used to calculate the saving in land area associated with each bay reduced;
10. The associated area reduced, combined with data gathered regarding property prices, is used to calculate the land value; and lastly
11. The social dimensions revealed in your questionnaire, based on Shaheen’s study are analysed.

6 ANALYSIS AND RESULTS

Due to the barriers and limitations experienced during the study, the survey results are indicative of an exploratory study to test a small sample of the larger population. The methodologies developed with the analytical tools are robust and once the barriers that have been noted are eradicated, the methodology and tools can be easily adopted for the survey of a larger population to be conducted in the future.

Extensive desktop research was required as a result of delayed response and lack of transparency from the parking office, which resulted in adopting reasonable assumptions to estimate the population size at Wits University and the projected number of vehicles on the University. These projections were then used to calculate the possible volume of carbon emissions that can be reduced as well as the number of reduced parking bays, as a result of carpooling.

6.1 Survey Sample Size

In 2011, the total Wits population figures reported by the Strategic Planning Division of Wits (2011) came to 32 739 staff and students. This comprised 29 332 students and 3 407 staff members. 26 staff responded to the survey in 2011, which represent 0.76% of the total staff, while only 111 students representing 0.38% of the total number of Wits students completed the survey.

Based on the ideal sample size methodology selected as utilised by IFAD (1998), Kennedy (2010) and IEEE (1997) the upper and lower acceptable survey sample size was calculated in Table 6.1 below:

Table 6.1: Ideal sample size results

| Sample Size (Upper and Lower Limits) | Corrected Sample Size (due to cluster sampling) | Contingency Factor (5%) |
|--------------------------------------|---|-------------------------|
| $n_{30\%} = 57$ | $Dn_{30\%} = 114$ | $0.95Dn_{30\%} = 119$ |
| $n_{60\%} = 65$ | $Dn_{60\%} = 130$ | $0.95Dn_{60\%} = 136$ |

The final sample size of University commuters that must complete the survey based on the range of prevalence of carpoolers between 30 and 60% is 119 – 136 commuters. 137 commuters responded to the survey and based on Table 6.1 above, this response is

adequate to conduct a meaningful analysis of the survey results. Any questions with under six responses (representing 4.4%), are not analysed as they would not be statically significant.

The result of the sample size test indicates that the survey sample is representative of the larger (Wits) population.

6.2 Successes and Barriers for Survey Response

In the Research Method section, the following barriers were noted, resulting in the provision of only an exploratory level of results. Table 6.2 and Table 6.3 present the successes and limitations of the survey and the desktop research respectively:

Table 6.2: Successes and barriers for survey response

| Successes | Barriers |
|---|---|
| 1. The survey was easily accessible, via a website that gave the detail regarding the study and housed the online survey, adapted for both desktops and cell phones | 1. The Survey was based on a car-sharing study that had been peer-reviewed. In the interest of distributing the survey in time, this survey was adapted to expedite the ethics clearance procedure. This resulted in an exhaustive but lengthy survey |
| 2. Using various networks made available by the University, the survey reached various areas throughout the University, through Faculty Registrars and orientation week, where over 3 000 pamphlets were handed out | 2. The online survey selection buttons were not tested thoroughly and resulted in not being able to amend responses, which could give slightly skewed results with multiple answers |
| 3. The online media attached in the website demonstrating the concept was visually appealing, and created a good first experience of carpooling concepts | 3. The survey provided too many options for selection, making the analysis of the data unwieldy |
| 4. There was a relatively positive response in the number of survey respondents that wanted to get involved in the WITSIT Carpooling concept in one or more ways | 4. The large number of variables resulted in complex tracking of interdependencies and trends |

Table 6.3: Desktop research

| Successes | Barriers |
|--|---|
| 1. The desktop approach to estimating the reduction in CO ₂ emissions and the reduction in land for parking due to carpooling was reviewed by external parties who work actively on carbon modeling in the field of transport | 1. Delayed response from internal administration processes at Wits parking department, resulted in less accurate data being made available for the research |
| 2. The results seem realistic based on the actual number of parking bays counted on a satellite map of Wits (Google Earth, 2011) | 2. Broad assumptions have therefore been made throughout the analysis in order to conduct a meaningful review. Future research would be required to test these assumptions, at this stage the results are indicative of likely outcomes |

6.3 Survey Sample Demographics and Traveling Characteristics

The “Facts and Figures” representing the demographic breakdown of the University of Witwatersrand’s total population could only be accessed for 2007- 2011. The results from the survey responses have been compared to the actual demographics of the University population, to determine the statistical validity of the survey sample.

6.3.1 Actual Demographics as of 2011 vs Survey Response Demographic

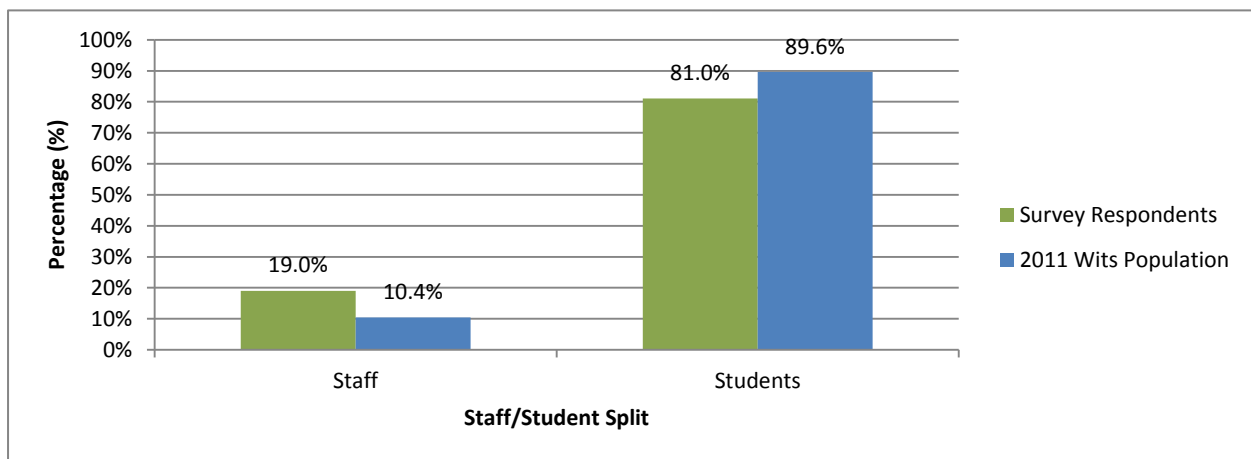


Figure 6.1: Survey response staff/students split vs. Wits 2011 staff/student split

The response rate of students vs. staff to the survey is statistically representative of the actual population demographic, based on the University of Witwatersrand Facts and Figures (2011:2-7), as supported by Figure 6.1. This demographic also represents the two different types of private vehicle users at Wits.

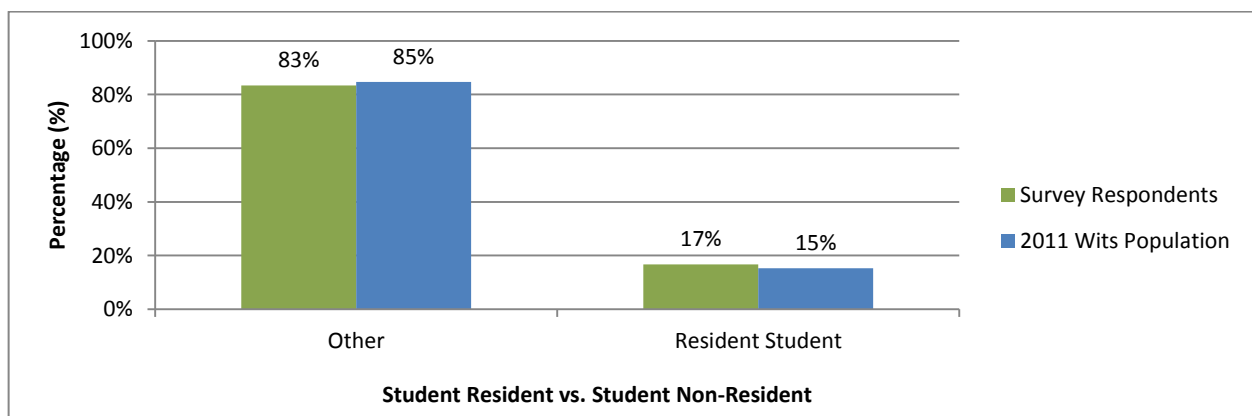


Figure 6.2: Survey response student residency vs. Wits 2011 student residency

There was a close representation of the number of resident to commuting students that responded to the survey, compared to the actual student population demographics documented in the University of Witwatersrand Facts and Figures (2011:7).

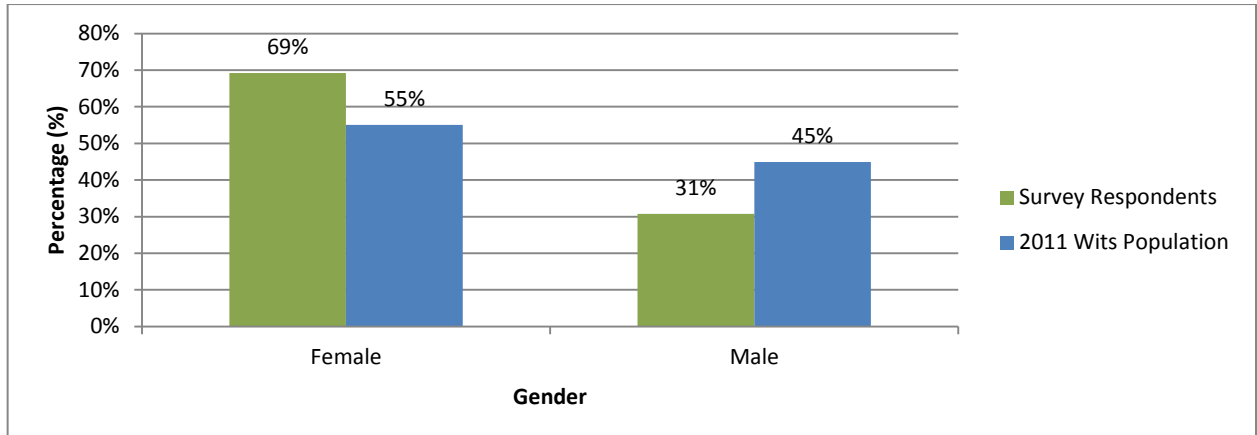


Figure 6.3: Survey response staff gender vs. Wits 2011 staff gender

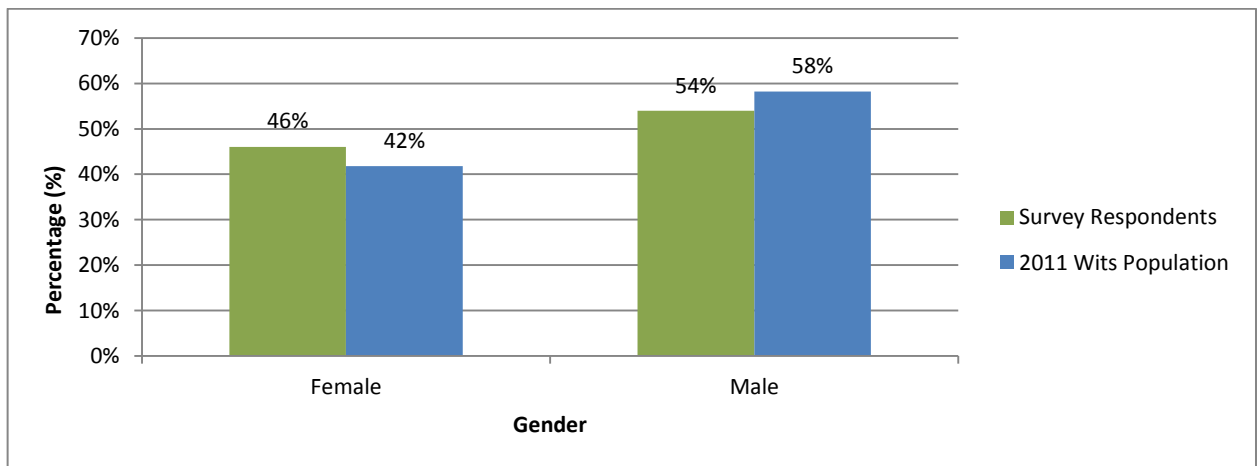


Figure 6.4: Survey response student gender vs. Wits 2011 student gender

Actual demographics based on the University of Witwatersrand Facts and Figures (2011:3) was a relatively close fit with student and staff gender representation further supporting that the survey sample is representative of the larger Wits population.

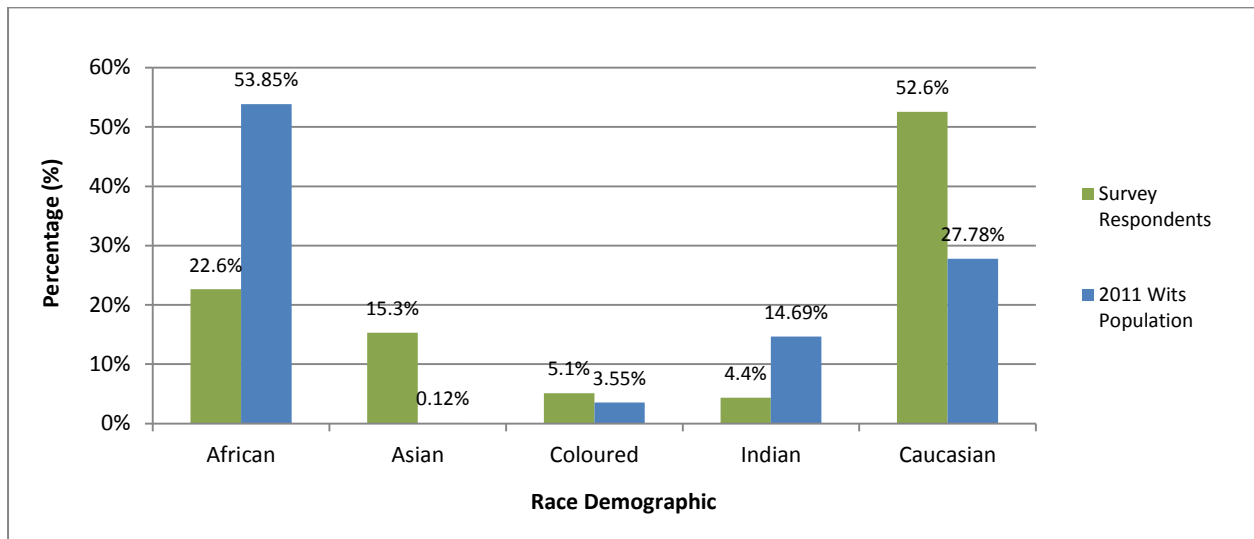


Figure 6.5: Survey response race demographics vs. Wits 2011 race demographic

Compared with the actual population demographics retrieved from the University of Witwatersrand Facts and Figures (2011:3) the majority of the students are African, however the majority of respondents for the survey were Caucasian. The Asians only make up 0.3% of the Wits population, yet there was a good response rate from this group in the survey at 15%. There was a very low response rate from the Indian community, and a relatively significant proportion of the coloured community responded, corresponding closely to the actual demographics. Given the lack of correspondence, one cannot make accurate inferences of race associated with the survey sample.

The two main private vehicle users namely staff and student commuters were also evaluated in more detail such as age groups, and household income in order to identify any obvious trends regarding their attitude to alternative transport.

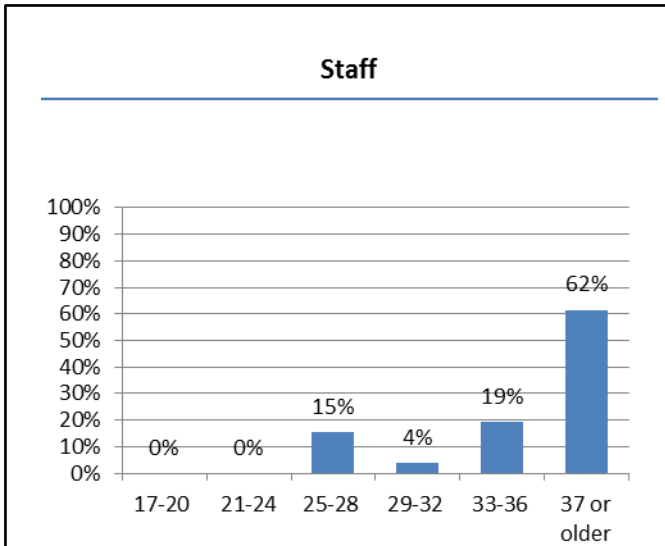


Figure 6.6: Staff respondents' age group

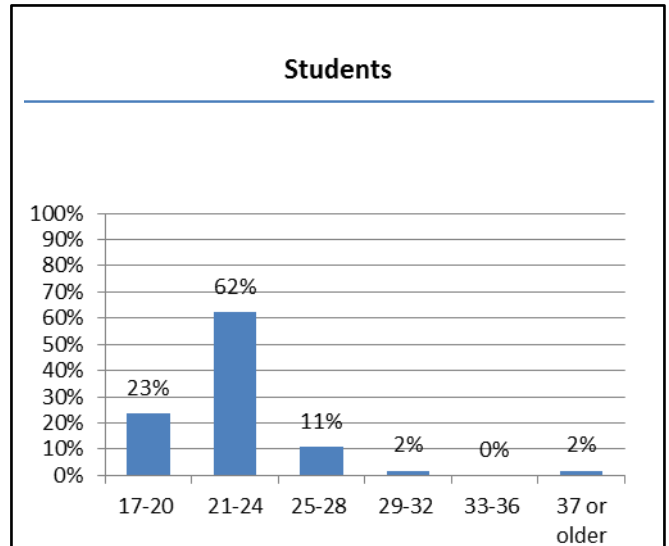


Figure 6.7: Student respondents' age group

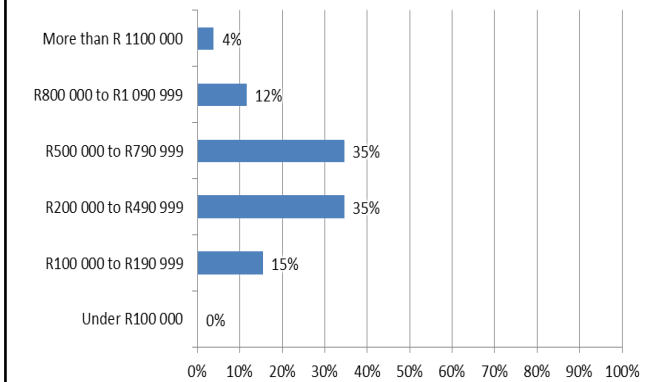


Figure 6.8: Staff respondents' household yearly income

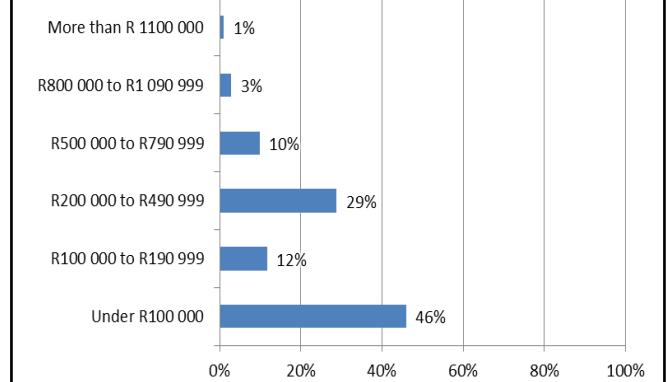


Figure 6.9: Student respondents' household yearly income

The majority of staff who responded were 37 years or older. With students, the majority of respondents were between the ages of 21 and 24 years.

The majority of the students that responded (at 46%) come from a household with income under R100 000, while only 14% of the respondents come from households that earn more than R500 000 a year.

These response rates were cross-referenced with the attitudes of the respondents to determine patterns to describe response rates across the different age groups and different income groups. Due to the small population no clear patterns were identified and will not be further analysed in this study, however could provide valuable insights in future studies.

In order to calculate the current carbon emissions due to private vehicle use, the respondents were asked what type of transport mode they currently utilise. However some respondents use more than one type of transport, thus the respondents were also asked to indicate their main type of transport mode.

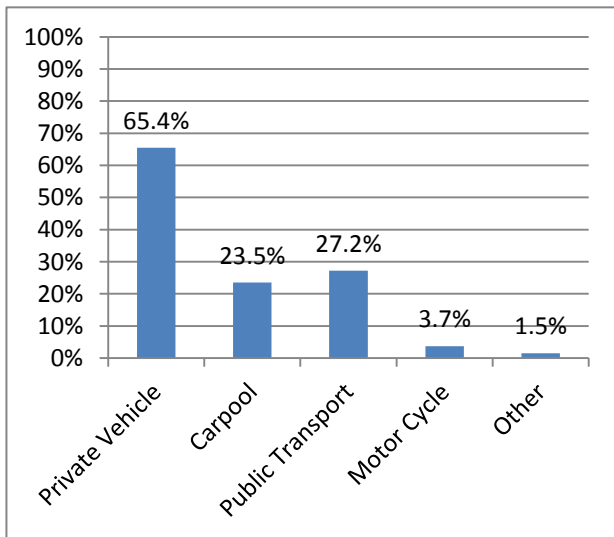


Figure 6.10: All types of transport used by respondents

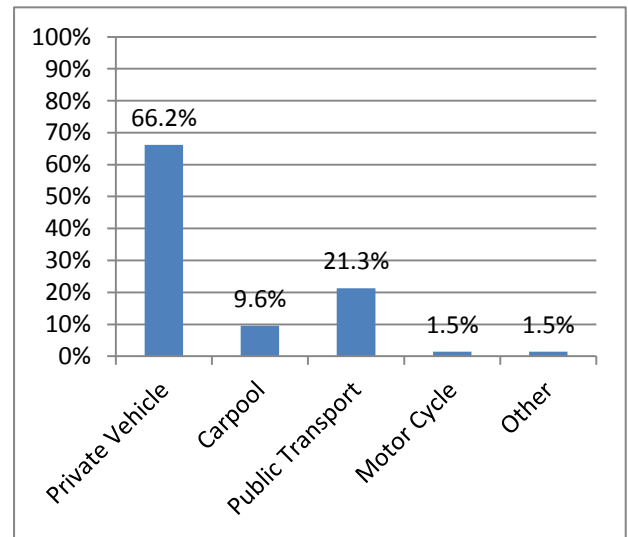


Figure 6.11: Main type of transport used by respondents

The majority of respondents (at 65%) use private vehicles, followed by 27% who use public transport and 23% who use carpooling. Because the respondents can use more than one transport mode the responses will not necessarily add to 100%. When these responses were analysed based on main transport, the transport modes followed the same order. Of the various modes, the selection was the transport mode used the most by the respondent. The responses should add to 100%, however does not add to 100% here due to rounding errors.

Two distinct categories of transport users were revealed, namely staff and students. The survey responses were evaluated for these distinct users in Figure 6.12 and Figure 6.13 to understand different types of transport modes used by staff and student as well as their main type of transport modes.

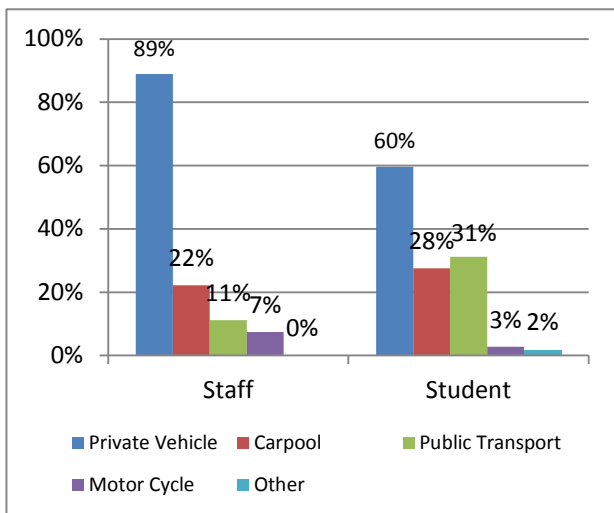


Figure 6.12: All types of transport modes used by student/staff

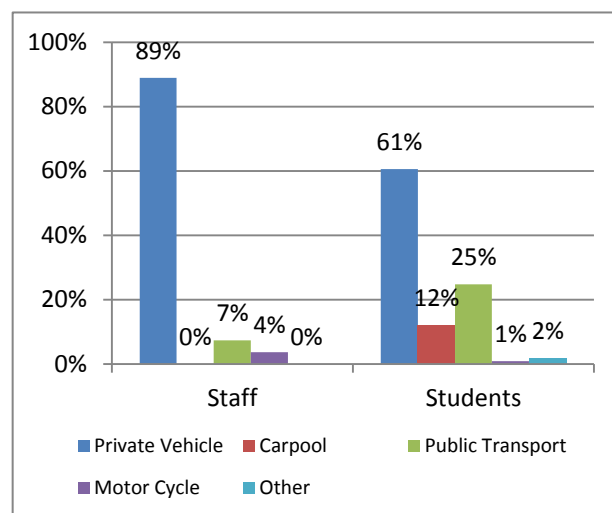


Figure 6.13: Main type of transport modes used by student/staff

The percentage of current carpoolers is critical for the analysis that follows. Based on the results of the survey carpooling percentage ratios depicted in Figure 6.13 above, 22% of staff carpool, and 28% of students carpool.

Those respondents that carpool indicated the number of people with whom they currently carpool. The percentage split has been captured in Table 6.4 below:

Table 6.4: Current number of passengers with whom commuters carpool

| Number of Passengers | Staff | Students |
|-----------------------------|--------------|-----------------|
| 1 | 66.67% | 46.67% |
| 2 | 16.67% | 23.33% |
| 3 | 16.67% | 10.00% |
| 4 | 0.00% | 20.00% |

Similarly the main type of transport responses as represented by Figure 6.13 will later be used to calculate the split between private vehicles and other types of transport modes.

In order to calculate the likely current carbon emissions and possible mitigation scenarios the sample survey that use private vehicles were asked to indicate the type of vehicle they drive. The results of the survey have been captured in Table 6.5.

Table 6.5: Percentage split of the type of vehicle respondents' use

| Engine Size (litres) | Percentage of respondent driving specific vehicle types |
|----------------------|---|
| 1.2 | 19% |
| 1.2-1.8 | 65% |
| 1.8-3 | 16% |

A key component to calculate the carbon emissions that are currently being created or could be potentially mitigated is the average distance travelled by staff and students.

The geographic dispersion of the current Wits University commuters was modelled on Google maps using the responses from the questionnaire Figure 6.14 shows a dispersal of respondents that follows the urban sprawl patterns discussed in the literature review section. This indicates that urban sprawl is a significant factor that applies to the Wits University population, and influences the extent to which a truly integrated transport system could be established, while maintaining ease of access and flexibility.



Figure 6.14: Geographic dispersion of Wits University commuter corridors (Google Maps, 2012)

The average distance travelled by respondents was captured by 'current transport mode' in the survey, however only the private vehicle, carpooling and motor cycle responses were utilised, as they most accurately reflected the distance travelled door to door from their homes to Wits.

The overall average distance is calculated across the different transport modes as a representation of all respondents, for both staff and students. The overall average travelled by staff and students both one way and for a round journey (to University and back home) has been noted below Table 6.6 and Table 6.7 respectively.

Table 6.6: Average distance travelled by staff per day

| Km Travelled | Private Vehicles | Carpool | Motor Cycle |
|------------------------------|------------------|--------------|--------------|
| 10 | 120 | 40 | 10 |
| 20 | 180 | 20 | 0 |
| 30 | 60 | 0 | 0 |
| 40 | 40 | 0 | 0 |
| 50 | 50 | 50 | 0 |
| Total | 450 | 110 | 10 |
| Number of Respondents | 25 | 6 | 1 |
| Average | 18.00 | 18.33 | 10.00 |

Overall Average travelled by staff one way = 15.44km

Overall Average travelled by staff round journey = 30.88km

Table 6.7: Average distance travelled by students per day

| Km Travelled | Private Vehicles | Carpool | Motor Cycle |
|------------------------------|------------------|--------------|--------------|
| 10 | 200 | 60 | 10 |
| 20 | 340 | 60 | 20 |
| 30 | 510 | 60 | 0 |
| 40 | 400 | 160 | 0 |
| 50 | 150 | 50 | 0 |
| Total | 1600 | 390 | 30 |
| Number of Respondents | 67 | 16 | 2 |
| Average | 23.88 | 24.38 | 15.00 |

Overall Average travelled by student = 21.09km one way

Overall Average travelled by student round journey = 42.18km

The average commuting distance for students is approximately 42.18km return per day and for staff is 30.88km per day. The average time spent travelling in off-peak times is between 7 to 51 minutes each way.

With these variables in mind and applying the same ratio of carpooling to the entire staff and student population, one could determine the impact of carbon emission mitigation most likely to take place if the current practices of the 137 survey respondents were representative of the rest of the Wits population.

6.4 Desktop Analysis

6.4.1 Environmental Measure A: Carbon Emission Mitigation

Carbon Emission Mitigation Target

The targets established at COP15 for South Africa were to reduce an accumulative amount of 253 Mt CO₂ eqt. by 2020 (over 10 years), thus the target per year equates to 23 Mt CO₂ eqt. In 2011, the International Energy Agency reported that the road transport industry contributed 12.6% of total CO₂ emissions in South Africa. Hence the target for the transport sector is 31.88 Mt CO₂ eqt. (2.88 Mt CO₂ eqt. per year from 2010 to 2020) by 2020.

These COP15 targets discussed in Section 4.1 were interpolated for Wits University based on the population of the University in proportion to South Africa's Population in 2011 as per data sourced from the South African Census (2011) and Facts and Figures, University of the Witwatersrand (2011).

The overall target for carbon emission reduction for Wits is based on the percentage of Wits total population to South Africa's population, as captured in Table 6.8 below. Wits would only be liable for reducing carbon emissions based on those created per commuter.

Table 6.8: Ratio of Wits staff and student population to South Africa's population (Wits, 2011; Statistics South Africa 2010)

| Population/Ratio | 2007 | 2008 | 2009 | 2010 | 2011 |
|--------------------------|------------|------------|------------|------------|------------|
| Wits Staff | 2 719 | 2 809 | 2 981 | 3 245 | 3 407 |
| Wits Student | 22 235 | 22 376 | 24 881 | 25 093 | 26 343 |
| Wits Total | 24 954 | 25 185 | 27 862 | 28 338 | 29 750 |
| South Africa | 48 502 063 | 48 793 022 | 49 040 520 | 49 991 300 | 50 586 757 |
| Wits Total: SA | 0.05% | 0.05% | 0.06% | 0.06% | 0.06% |
| Wits Staff: Wits Total | 10.90% | 11.15% | 10.70% | 11.45% | 11.45% |
| Wits Student: Wits Total | 89.10% | 88.85% | 89.30% | 88.55% | 88.55% |

Thus for 2011, the ratio of the total Wits population to total SA population for 2011 is 0.06%. The ratio of staff population to total Wits population in 2011 is 11.45%, while the student population to total Wits population in 2011 is 88.55%.

The total target carbon emission reduction for the University for 2011 is calculated by multiplying the Wits/SA population ratio by total SA emissions targets for 2011 at $23\,000\,000 \times 0.06\% = 13\,526$ T CO₂ eqt.

The 2011 target carbon emission mitigation can possibly be achieved solely or partially by reducing single private vehicle journeys to the University premises. The transport target for Wits staff and students together was calculated by multiplying the Wits/SA ratio by the 2011 Total SA emission mitigation target for the entire transport sector, which is represented here as $2\,898\,000 \times 0.06\% = 1\,704$ T CO₂ eqt. Of this, the Wits staff transport target is 11.45% of the overall Wits transport carbon emission mitigation target, coming to 195 T CO₂ eqt. and the Wits student transport target is 88.55% of the overall Wits transport carbon emission mitigation target, coming to 1 509 T CO₂ eqt. for 2011

Private Vehicle Journey Reduction Targets

As expressed in Section 4.1.3: Environmental Implication as a result of Private Vehicle, carbon emissions are determined by engine size in this study. These emissions were assumed for vehicles manufactured in 2011. This may be a bit conservative for the Wits sample population as the commuters are most likely driving various models from the last five years and older. The indices for petrol engines and the split of the respondents' vehicle engine size drawn from the survey are given in the Table 6.9 below.

Table 6.9: Carbon Emissions related to Engine size (RAC Motoring Services, 2012)

| Engine Size (litres) | Emissions (grams CO ₂ /km) | Percentage of respondent driving specific vehicle types |
|-------------------------|--|--|
| 1.2 | >150 | 19% |
| 1.2-1.8 | 150-185 | 65% |
| 1.8-3 | 185-250 | 16% |

Using these weighted averages, 196 grams of CO₂ eqt per passenger km is emitted per vehicle by the sample population and will represent the larger Wits population.

To test this index, three carbon calculators were used, one of which takes into account the model year of the vehicle, the second and third takes into account the litre to kilometre consumption of the vehicle. Student car types range from high end vehicles like sport Mercedes and 15 year old Toyotas. It was therefore assumed a typical student car type would be a second hand Ford Focus 1.6l engine, 2003 model or a 1.6 Polo to represent a more average vehicle, which could be selected from the list provided by the carbon calculators used:

- For the first carbon calculator developed by RADsite (2012), using an EU database, a typical Wits commuter car was assumed to be a Ford Focus, 1.6 l engine 2003. For 1km, this vehicle emits *192 grams CO₂ eq*;
- For the second carbon calculator developed by Menex Electrovehicles(2012), which utilised a South African192 database, it was assumed the typical Wits commuter vehicle has a consumption of 10 l/100km, calculated for 1km, which resulted in a reading of *230 grams CO₂ eqt per passenger km*; and
- The third carbon calculator for vehicle emissions NAAMSA (2012) also uses a South African database. Again a typical Wits commuter vehicle was assumed to be a 1.6 Polo, which according to the calculator emits *153 grams CO₂ eqt per passenger km*.

The average of these three results is 192 grams CO₂ eqt per passenger km. The value assumed above at 196 grams CO₂ eqt, is therefore a reasonable approximation.

Based on the average distance travelled by staff and student, the number of vehicles that must be reduced based on the Wits transport carbon mitigation target is demonstrated below. As stated in the methodology chapter, Section 5, it is assumed that there is 1 driver in the vehicle when calculating targets, in order to more easily calculate the base case.

$$\begin{aligned}
 & \text{Carbon Emissions per Passenger km} \times \text{average km's travelled by Staff} \\
 & \quad \times 48 \text{ weeks of the year on campus} \times 5 \text{ days a week} / 1\,000\,000 = \\
 & 196 \text{ CO}_2 \frac{\text{grams}}{\text{km}} \times 30.88 \text{ km} \times 48 \times 5 / 1\,000\,000 = 1.453 \text{ Tons CO}_2 \text{ eqt per vehicle}
 \end{aligned}$$

Based on the Wits transport target for staff at 195 T CO₂ eqt, if one vehicle for typical staff journeys emits 1.453 CO₂ eqt this translates to 134 passenger vehicle journeys needing to be reduced to meet the COP15 target.

The same approach is used to calculate the number of vehicle journeys that need to be mitigated for typical student journeys to meet the Wits carbon emissions mitigation targets established above, however the 48 working weeks per year associated with staff travel are replaced with 26 lecture weeks per year and the average distance travelled by student is 42.18km. The respective typical student journey emits 1.075 CO₂ eqt with a mitigation target of 1 509 T CO₂ eqt. and this would require the reduction of 1 405 passenger vehicle journeys for the student population to meet the emission reduction target.

A physical count of the current parking bays at Wits was completed in 2011 using an aerial view from Google Earth, 2011 and a walk about to count any underground parking bays or parking bays that were not visible in the Google Earth aerial view. 3 000 student bays were counted, while 1 500 staff parking bays were counted. Where 75 of the staff parking bays (5%) are allocated for visitors.

The calculations above for required reduction in vehicles, total staff vehicles on the campus must be reduced to 1 366 (1 500-134) and total student vehicles on the campus must reduce to 1 595 (3 000 – 1 405), coming to a total of 2 961 vehicles.

The carbon emissions created by single passenger vehicle journeys for staff, is calculated below.

$$\begin{aligned}
 & \text{Number of single passenger private vehicle trips for staff} \\
 & \quad \times \text{Carbon Emissions per Passenger km} \times \text{average km's travelled by Staff} \\
 & \quad \times 48 \text{ weeks of the year on campus} \times 5 \text{ days a week} / 1\,000\,000 = \\
 & 1500 \text{ single passenger private vehicles trips} \times 196 \text{ CO}_2 \frac{\text{grams}}{\text{km}} \times 30.88 \text{ km} \times 48 \text{ weeks} \\
 & \quad \times 5 \text{ days a week} / 1000\,000 = 2\,180 \text{ Tons CO}_2 \text{ eqt}
 \end{aligned}$$

The same approach applies to student commuters, where the 48 weeks is replaced by 26 weeks and the 30.88 average distance travelled by staff replaced by the average distance of

42.18km travelled by student, which equates to 3 224 T CO₂ eqt. being emitted by 3 000 single passenger vehicle journeys.

Based on the Wits transport carbon emission reduction targets the carbon emissions for vehicle journeys must be reduced by 195 T CO₂ eqt and 1 509 T CO₂ eqt for staff and students respectively. Thus the total tons of carbon equivalent currently created by staff private vehicle journeys needs to reduce to 1 986 T CO₂ eqt (2 180 – 194) for staff and 1 715 T CO₂ eqt (3 224- 1 509) for student commuters. The total Wits Transport carbon emission target comes to 3 701 T CO₂ eqt for 2011.

Scenarios for reduction in Carbon Emission and Parking Bays

The approach taken in the Delhi Case Study (Dewan et al., 2007) was used to estimate the number of cars that need to be reduced on Wits University campuses if staff and students carpool with 1, 2, 3 or 4 people. The carbon emissions mitigation was calculated by multiplying the number of vehicles reduced by the average passenger distance travelled in that vehicle per year.

Only 4 scenarios could exist to ensure carpooling does not exceed the maximum allowable number of passengers in a standard sedan or hatchback private vehicle, as described below:

Y= total cars in sample population

- 1 person carpooling relates to 50 % less cars = Y x 50%
- 2 people carpooling relates to 66.66 % less cars = Y x 66.666%
- 3 people carpooling relates to 75 % less cars = Y x 75%
- 4 people carpooling relates to 80% less cars = Y x 80%

The total reduction in vehicles on the road as a result of carpooling =

$$\sum_{x=1}^{n=\text{Number people carpooling}} \text{Total number single occupied vehicles} \times \frac{x}{x+n} \times$$

Percentage of people willing to carpoolEquation 1

Where A, B, C, D... are the percentage of people willing to carpool with that many passengers.

The total reduction in vehicles on the road as a result of carpooling = (Y × 50% × A) + (Y × 66.66% × B) + (Y × 75% × C) Equation 1

Whereas;

The total expected number of vehicles on campus as a result of carpooling = (Y × (1 – 50%) × A) + (Y × (1 – 66.66%) × B) + (Y × (1 – 75%) × C).....Equation 2

Staff respondents commute an average distance of 30.88km, and are assumed to travel to campus 48 weeks of the year.

$$\begin{aligned}
 \text{Total Vehicle distance travelled per year}_{\text{Staff}} & \\
 &= 30.88\text{km} \times 5 \text{ days a week} \times 48 \text{ weeks a year} \\
 &= 7\,413\text{km per year per private vehicle}
 \end{aligned}$$

$$\begin{aligned}
 \text{Total Vehicle km travelled a year}_{\text{Student}} &= 42.18\text{m} \times 5 \text{ days a week} \times 26 \text{ weeks a year} \\
 &= 5\,482\text{km a years per private vehicles}
 \end{aligned}$$

The number of passenger km × Number of vehicles reduced =
 Passenger km reduced.....Equation 3

*Passenger km reduced × Typical petrol vehilces grams of Carbon per passenger km =
 Carbon Emissions reduced.....Equation 4*

Thus for 2011 if all the Wits University staff commuters were to carpool with just one person, the number of vehicles required to transport the same number of commuters would reduce by 50%. = 750 vehicles, which equates to a reduction of 1090 T CO₂ eqt

Based on the methodology described above, the number of vehicles reduced for carpooling with 1, 2, 3 and 4 passengers respectively as well as the most likely carpooling outcome based on the current carpooling responses based on Table 6.4, is depicted in Table 6.10 below. The most likely carpooling outcome is the sum of the percentage of carpools with 1, 2, 3 or 4 passenger based that was reported by the sample survey.

There will however never be zero parking bays on the campus. A certain number of bays are required for those students who are in residences on the University property, handicapped parking zones and general visitors that will travel to Wits. However in an ideal state, disabled commuters would be only types of commuters allowed on campus all other staff and students can ultimately be banned from bringing their private vehicles onto the premises, as happens in many European universities. The saturation point for this study is when all cars entering the campuses have four passengers. At this point, any additional savings would have to be through conversion to public and non-motorised transport, thereby reducing the remaining commuter bays (other than those for the disabled) to zero.

An article from Newsday J. Carwright (2012) comments on handicapped parking issues. The article states that the federal Americans with Disabilities Act require a minimum number of accessible spaces, depending on the total spaces in a parking lot. For every 1 000 parking bays 20 parking bays should be marked for handicap use plus one for each 100 bays over 1 000 bays. The number of people with physical disabilities at Wits is a small percentage of the University population, so these bays would need to remain. For Wits with 4 500 parking bays this comes to 55 parking bays reserved for the disabled.

The Planning Service UK (2000:8) provides guidelines for that one third of total staff provision for visitors for further education institutes and one parking bay for every three seats in a theatre. As per Soweto Tourism Site (2013), Wits theatre has 367 seats, of which 1/3 is 122 bays required for theatre customers; however the visitor bays used during the teaching operating hours of the University is used by theatre customers after teaching hours. If 1 500 bays have been made available to staff on third equates to 500 bays that should be allocated to visitor/theatre customers.

The trips made by residential students' emissions are not factored into carbon reduction calculations. Likewise, for these non-commuting vehicles, the parking bays allocated to resident students would still need to be reserved, but this is beyond the scope of this study.

In total 555 bays will need to be made available at Wits, which is 12% of the total 4 500 parking bays.

Private vehicle journey reductions when carpooling with 1,2,3 and 4 passengers is represented in Table 6.10 below.

Table 6.10: Total Number of Vehicles Reduced at Wits due to Carpooling Scenarios in 2011

| | | | Staff (# Vehicles) | Student (# Vehicles) | Total (# Vehicles) |
|----|--------------------------|------------|-----------------------|-------------------------|-----------------------|
| | Target | | 134 | 1405 | 1539 |
| S0 | Driver | Worst Case | 0 | 0 | 0 |
| S1 | Driver + 1 Passenger | 50% | 750 | 1 500 | 2 250 |
| S2 | Driver + 2 Passengers | 33% | 1 000 | 2 000 | 3 000 |
| S3 | Driver + 3 Passengers | 25% | 1 125 | 2 250 | 3 375 |
| S4 | Driver + 4 Passengers | 20% | 1 200 | 2 400 | 3 600 |
| S5 | Current Carpooling Trend | N/A | 936 | 1708 | 2644 |

Based on the staff target, the least committal carpooling scenario of carpooling with one other passenger exceeds this target by 458%, while the same scenario exceeds the student vehicle reduction target by 7% while the most intensive scenario of carpooling with four other passengers results in exceeding the target by 793% for staff and 71% for students. The most likely outcome based on the current sample carpooling trend, results in exceeding the target by 597% for staff and 22% for students.

The number of parking bays required due to the reduction in vehicles on Wits has been captured in Table 6.11 below associated to the number of vehicles expected on the campus, calculated by subtracting the different carpooling scenarios from the base case of 1 500 staff parking bays and 3 000 student parking bays. The values in Table 6.11 will be used later to determine the parking bays required on Wits campus.

Table 6.11: Total number of vehicles at Wits due to carpooling scenarios in 2011

| | | | Staff (# Vehicles) | Student (# Vehicles) | Total (# Vehicles) |
|----|--------------------------|------------|-----------------------|-------------------------|-----------------------|
| | Target | | 1 366 | 1 595 | 2 961 |
| S0 | Driver | Worst Case | 1 500 | 3 000 | 4 500 |
| S1 | Driver + 1 Passenger | 50% | 750 | 1 500 | 2 250 |
| S2 | Driver + 2 Passengers | 33% | 500 | 1 000 | 1 500 |
| S3 | Driver + 3 Passengers | 25% | 375 | 750 | 1 125 |
| S4 | Driver + 4 Passengers | 20% | 300 | 600 | 900 |
| S5 | Current Carpooling Trend | N/A | 564 | 1292 | 1856 |

Based on Table 6.10 the total reduction in carbon emissions due to carpooling have been captured below in Table 6.12 and calculated using Equation 4. The results have been plotted in Figure 6.15 and Figure 6.16 for staff and student respectively.

Table 6.12: Staff and student CO₂ reduced at Wits due to carpooling scenarios per year

| | | | | Staff | Student | Total |
|--------------------------|---------------------------------|------------|--|---------------------------------------|---------------------------------------|---------------------------------------|
| | | | | Carpooling (T CO ₂ eqt) | Carpooling (T CO ₂ eqt) | Carpooling (T CO ₂ eqt) |
| Target | | | | 195 | 1 509 | 1 704 |
| Driver Worst Case | | | | 0 | 0 | 0 |
| S0 | Driver + 1 Passenger | 50% | | 1 090 | 1 612 | 2 810 |
| S1 | Driver + 2 Passengers | 33% | | 1 453 | 2 149 | 3 782 |
| S2 | Driver + 3 Passengers | 25% | | 1 635 | 2 418 | 4 295 |
| S3 | Driver + 4 Passengers | 20% | | 1 744 | 2 579 | 4 625 |
| S4 | Current Carpooling Trend | N/A | | 1360 | 1836 | 3195 |

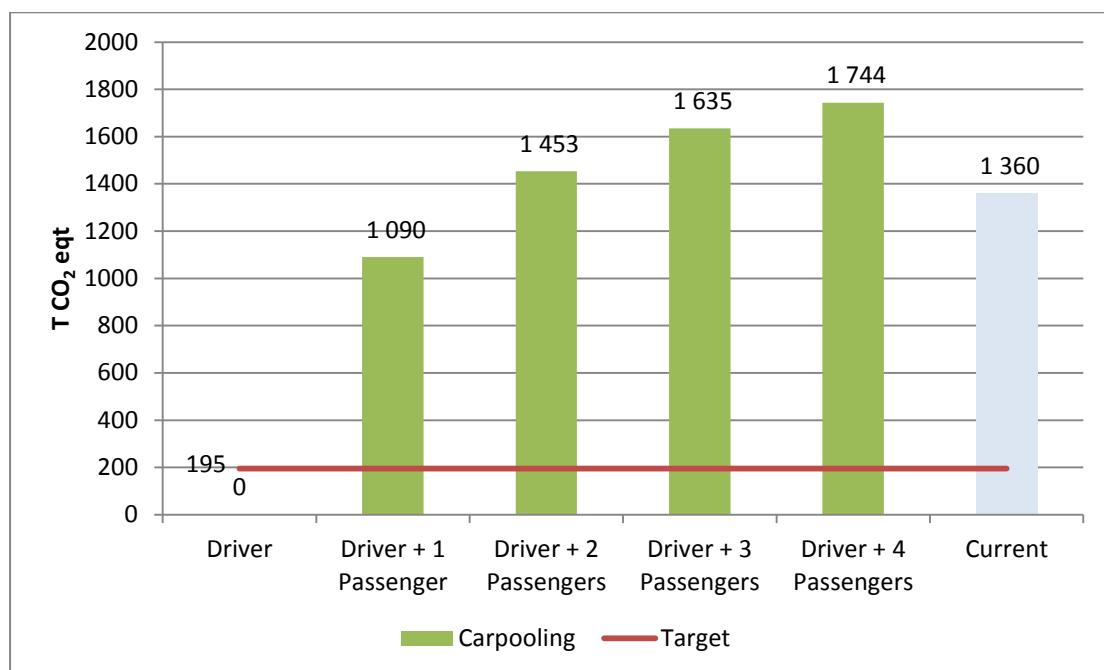


Figure 6.15: Yearly carbon emission mitigation at Wits due to carpooling scenarios by staff

All staff carpooling with just one other passenger, exceeds the target of reducing carbon emissions of 195 T CO₂ eqt by 895 T CO₂ eqt in that year. While the most likely outcome results in 1 165 T CO₂ eqt more carbon emission mitigated, than the required target.

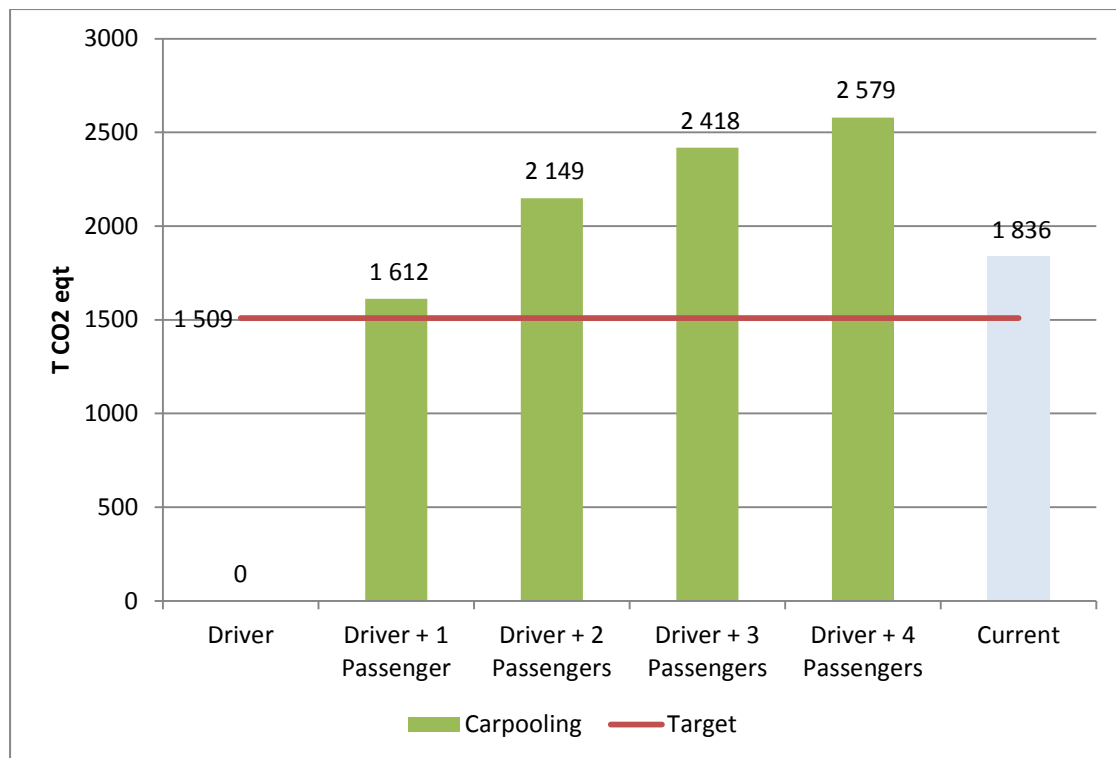


Figure 6.16: Yearly carbon emission mitigation at Wits due to carpooling scenarios by student

If a student carools with one other passenger the target for mitigating carbon emissions of 1 509 T CO₂ eqt is exceeded by 103 T CO₂ eqt in a year. The effect is slightly less aggressive than that of staff, as it was assumed that a student travels to Wits only 26 weeks per year, whereas staff are assumed to travel to Wits 48 weeks of the year, however the total carbon mitigation per student at 1 612 T CO₂ eqt is higher than that for staff at 1 090 T CO₂ eqt, as students travel further on average than staff per journey.

The added effect for both staff and student is graphically represented in Figure 6.17:

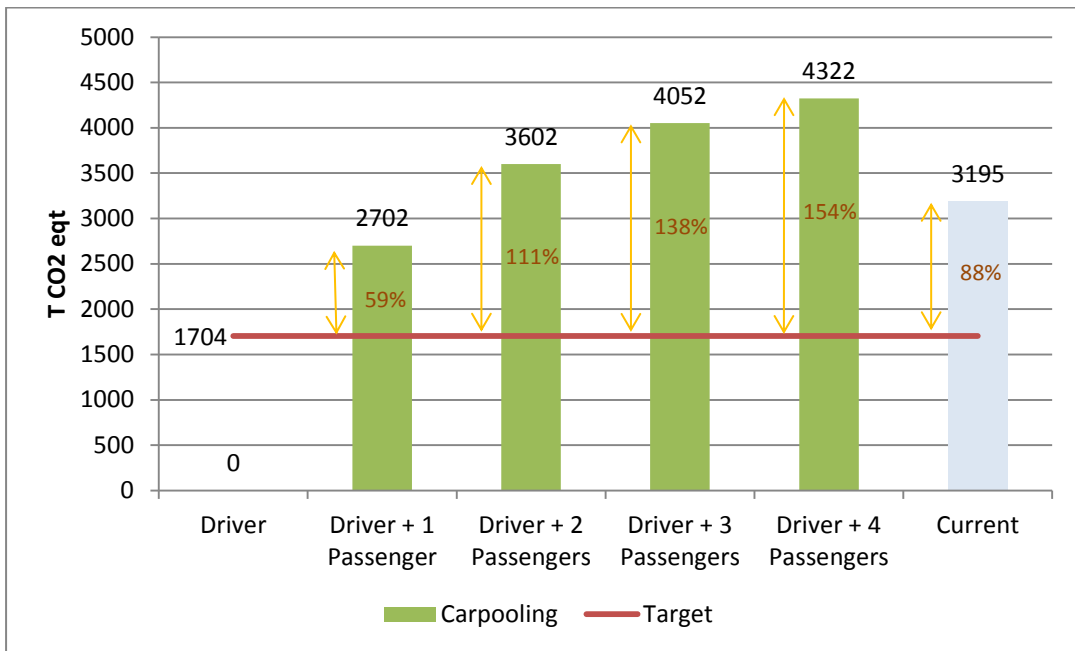


Figure 6.17: Yearly total carbon emission mitigation at Wits due to carpooling scenarios

If the entire Wits population were to carpool with just one passenger, the Wits transport carbon emission mitigation target of 1 704 T CO₂ eqt could be exceeded 1.6 times while if the Wits population was to carpool with four other passengers, the target could be exceeded 2.5 times. Based on the current sample’s carpooling trend the likely outcome due to the most probably adoption rate would result in the mitigation target being exceeded by 1.9 times.

6.4.2 Environmental Measure B: Impervious Land Reduction

The land required for parking reduces as the number of vehicles that are parked at Wits University reduces due to carpooling. Based on the five scenarios that have been modelled and literature review findings, the space required by a single vehicle is between 35m² and 40m², which includes associated internal access routes. The reduction in parking space and associated cost saving has been modelled for staff and students using 35m². The identical methodology would apply if it is assumed that a parking bay is 40m², however only slightly higher savings would be observed.

Currently 4 500 parking bays are available for parking, and based on the assumed parking bay area equates to 157 500 m² of land. Using Google Earth Pro it was possible to trace the area's for required for parking bays and internal access around the University. The sum of the traced areas came to 156 811m² , seen in Figure 6.18 which supports the index used to measure the parking bays. The total measure based on this index is therefore a closely representative of the actual land area used parking at Wits.

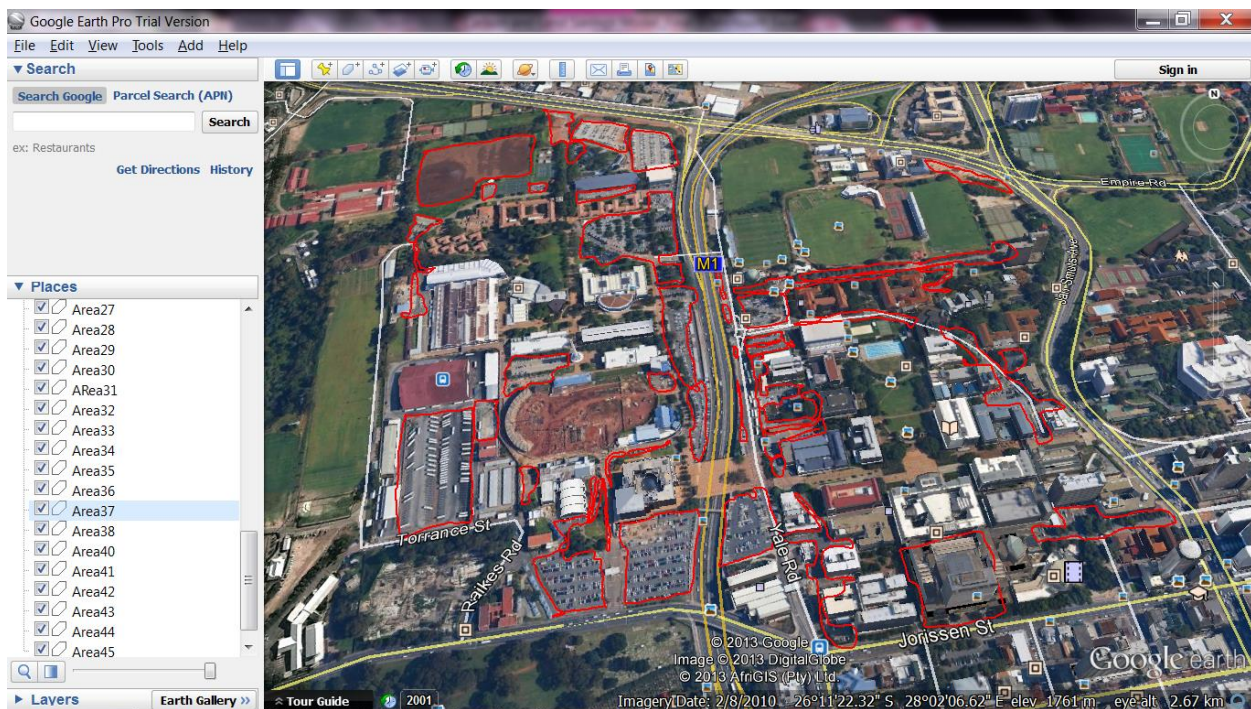


Figure 6.18: Google Earth Pro Wits Parking Traces.

The first scenario, in which all Wits University commuters carpool with one other person who normally uses their private vehicle for commuting to Wits using 2011 data, is used to demonstrate land size savings calculation.

The total number of vehicles that will park on the University reduces by 2 250 vehicles, as captured in Table 6.10. With the size of land associated with one parking bay being 35m², the associated land required is: $2\,250 \text{ vehicles} \times 35\text{m}^2 = 78\,750\text{m}^2$.

The associated reduction in land required for parking bays for the remaining carpooling scenarios has been captured in Table 6.13. The target of number bays to be reduced as calculated in the previous sections has also been included in the evaluation.

Table 6.13: Reduction in land requirement for parking bays at Wits due to carpooling

| Carpooling Scenarios | | | Land requirements reduced from Staff carpooling (m ²) | Land requirements reduced from Students carpooling (m ²) | Total reduction land requirement for parking (m ²) |
|----------------------|--------------------------|------------|---|--|--|
| S0 | Driver | Worst Case | 0 | 0 | 0 |
| S1 | Driver + 1 Passenger | 50% | 26 250 | 52 500 | 78750 |
| S2 | Driver + 2 Passengers | 67% | 35 000 | 70 000 | 105000 |
| S3 | Driver + 3 Passengers | 75% | 39 375 | 78 750 | 118125 |
| S4 | Driver + 4 Passengers | 80% | 42 000 | 84 000 | 126000 |
| S5 | Current Carpooling Trend | N/A | 32 754 | 59 792 | 92 546 |
| Target | | | 4 701 | 49 158 | 53 859 |

However at least 555 parking bays need to be made available for visitors and the disabled as previously discussed in Section 6.4.1. the minimum land requirement for these 555 parking bays would thus be 19 425 m². Therefore if the current land for parking is 157 500 m² and it could only be reduced to 19 425 m², the total maximum allowance for reduction in land is 157 500 m² – 19 425 m² =138 075 m². The target would be to only required 52 859 m² of land, this is a reduction of 158 500 m² – 53 859 m² = 103 641 m².

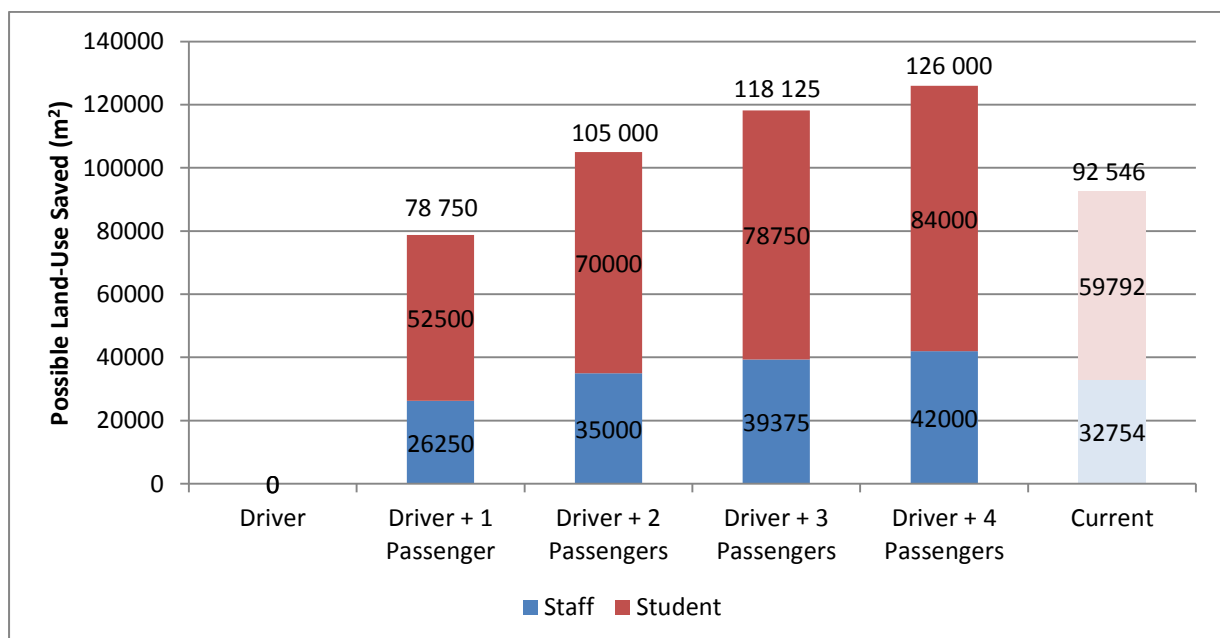


Figure 6.19: Total possible land use saved from parking use due to Wits University student and staff carpooling

Staff carpooling with one to four passengers could result in reduced requirement in land for parking bays between 26 250m² and 42 000m² respectively. Students carpooling with between one and four passengers could result in reduced requirement in land for parking bays between 52 500m² and 84 000m². The total maximum reduction in land equates to 126 000m², which would be possible as the limit to the reduction in land must not be more than 138 075 m². The most likely achievable total reduction in land from staff and student carpooling based on the current sample carpooling trend results in 92 546 m².

6.4.3 Economic Measure: Associated Monetary Land Savings

Wits University Property Valuation

In order to derive the value of land freed up through reduced parking facilities due to carpooling scenarios adopted, the trend of inner city property values surrounding Wits University was accessed by Cleland (2012) from the Deeds Office for all properties transferred in the greater Johannesburg area between 1 January 2000 and 31 December 2011. It is a reasonable assumption to evaluate the Wits University property at this value as residential property demand in the neighbouring areas has increased substantially at 17% between 2000 and 2011, as reported by Cleland (2012). The surrounding areas in the Cleland (2012) analysis includes 20 areas: Berea, Yeoville, Bellevue Jhb, Bellevue Central, Bellevue East, Braamfontein Werfm, Braamfontein, Troyeville, Fairview JHB, New Doornfontein, Selby Ext – Crown City, Selby Ext – Selby, Ferreirasdorp, Highlands, Highlands North, Lorentzville, Bertrams, Hillbrow, Jeppestown and Joubert Park. The 2011 average land value of R2 809/m² is utilised for further calculation.

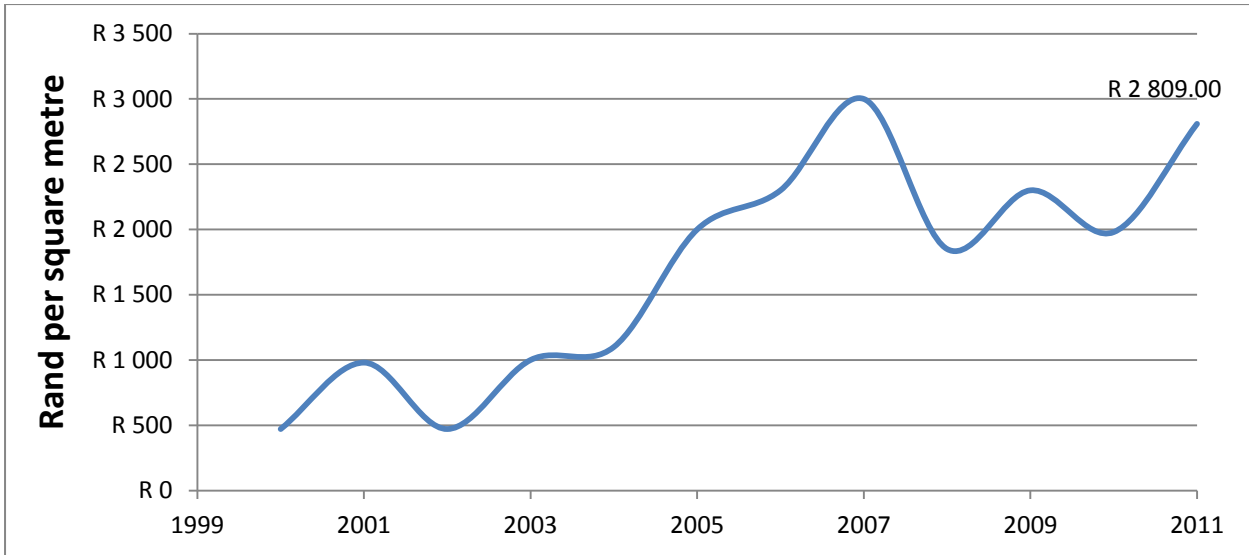


Figure 6.20: Projected property value in the Johannesburg Inner City

Based on Figure 6.20 above, the property value for the suburbs around Wits University came to approximately R2 809 per m² in 2011. The value of property that could be converted for alternative use comes to 78 750 m² × R2 809 per m² = R 221 208 750.

Table 6.14: Land monetary saving from reduced parking bay requirements at Wits due to carpooling

| Carpooling Scenarios | | | Land monetary savings from Staff carpooling (Rmn) | Land monetary savings from Students carpooling (Rmn) | Total land monetary savings from parking bays reduced (Rmn) |
|----------------------|--------------------------|------------|---|--|---|
| S0 | Driver | Worst Case | - | - | - |
| S1 | Driver + 1 Passenger | 50% | 73.74 | 147.47 | 221.21 |
| S2 | Driver + 2 Passengers | 67% | 98.32 | 196.63 | 294.95 |
| S3 | Driver + 3 Passengers | 75% | 110.60 | 221.21 | 331.81 |
| S4 | Driver + 4 Passengers | 80% | 117.98 | 235.96 | 353.93 |
| S5 | Current Carpooling Trend | N/A | 92.01 | 167.95 | 259.96 |
| Target | | | 9.43 | 98.63 | 108.06 |

As seen in Table 6.14, savings decrease as fewer people carpool together. The driver scenario demonstrates the “worst case” scenario where if no commuters were to carpool, no land would be “freed up”. This land to the value of approximately R442 million would be utilised for 4 500 parking bays and there would be no savings, however as stated before, at least 21% of current parking bays is estimated as the minimum number of parking bays

required. As stated above, a minimum of 555 parking bays is required for the disabled and visitors, which results in 19 425m².

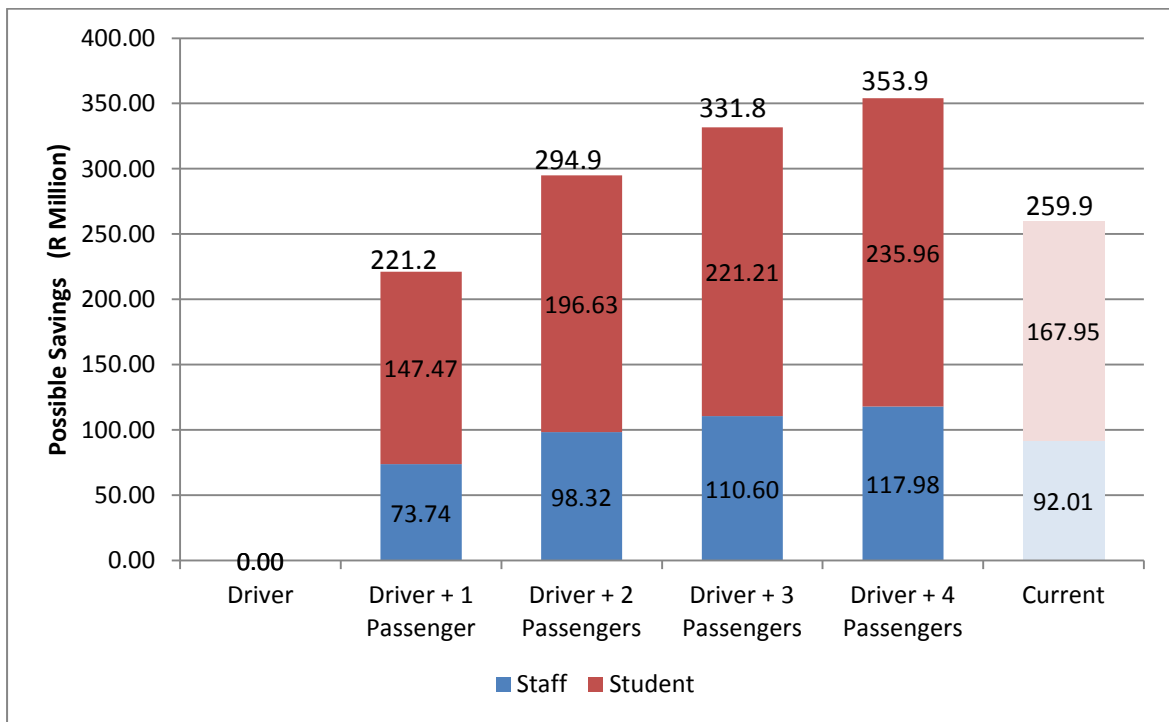


Figure 6.21: Total possible savings value of the land due to Wits university students and staff carpooling

Possible savings from the efforts of staff carpooling with one passenger could result in land worth R73.74 million being utilised for other facilities like new lecture halls, sport facilities or for trees to provide recreational areas. The efforts from students carpooling with one passenger could result in land worth R147.47 million; therefore land worth a total of R221.21 million could be made available for other uses. The most likely rand value in land savings based on the current sample carpooling trends is between carpooling with one and two passengers. A total probably saving to the amount of R259.90 million could be achieved if the entire Wits population follow the sample carpooling trend.

The results of this section have shown there are significant economic benefits to the University as a whole, in the form of land saved, but there are also economic benefits to the commuting population, which will be elaborated on in the next section.

Vehicle Operating Cost Reduced due to Carpooling

To determine the total annual operating cost of a vehicle, one can calculate it by following the recommended approach provided by AA (2012) as follows:

1. Establish the vehicle's Fixed Cost Value (see Fixed cost Table 6.16).
2. Determine the Running Cost Value (see appropriate Running costs Table 6.17).
3. Add these two figures together (Fixed Cost and Running Cost) to get the Total Vehicle Operating Cost in cents per km.

The fixed costs can be calculated using the tables below, which incorporate the depreciation on the vehicle's value, any comprehensive insurance as well as the licensing costs of the vehicle.

The fixed cost includes a percentage of the vehicle's purchase price as presented in the Table 6.15 below:

Table 6.15: Fixed cost as a percentage of the purchase price (AA, 2012)

| Purchase Price | Percentage Of the Purchase Price as part of the Fixed Cost |
|----------------------------|---|
| 1 – R100 000 | 11.92% |
| R100 001 – R250 000 | 7.43% |
| R250 001 – R400 000 | 5.29% |
| R400 001 + | 4.69% |

*Add a 30% loading for a driver with a driver's licence held for less than 5 years

Table 6.15 accessed from the AA (2012), uses as a correction factor in conjunction with Table 6.16 below, to provide an accurate fixed-cost value.

From the first column of Table 6.16, select the purchase price (not the current value) paid for the vehicle. Estimate the total kilometres travelled on average each year, which must include both business and personal travel. The value where the row and column meet is the Fixed Cost value of the vehicle.

On average, students travel 42.17 km per day, which equates to approximately 5 482 km over 26 weeks of the year. Staff, on average, travel 30.89km per day, which equates to approximately 7 413 km over 48 weeks of the year.

From the surveys, staff's purchase price of vehicles is between R100 000 and R125 000 and student purchase price of vehicles is between R50 000 and R75 000. Thus from the table below, the fixed cost for staff is R3.90/km and for student is R2.73/km.

Table 6.16: Fixed cost table (AA, 2012)

| Purchase Price (Incl. VAT) | | Fixed Cost Table | | | | | | | |
|----------------------------|------------------|---|------------------|------------------|------------------|------------------|---------|------|--|
| | | Averaged Fixed Cost (R/km) – All costs inclusive of VAT | | | | | | | |
| | | Annual Distance Travelled | | | | | | | |
| <10 000 | 10 001 to 15 000 | 15 001 to 20 000 | 20 001 To 25 000 | 25 001 to 30 000 | 30 001 to 35 000 | 35 001 to 40 000 | >40 001 | | |
| up to R30 000 | 1.08 | 7.1 | 5.4 | 4.3 | 3.6 | 3.3 | 2.8 | 2.6 | |
| R30 001 – R50 000 | 1.81 | 1.20 | 9.1 | 7.4 | 6.2 | 5.4 | 4.8 | 4.3 | |
| R50 001 – R75 000 | 2.73 | 1.82 | 13.8 | 11.1 | 9.4 | 8.2 | 7.2 | 6.5 | |
| R75 001 – R100 000 | 3.61 | 2.41 | 18.1 | 14.7 | 12.3 | 10.8 | 9.5 | 8.6 | |
| R100 001 – R125 000 | 3.90 | 2.60 | 19.6 | 15.8 | 13.3 | 11.7 | 10.4 | 9.4 | |
| R125 001 – R150 000 | 4.48 | 2.99 | 22.5 | 18.2 | 15.3 | 13.5 | 11.9 | 10.8 | |
| R150 001 – R175 000 | 5.26 | 3.51 | 26.5 | 21.3 | 17.9 | 15.9 | 14.0 | 12.7 | |
| R175 001 – R200 000 | 6.04 | 4.04 | 30.3 | 24.5 | 20.7 | 18.2 | 16.1 | 14.7 | |
| R200 001 – R250 000 | 7.60 | 5.08 | 38.2 | 30.9 | 25.9 | 22.9 | 20.2 | 18.4 | |
| R250 001 – R300 000 | 8.50 | 5.68 | 42.8 | 34.6 | 29.1 | 25.6 | 22.8 | 20.7 | |
| R300 001 – R350 000 | 9.56 | 6.38 | 48.0 | 38.9 | 32.7 | 28.9 | 25.6 | 23.2 | |
| R350 001 – R400 000 | 11.00 | 7.35 | 55.3 | 44.8 | 37.7 | 33.2 | 29.5 | 26.8 | |
| more than R400 001 | 12.20 | 8.14 | 61.3 | 49.6 | 41.7 | 36.8 | 32.7 | 29.7 | |

However, it is unlikely that those staff and students who carpool will sell their vehicles; the fixed cost will therefore never be recovered through carpooling and will only be saved in a year if the vehicle is sold.

The running costs of the vehicle are calculated by estimating the maintenance costs (such as servicing, repairs and tyres) and fuel costs.

The majority (71%) of respondents use petrol vehicles and hence Table 6.17 was utilised from the AA website (2012).

A large portion (35%) of Wits staff commuters use vehicles with an engine capacity in the range 1500 to 1800cc's, while the majority (38%) of Wits student commuters use vehicles with an engine capacity between 1300 and 1500cc's. Using these respective engine capacities of the vehicles, one can utilise Table 6.17 to estimate running costs for staff and students respectively.

Table 6.17: Running costs table- petrol vehicles (AA, 2012)

| Engine Capacity (cc) | Running Costs Table – Petrol Vehicles | | |
|----------------------|--|------------------------------------|----------------------|
| | Average Running Cost (R/km) – All costs inclusive of VAT | | |
| | Fuel | Maintenance | |
| | Petrol Factor (l/km) | Service And Repair Costs (in Rand) | Tyre Costs (in Rand) |
| | A | B | C |
| < 1 300 | 0.069 | 0.171 | 0.096 |
| 1 301 – 1 500 | 0.077 | 0.187 | 0.134 |
| 1 501 – 1 800 | 0.083 | 0.192 | 0.163 |
| 1 801 – 2 000 | 0.093 | 0.224 | 0.234 |
| 2 001 – 2 500 | 0.108 | 0.292 | 0.270 |
| 2 501 – 3 000 | 0.109 | 0.338 | 0.322 |
| 3 001 – 4 000 | 0.122 | 0.352 | 0.337 |
| > 4 001 | 0.145 | 0.526 | 0.528 |

To calculate the final running cost, multiply the fuel factor (Column A) by the current fuel price in Rands per litre. The result in Table 6.16 provides cost in change to Rands per kilometre. Then add service and repair costs (Column B) and finally add the tyre costs (Column C).

$$\text{Running Costs Calculation (R/km)} = (\text{A multiplied by fuel price in R/litre}) + \text{B} + \text{C}$$

Running Costs Calculation_{Students}

$$= (0.077\text{l/km} \times \text{R}11.75 \text{ per litre}) + \text{R}0.19/\text{km} + \text{R}0.13/\text{km} = \text{R}1.22$$

$$\begin{aligned} \text{Running Costs Calculation}_{\text{Staff}} &= (0.083\text{l/km} \times \text{R}11.75 \text{ per litre}) + \text{R}0.19/\text{km} + \text{R}0.16/\text{km} \\ &= \text{R}1.33 \end{aligned}$$

The total vehicle operating cost is the sum of the fixed and operating costs

$$\text{Total operating Cost}_{\text{Students}} = \text{R}1.22 + \text{R}2.73 = \text{R}3.95/\text{km}$$

$$\text{Total operating Cost}_{\text{Staff}} = \text{R}1.33 + \text{R}3.90 = \text{R}5.23/\text{km}$$

Finally, the cost of driving alone compared to carpooling has been captured in Table 6.18 below by simply dividing the “base case” scenario by the number of people carpooling together.

For simplicity in the calculations, it was assumed that there are no travel costs for passengers to meet the driver and the driver has no additional travelling to collect the passenger.

Table 6.18: Total vehicle operating costs per person for carpooling scenarios

| Scenario | | Staff (R/km) | Student (R/km) |
|----------|-----------------------|-----------------|-------------------|
| S0 | Driver | 5.23 | 3.95 |
| S1 | Driver + 1 Passenger | 2.61 | 1.98 |
| S2 | Driver + 2 Passengers | 1.74 | 1.32 |
| S3 | Driver + 3 Passengers | 1.31 | 0.99 |
| S4 | Driver + 4 Passengers | 1.05 | 0.79 |

Finally the total costs can be calculated by multiplying the average distance driven per year, multiplied by the respective cost per km calculated for a specific scenario. The difference between the “worst case” where the driver does not carpool compared to the four other scenarios will be tested below. The carpooling costs would be original running costs with one occupant divided by the number of passengers. The savings per carpool for the week/month/year is the sum of the running costs saved by each passenger.

The overall operating cost saved by the carpool would be more complex to calculate, since one cannot assume that the passengers will sell their cars, so some of these costs will remain (insurance, annual service cost, depreciation) whether the passengers are driving their cars or not, thus the for the ease of analysis, the savings for the passengers will be evaluated for the driver if the passengers shared the running cost of the journeys equally.

A journey for a single driver would cost R807.16, as per the above calculation. Sharing the cost of that journey with one other passenger comes to R403.58, therefore if the passenger pays the driver for the total running cost per journey, the driver and passenger each save R403.58 per week.

Table 6.19: Staff journey cost per vehicle occupant due to carpooling

| | Single Occupant (Driver) | Driver Carpooling with 1 Passenger | Driver Carpooling with 2 Passengers | Driver Carpooling with 3 Passengers | Driver Carpooling with 4 Passengers |
|---------------|--------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Weekly Costs | R 807.16 | R 403.58 | R 269.05 | R 201.79 | R 161.43 |
| Monthly Costs | R 3 228.65 | R 1 614.33 | R 1 076.22 | R 807.16 | R 645.73 |
| Yearly Costs | R 38 743.84 | R 19 371.92 | R 12 914.61 | R 9 685.96 | R 7 748.77 |

Table 6.20: Staff journey savings per vehicle occupant due to carpooling

| | Single Occupant (Driver) | Driver Carpooling with 1 Passenger | Driver Carpooling with 2 Passengers | Driver Carpooling with 3 Passengers | Driver Carpooling with 4 Passengers |
|-----------------|--------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Weekly Savings | R 0 | R 403.58 | R 538.11 | R 605.37 | R 645.73 |
| Monthly Savings | R 0 | R 1 614.33 | R 2 152.44 | R 2 421.49 | R 2 582.92 |
| Yearly Savings | R 0 | R 19 371.92 | R 25 829.23 | R 29 057.88 | R 30 995.08 |

Table 6.21: Student journey cost per vehicle occupant due to carpooling

| | Single Occupant (Driver) | Driver Carpooling with 1 Passenger | Driver Carpooling with 2 Passengers | Driver Carpooling with 3 Passengers | Driver Carpooling with 4 Passengers |
|---------------|--------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Weekly Costs | R 833.26 | R 416.63 | R 277.75 | R 208.32 | R 166.65 |
| Monthly Costs | R 3 333.05 | R 1 666.53 | R 1 111.02 | R 833.26 | R 666.61 |
| Yearly Costs | R 21 664.85 | R 10 832.42 | R 7 221.62 | R 5 416.21 | R 4 332.97 |

Table 6.22: Student journey savings per vehicle occupant due to carpooling

| | Single Occupant (Driver) | Driver Carpooling with 1 Passenger | Driver Carpooling with 2 Passengers | Driver Carpooling with 3 Passengers | Driver Carpooling with 4 Passengers |
|-----------------|--------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Weekly Savings | R 0 | R 416.63 | R 555.51 | R 624.95 | R 666.61 |
| Monthly Savings | R 0 | R 1 666.53 | R 2 222.04 | R 2 499.79 | R 2 666.44 |
| Yearly Savings | R 0 | R 10 832.42 | R 14 443.23 | R 16 248.64 | R 17 331.88 |

Therefore a staff member who is the driver in a carpool could earn fares between R1 600 and R2 600 per month depending on the number of people they carpool with, while student drivers would earn between ~R1 700 and ~R2 700 per month.

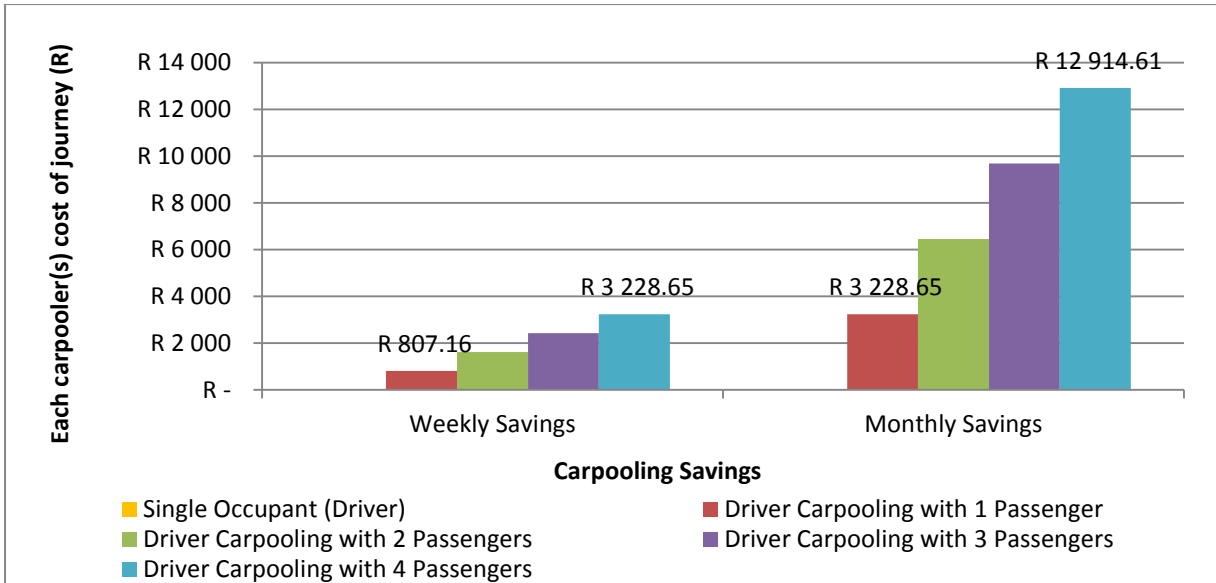


Figure 6.22: Staff vehicle weekly and monthly savings due to carpooling

If staff were to carpool with one, two, three or four passengers as a carpool group, they could save between ~R3 300 and ~R12 900 per month.

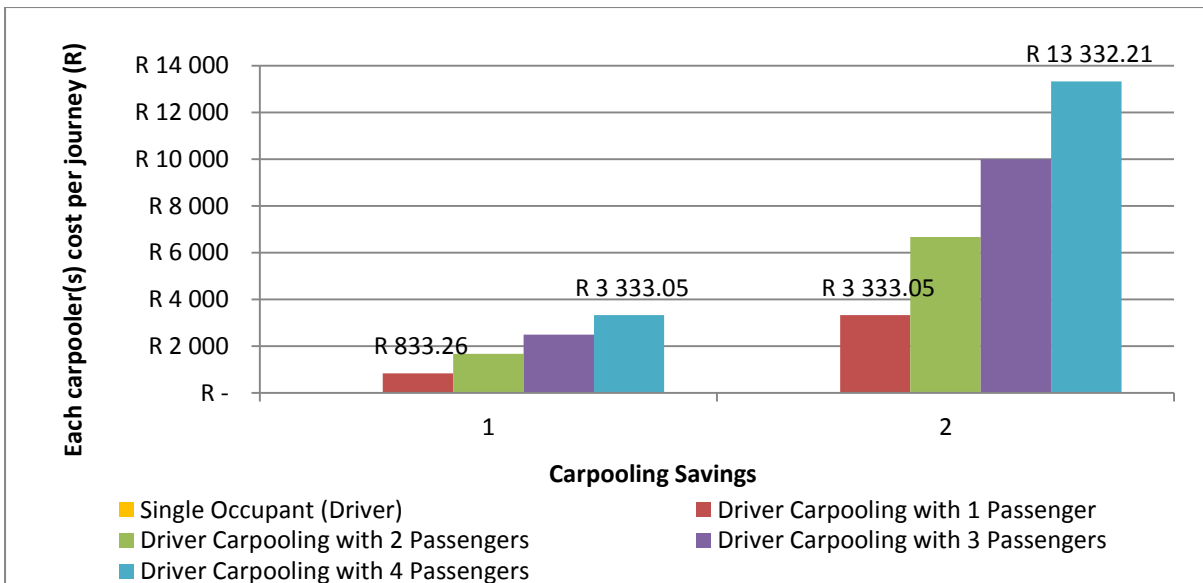


Figure 6.23: Student vehicle weekly and monthly saving due to carpooling

If students were to carpool with one, two, three or four passengers as a carpool group, they could save between ~R3 300 to ~R13 300 a month. Although they might travel in slightly cheaper vehicles than staff, the average distance a student drives is further, therefore saving slightly more than five staff carpooling.

6.5 Qualitative Research Analysis

As explained in section 3 one needs to be aware that the sample is not truly reflective of a random sample, but rather a self-selection as people who were already interested in alternative transport, or at least aware of environmental issues were more likely to have completed the survey. The sample is therefore not necessarily representative of the university-wide attitude.

6.5.1 Survey Respondents' Attitude towards Adopting Carpooling

The questions in the survey tested the respondents' attitudinal behaviour towards their current travelling modes, investigating their current travelling mode strengths and weaknesses. The survey also investigated the survey respondents' behavioural influencers. The participants were also exposed to the emergency WITSIT car-sharing scheme proposed in the model. This scheme represents the second phase of car-sharing and tests the participant's attitude towards a "new intermodal transportation service." Lastly the survey tested the likely extent of involvement of the participants in a future carpooling service.

The first level of analysis evaluates the responses from the entire survey group of 136 people by their mode of transport. Figure 6.24 demonstrates that the primary mode of transport by Wits commuters (65%) is private vehicles, followed by public transport (27%), carpooling (24%), and lastly motor cycles (4%). 1.5% use other modes, including walking.

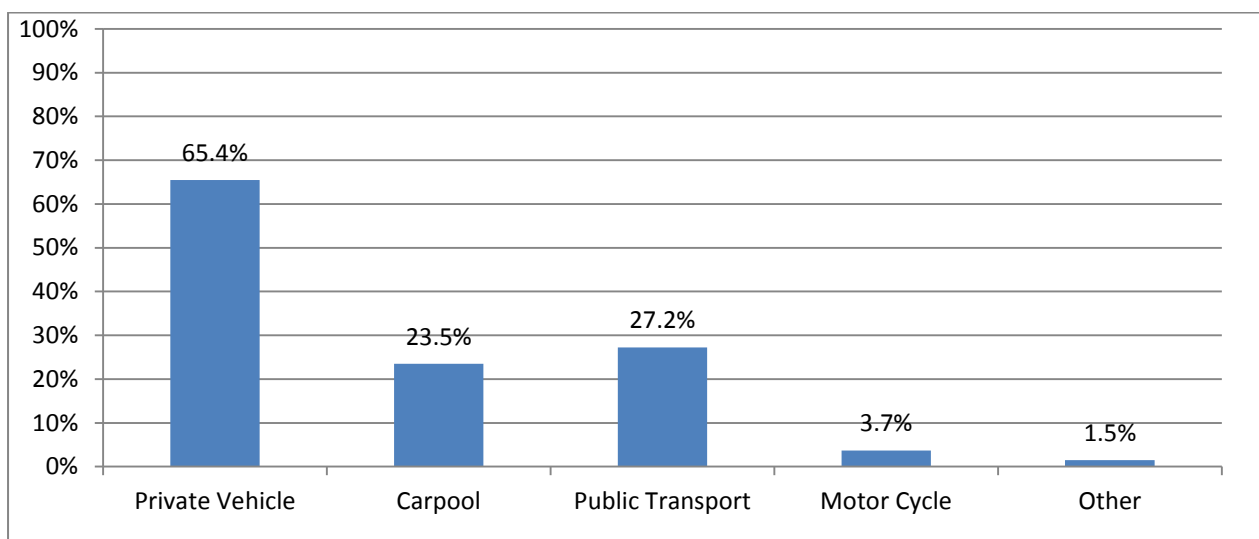


Figure 6.24: Types of transport modes used by respondents

The second level of evaluation looked at the subset of the group who expressed the desire to participate in carpooling. The results in Table 6.23 demonstrate a large portion of the respondents were keen to get involved in the WITSIT Carpooling service. What is most pertinent to this section is to analyse the attitudes of those who will actually carpool, namely 96% of staff and 57% of the students, giving a total of 88 people of the 136 survey respondents.

Table 6.23: Likelihood of type of future involvement

| <i>Participation</i> | <i>Staff</i> | <i>Student</i> | <i>Staff</i> | <i>Student</i> |
|-------------------------------|--------------|----------------|--------------|----------------|
| <i>Carpool</i> | 26 | 62 | 96% | 57% |
| <i>Marketing</i> | 0 | 2 | 0% | 2% |
| <i>Programmer</i> | 1 | 6 | 4% | 6% |
| <i>Committee</i> | 3 | 13 | 11% | 12% |
| <i>Not participate at all</i> | 0 | 26 | 0% | 24% |
| Total Respondents | 27 | 109 | | |

Figure 6.24 was utilised in the desktop study to facilitate part of the analysis. As stated before, two distinct users were identified: staff and students, differentiated by different driving distances and proportion of the year that they were required to travel to Wits. These users are analysed as the third level of detail and will only be discussed where differing or distinct patterns are observed for the different user types.

Current Travelling Mode Strengths

The responses to questions that tested participants' attitudes towards their current primary mode of transport were based on the five grade Likert Scale. Although the participants had the option of selecting a neutral feeling, only the decisive responses are analysed to understand what the motivating factors will be and the factors that could discourage commuters from carpooling.

The statements that were tested include:

1. Gives me a sense of freedom
2. Is comfortable
3. Allows me to quickly respond to an emergency
4. Says a lot about who I am

- 5. Helps me go everywhere
- 6. Fits my budget
- 7. Is enjoyable to me

Figure 6.25 depicts the percentage of Wits respondents that agree with the statements based on their current transport modes, while Figure 6.26 depicts the percentage of Wits respondents who disagree with the statements.

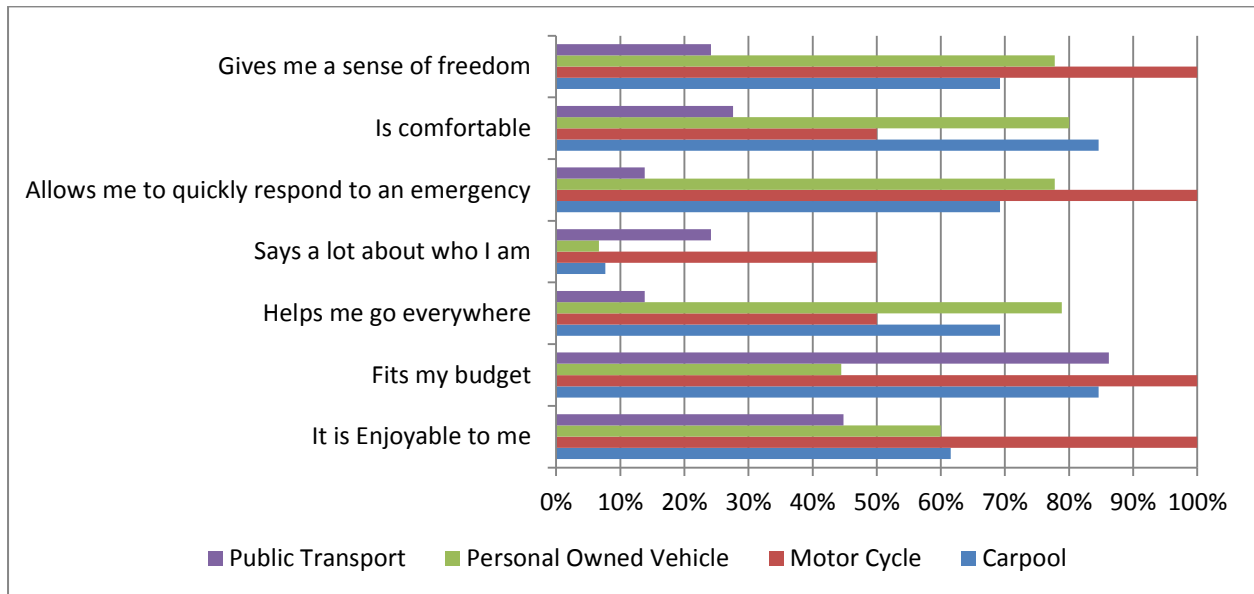


Figure 6.25: Respondents agree that their current transport mode has this strength

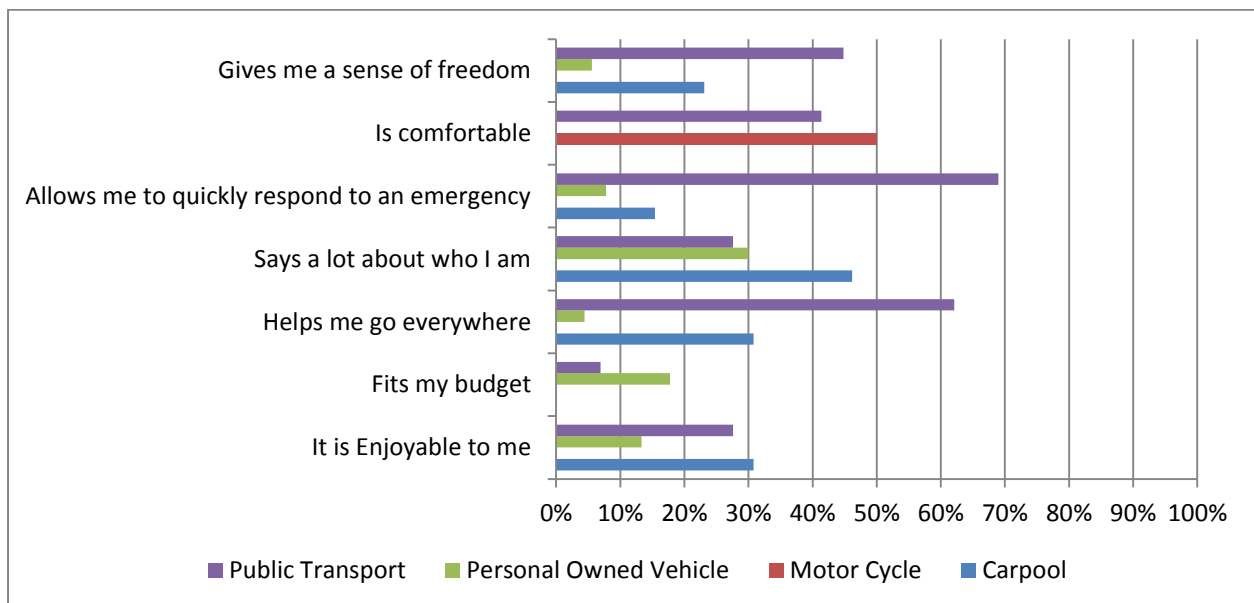


Figure 6.26: Respondents disagree that their current transport mode has this strength

The most significant patterns in Figure 6.26 suggest that a large percentage of respondents who utilise private vehicles agree that the greatest strength driving a vehicle has, is it gives them a sense of freedom, allows quick response to emergencies and it facilitates mobility, where the opposite was true for those who use public transport. The significant percentage at 45% and 62% respondents who use public transport and those who use carpooling respectively, agreed that it fits their budget.

When implementing the WITSIT service, it would be important to demonstrate how carpooling will allow the commuters to have enough flexibility in changing their carpool group at short notice to meet their change in schedule so that they still have a sense of freedom by having a certain level of control in when and where they travel to. Secondly, the savings one could attain through carpooling must be clearly demonstrated as this is a significant motivation to use alternative modes to private vehicles. Both these views are supported by the insights provided by the other works reviewed in the literature survey, section 4.3.

The results from this question were evaluated against those respondents who indicated they would like to carpool through the use of a pivot table. Figure 6.27 demonstrates the most likely participants to carpool and the percentage who agree their current transport modes have these strengths listed, while Figure 6.28 depicts the respondents most likely to carpool and the percentage that disagree with that their current transport mode has these strengths.

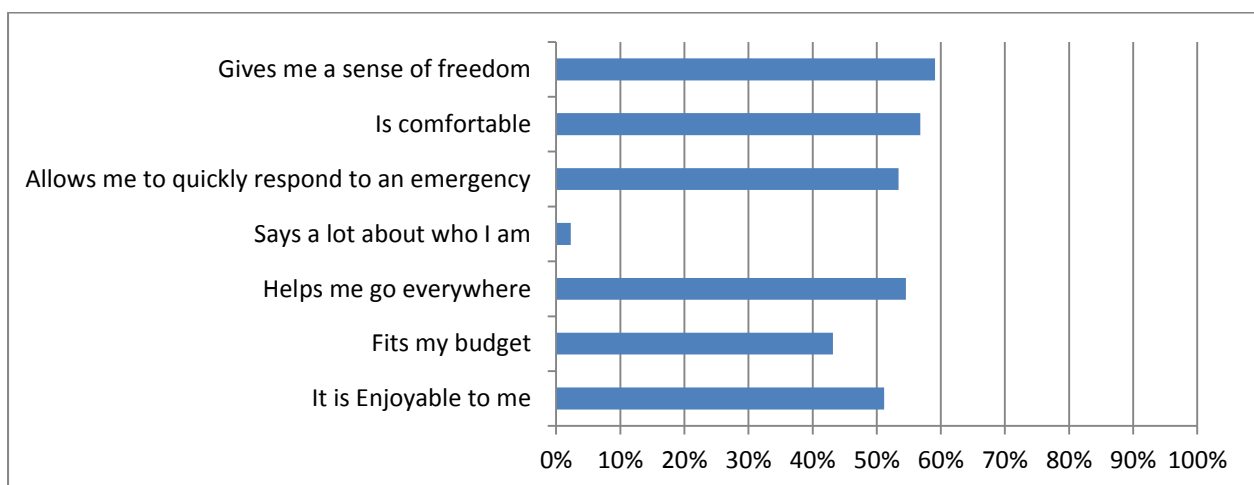


Figure 6.27: Likely carpool participant agree that their current transport mode has these strengths

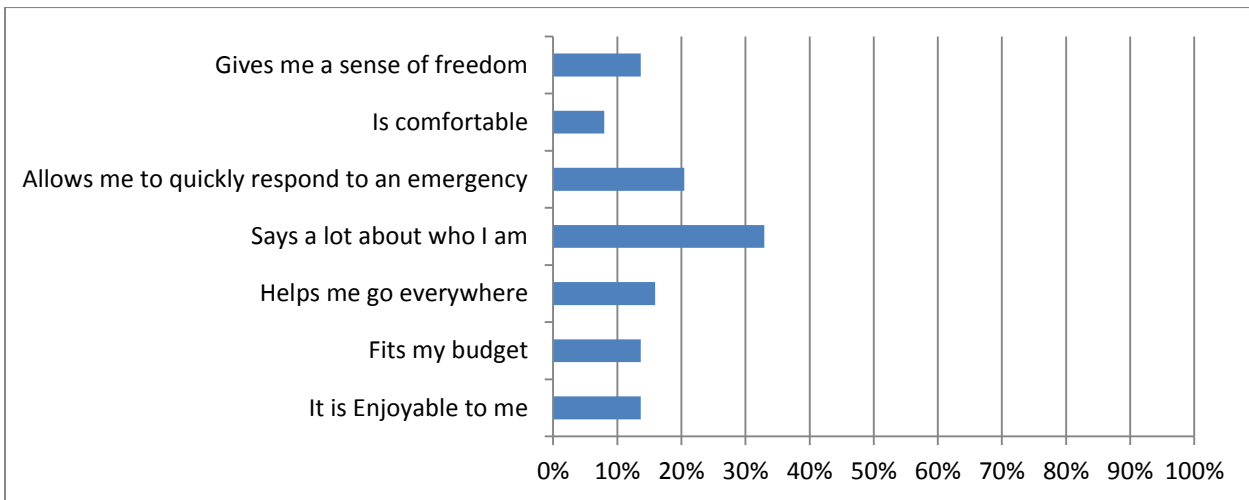


Figure 6.28: Likely carpool participant disagree that their current transport mode has these strengths

The patterns in Figure 6.27 and Figure 6.28 reaffirm that people wanting to carpool most value a transport mode that allows the commuter to have flexible levels of control to give them a sense of freedom, and allows them to travel where they would like and quickly respond to emergencies. A new motivating factor identified for a transport mode selection is that the journey must be comfortable. A significant response by those who were willing to carpool is that they do not feel that the transport mode says a lot about them, which indicates there is a weak affiliation with their personal social status based on their transport mode. This is favourable for the adoption of carpooling, as it was assumed that a barrier to carpooling could have been that commuters associate their social status with private vehicle use. If this association does not exist, carpooling could be more easily adopted.

Current Travelling Mode Weaknesses

The questions that were asked of the participants to test their greatest dislikes with respect to their current primary mode of transport required them to rate their level of dislike: 3 being their least favourite and 1 being something they dislike, but not as much as 3 or 2. Participants were to select only three options to identify the least favourite aspects of their current travel mode, but respondents in some cases gave more than one item a 3, 2 or 1.

The statements that were tested included:

1. It is not flexible enough
2. It is not environmentally-friendly
3. It takes too long to get to a destination
4. It is not reliable enough
5. Vehicle maintenance is a hassle
6. I waste too much time in traffic
7. Parking is a hassle
8. It is too expensive

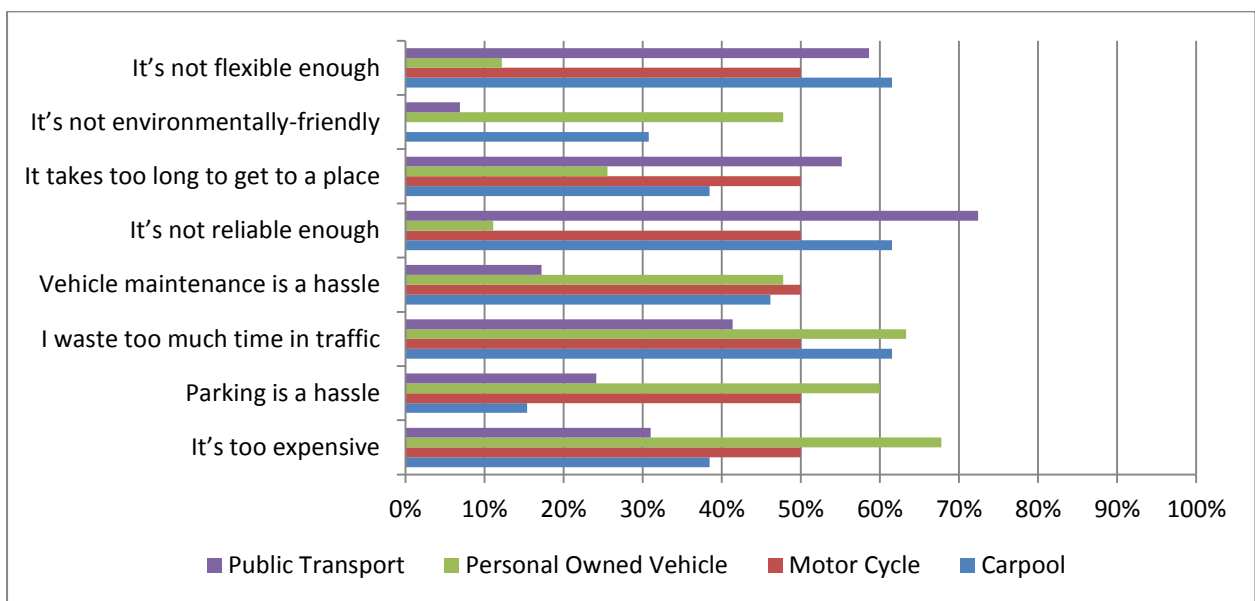


Figure 6.29: Aspects the respondents dislike the most about their current transport mode

From Figure 6.29, one can infer that the 68% of Wits commuters that use private vehicles feel it is too expensive, which supports their views expressed previously and depicted in Figure 6.25, where private vehicles do not fit their budget. As expected, those who use private vehicles, both as single occupants and carpooling, feel they spend too much time in traffic. Public transit commuters would most likely spend the same time in the same traffic; however they do not perceive this as an issue. Private vehicle users also find parking an issue, where carpoolers do not share this sentiment. About 60% of both public transit users and carpoolers feel this mode is not flexible enough and 60% to 70% of these transit users also feel it is an unreliable form of transit.

This supports the views previously expressed, that demonstrating how flexible and reliable the WITSIT Carpooling service is, will be crucial to the adoption of the system.

The analysis of Figure 6.29 reveals what private vehicle owners like least about their mode of transport: Firstly it is too expensive, secondly they waste too much time in traffic and lastly parking is an inconvenience; whereas public transport users indicate this mode is not flexible enough, it is not reliable enough and they waste too much time in traffic. What is important to note is that that commuters who currently carpool, find it not reliable and not flexible enough.

These characteristics would be the five biggest barriers for adoption of the WITSIT Carpooling service if not addressed adequately.

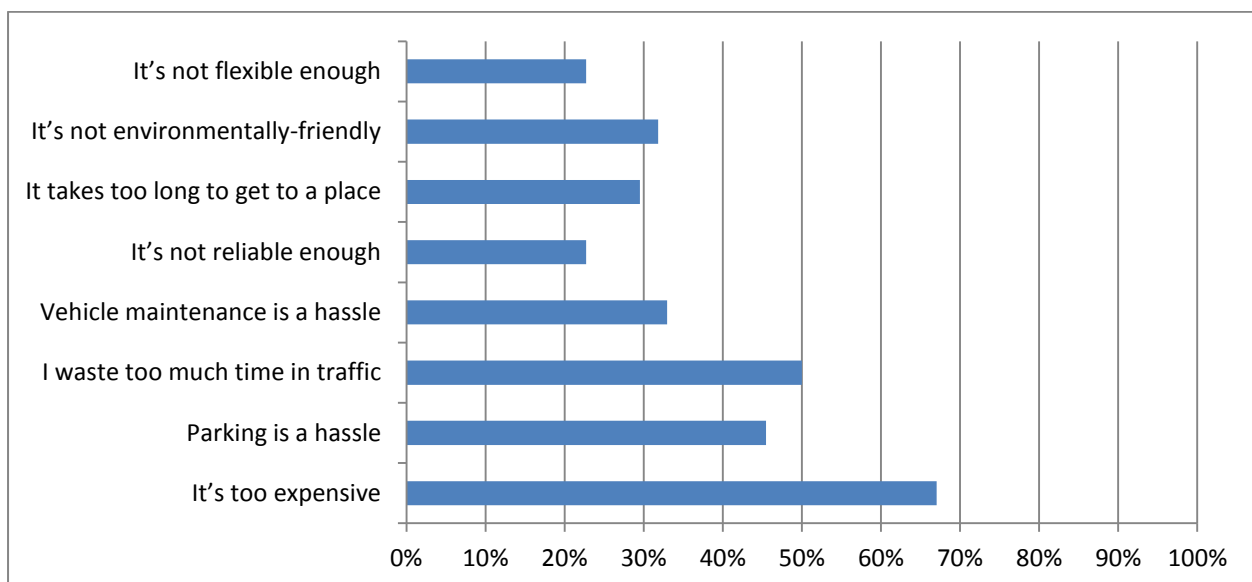


Figure 6.30: Aspects the likely carpool participants dislike the most about transport modes

When grouping the respondents' answers to what aspects they dislike the most about their current transport mode by those who also indicated they are likely to adopt carpooling, allows one to develop Figure 6.30. From the figure above it is evident that what likely carpoolers most dislike about transport modes they use is that they are too expensive, secondly that it causes them to waste too much time in traffic and lastly it results parking inconvenience. These three aspects echo the results observed in Figure 6.30, and would suggest that the WITSIT Shared Transport system needs to provide a solution that is less expensive than current transport modes, could possibly result in spending less time in traffic or at least

makes the time spent in traffic more bearable and lastly results in less parking inconvenience, for the majority of the carpool members.

Survey Sample Behavioural Influencers

The questions that were asked of the participants to test their attitude towards their current primary mode of transport, was again based on the Likert Scale, where only the definite emotions are analysed, i.e. the neutral responses are ignored.

The statements that were tested included:

1. The benefits of owning a car are higher than the costs
2. I know transit schedules and routes relatively well
3. I'd be willing to ride a bike or take transit to help to improve air quality
4. I am willing to drive an electric or other clean-fuel vehicle to improve air quality if I can afford one
5. I sometimes don't drive because finding a parking space is difficult and frustrating
6. I would like to reduce my auto use to reduce congestion and improve air quality
7. Once I'm happy with something, I don't want to change it
8. I like to experiment with new ways of doing things
9. If friends and neighbours reduced their driving, I would follow their example
10. It is time to change the way we live to help address environmental problems
11. Traffic fumes are a major contributor to global warming, smog, and other environmental problems

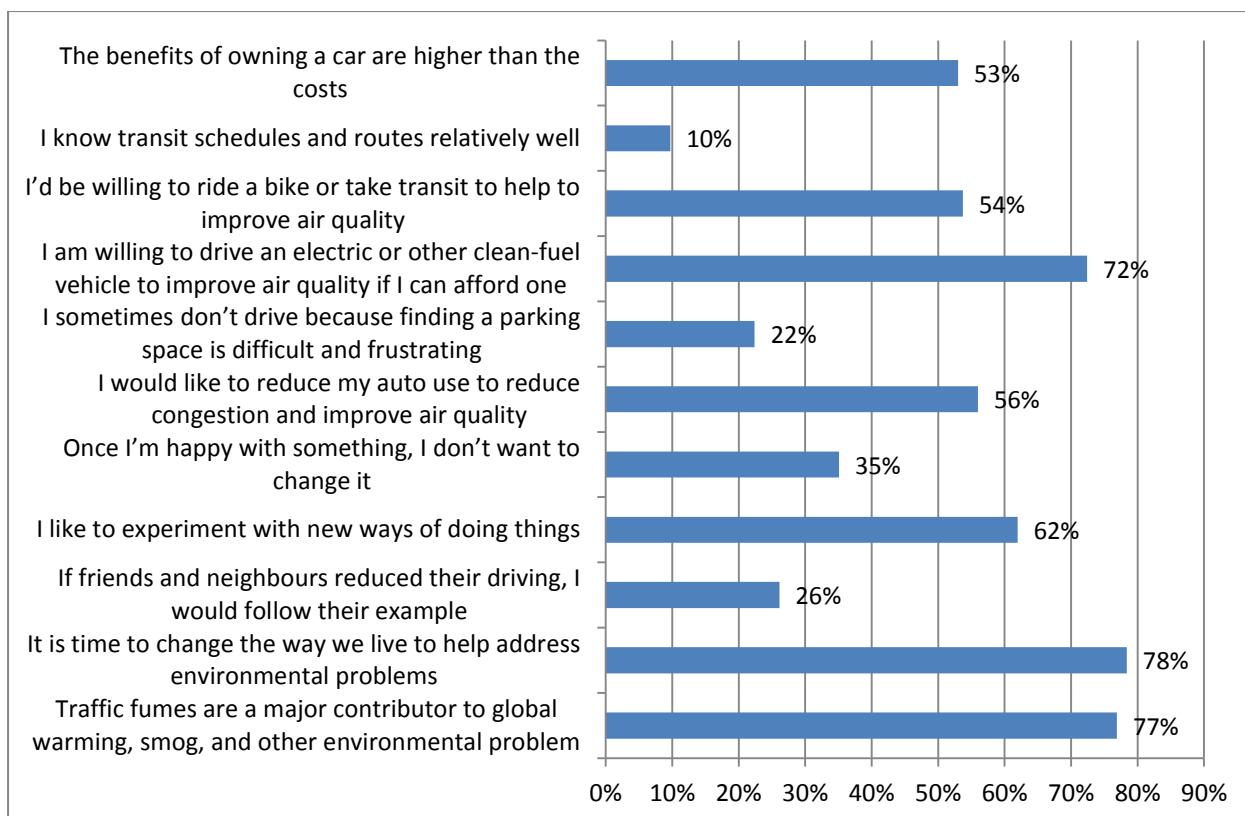


Figure 6.31: Environmental attitudes the respondents identify with most

When reviewing the responses from all the survey participants, 77% agree that traffic fumes are a major contributor to environmental problems and 78% agree that it is time to change the way they live to address environmental problems. A positive result is that 62% are also willing to experiment with new ways of commuting, which is supported by the result that only a few respondents at 35% agree that once they are happy with things they would not want to change it. 72% agreed that they would go as far as changing their vehicle to an electric or other clean-fuel vehicle and 54% would even ride a bike or take public transit to help improve air quality. This said, 53 % of respondents agreed that the benefits of a vehicle are higher than the cost, and this could pose as a barrier for adoption. To understand what type of commuters might need convincing, the same results have been analysed across different transport mode users, depicted in Figure 6.32 and Figure 6.33.

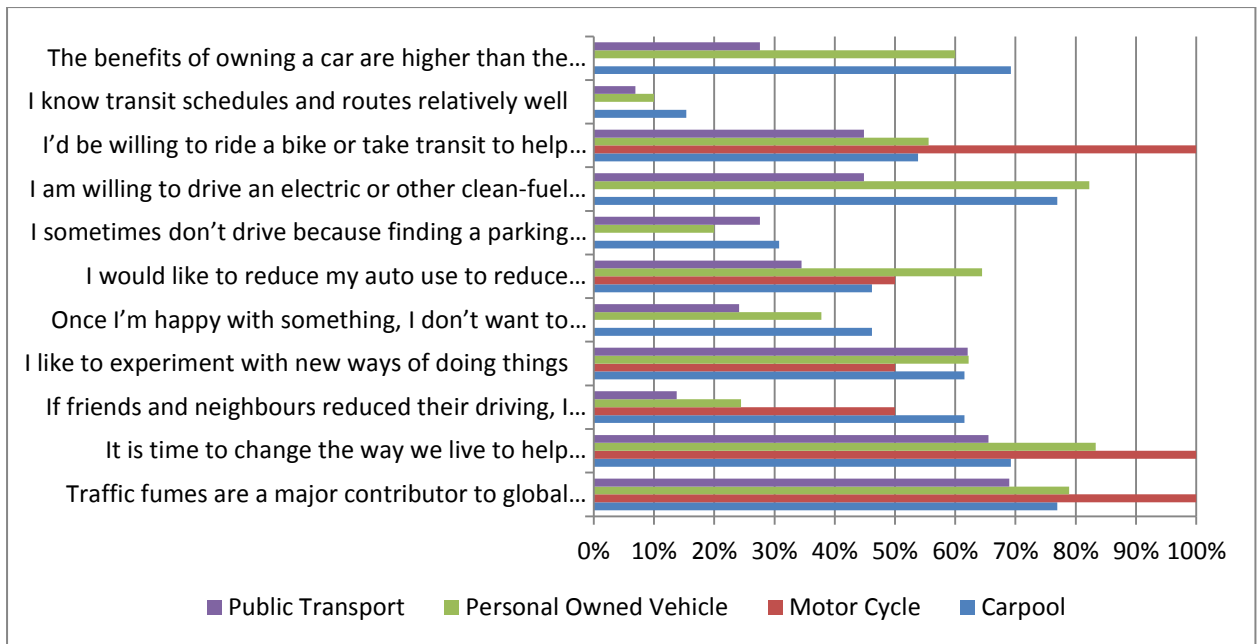


Figure 6.32: Environmental attitudes the respondents identify with most (by current transport mode)

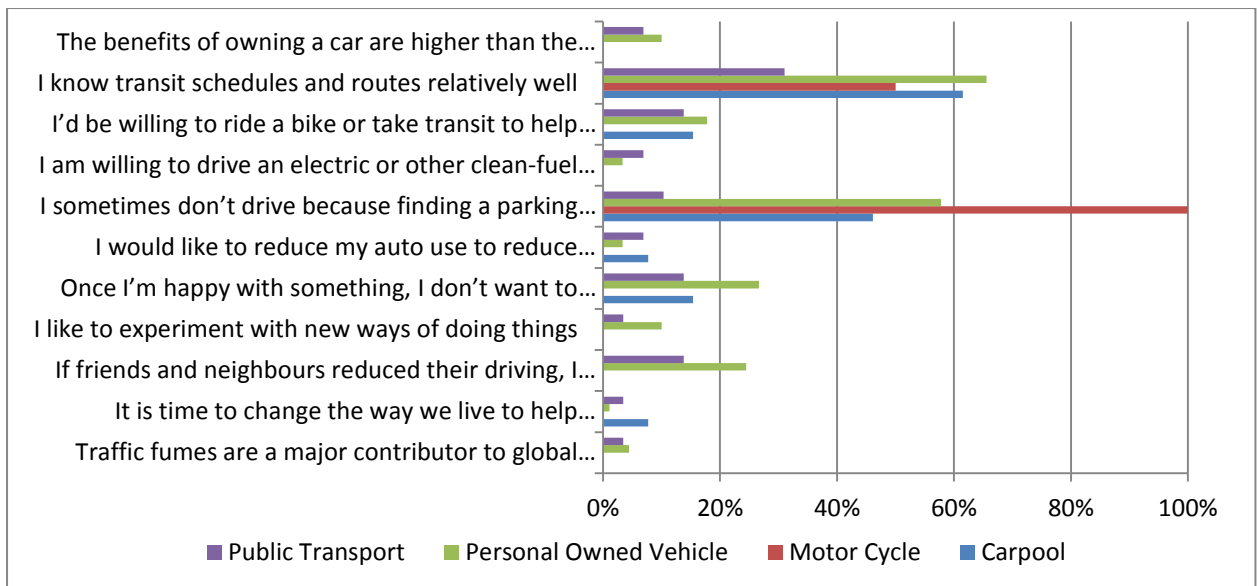


Figure 6.33: Environmental attitudes the respondents identify with least (by current transport mode)

By categorising the responses by the transport mode that respondents most use, some interesting patterns are revealed. 80% of both carpoolers and private vehicle users agree that traffic fumes are a major contributor to environmental problems, and are therefore seem to be aware of the impact of their transport modes on the environment. There are still 70% of

carpoolers that agree that the benefits of owning a vehicle are higher than the cost, compared to 60% of respondents who use private vehicles who also agree to this statement, and 66% would still drive although finding parking is difficult, as depicted in Figure 6.33. It may be that those who carpool appreciate the flexibility offered by having one's own car on campus. The flexibility of the WITSIT Carpooling service would need good marketing along with better information on other transport options to change this perception.

Approximately 80% of both the carpoolers and private vehicle owners would be willing to improve the impact of their current mode on the air quality, if they could afford it. A higher percentage of private vehicle owners, at 65%, would agree to reducing their vehicle use to reduce congestion and air quality, whereas only 50% of carpoolers agreed to this. This demonstrates that there is a possible willingness to change behaviour in the target group, the private vehicle owners, where 83% agreed it was time to change the way they live to help address environmental problems.

The carpoolers' response patterns seem to suggest they are cognisant of the fact that carpooling is a less destructive mode of transport towards the environment than driving alone, however a large percentage of carpoolers at 70% are willing to change to address environmental problems.

The possible reason why carpoolers and private vehicle owners have not adopted public transport options is that a large portion, at 50% and 66% as depicted in Figure 6.33, do not know these transit schedules and routes well.

It is not easy to find this information for metro bus routes and taxis; it would appear that the only way to locate the bus stops and where to purchase tickets is by consulting a public transit user.

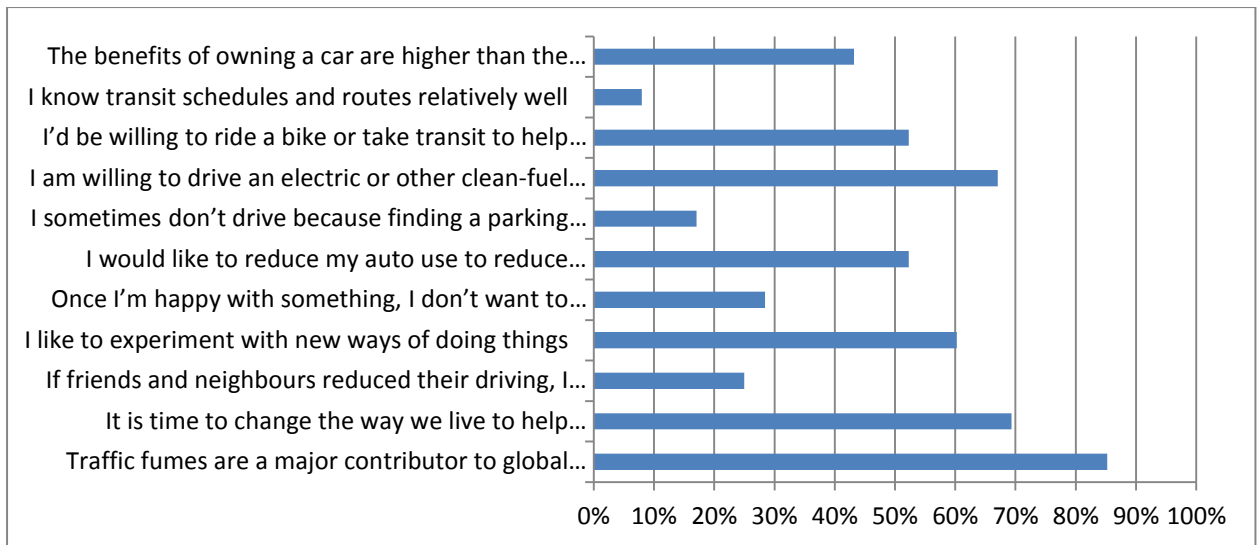


Figure 6.34: Environmental attitudes the likely carpoolers identify with most

Figure 6.34 indicates that likely carpoolers are environmentally aware, as 85% of this sub category of commuters who have indicated interest in carpooling, agree that traffic fumes are a major contributor to environmental issues, and 69% of these respondents agree “it’s time to change the way we live”, while 60% indicate that they like to experiment in new ways of doing things, which is evident in their willingness to participate in the WITSIT solution.

These are the types of commuters that the WITSIT service must target, to ensure initial uptake. Thereafter, focus can be placed on the “non-participants”, using a stronger motivator.

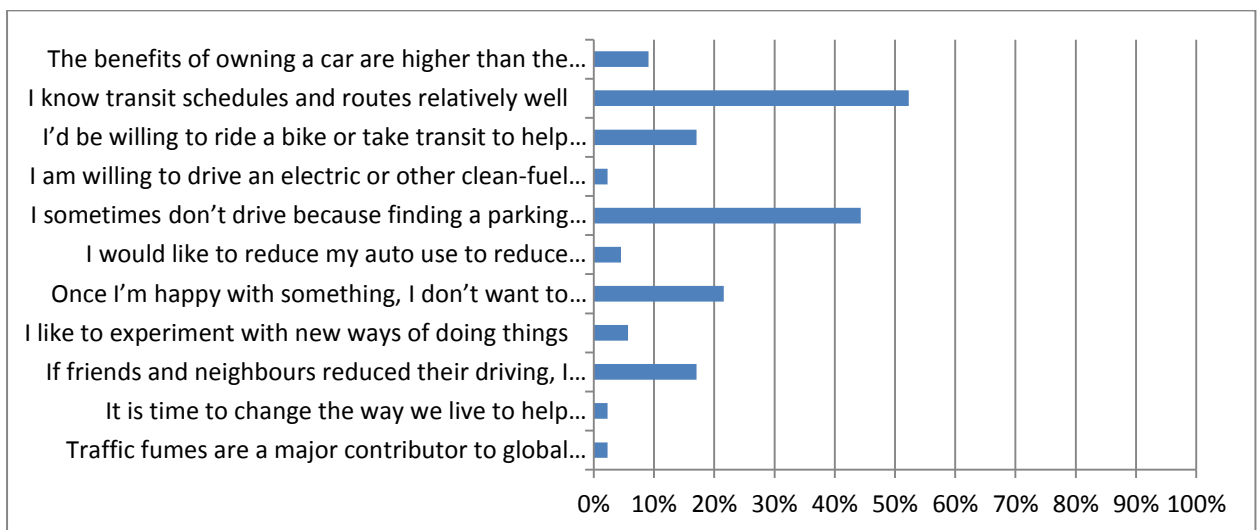


Figure 6.35: Environmental attitudes the likely carpoolers identify with least

Although 45% of likely carpoolers indicate that the aspect they dislike the most about their current mode is the parking inconvenience, most of these commuters, at 44%, still use their vehicle regardless of whether there is parking availability. This is most likely due to the fact that currently carpoolers are not given anything in return for “doing their bit” for alleviating traffic at the campus, such as preferred parking or reduced parking rates resulting in carpoolers jaundiced survey results.

A high percentage of the commuters have a problem finding parking, the UCT strategy of preferential parking would be a good incentive to adopt in the WITSIT solution. To ensure a more aggressive uptake of the WITSIT solution, the transit schedules and routes must be easily accessed.

Proposed Emergency WITSIT Service

These questions were included in order to establish attitudes to the next possible phase of car-sharing, where a fleet of vehicles kept on the university grounds is made available to the commuters. Commuters would be able to book the vehicle online 30 minutes before use and would only be required to pay per hour of use. This service introduces the commuters to true share-use transport systems as discussed in the literature review, which would ideally replace all private vehicle use, both single passenger journeys and carpooling journeys in the future.

These questions were rated on a number scale from most important to least important. The first set of questions evaluates what the respondents like about the proposed service. The most popular aspects should be used to promote the service to a wider population. The results have been captured in Figure 6.36 based on current transport modes that the respondents use, and in Figure 6.37 based on those who have indicated their likely participation in carpooling.

The participants were asked to rank the aspects listed below between one and three to represent the top three aspects they most liked about the proposed emergency WITSIT service. Evaluating the groups by rating of one, two and three resulted in too few responses to evaluate a meaningful pattern. Therefore all three responses were grouped as an aspect

the respondent liked about the WITIT emergency system, the rest of the aspects were left blank by the respondent. This way aspects listed were grouped to more easily understand what aspects the Wits commuters would value.

1. Helps me do my part to reduce congestion and air pollution
2. Includes maintenance and licensing
3. Means I do not have to buy another car
4. Saves me money
5. Let's me run errands during the day
6. Fits my schedule better than buses
7. Parking is easier and less expensive

Question 7 above combines two aspect that would have been preferable tested apart however this is an inherent issue due to using Shaheen's questionnaire. Although not correct, one needs to be aware that the cost and convenience aspects have been conflated in the analysis of this question.

The second set of questions listed below, evaluates what the respondents do not like about the proposed service ranked between one and three. Again any aspect allocated with a one, two and three was grouped as aspects the respondents did not like, as evaluating these aspects by ranking resulted in too little responses to validate a clear pattern. These grouped aspects highlight areas for improvement to ensure future adoption of the service. The results have been captured in Figure 6.38 based on current transport modes that the respondents use, and in Figure 6.39 based on those who are have indicated their likely participation in carpooling.

1. Using dirty vehicles
2. I have privacy concerns about the technology employed in the Shared Transport service
3. I won't be able to be as spontaneous as I might like
4. I won't be able to keep my personal items in the car (tools, sunglasses, etc.)
5. I'm unfamiliar with the transit systems
6. It will take me more time to go places
7. Availability of vehicle when I need one
8. The costs of being a member
9. Having a Shared Transport vehicle break down or run out of fuel

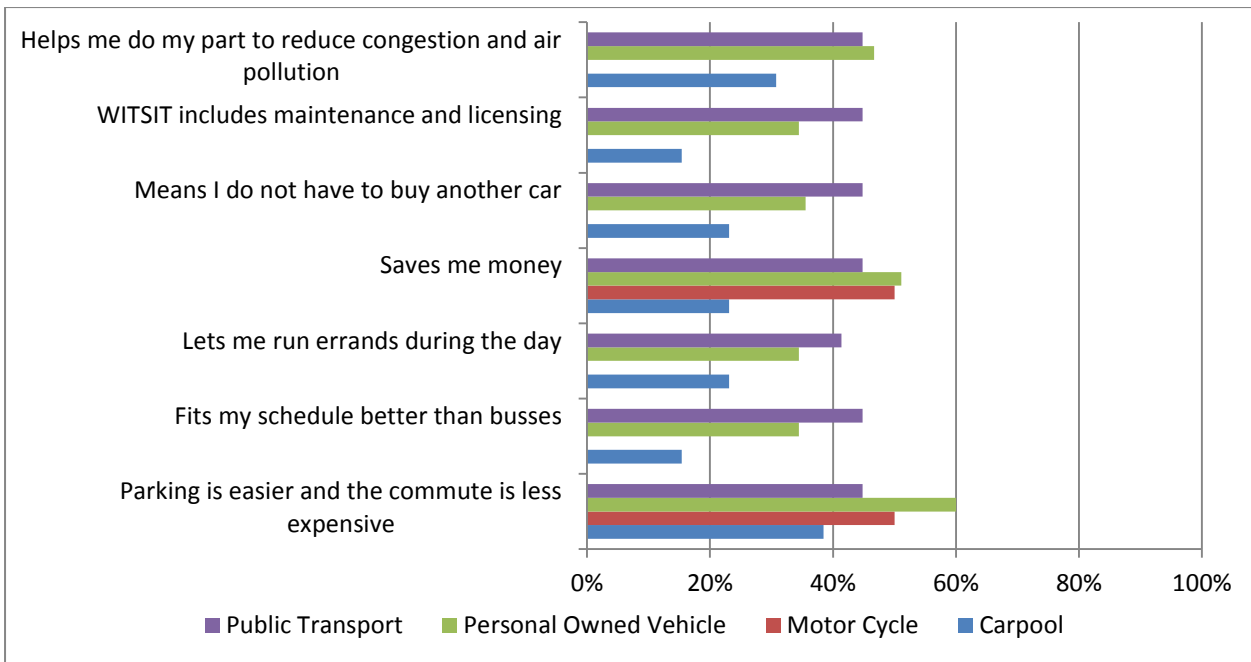


Figure 6.36: Aspects the respondents enjoy about the emergency WITSIT service (by current transport mode)

Notably in Figure 6.36, all transport mode commuters ranked the highest benefit of the emergency WITSIT service as parking being made easier and that the commute would be less expensive, which supports the next highest ranking of the service - saving the commuters money. Private vehicle commuters also highly ranked the fact that the service would help them to reduce congestion and air pollution.

These two benefits indicate that, for the more advanced WITSIT shared transport solution to be adopted further, savings over and above the carpooling saving must be demonstrated. The service users must also be recognised for the positive effect that their change in behaviour will have on the environment.

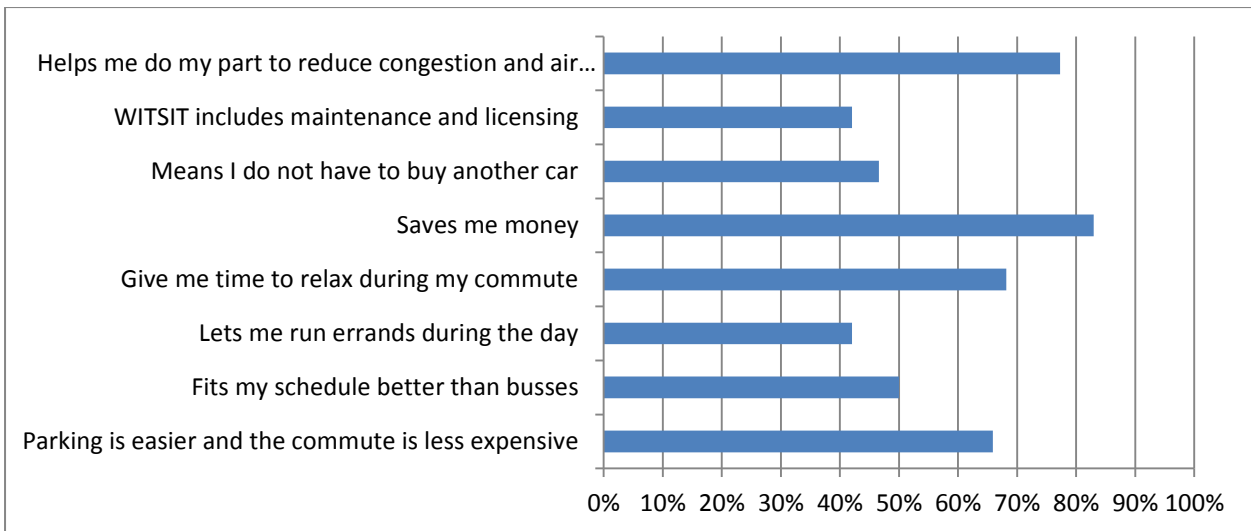


Figure 6.37: Aspects likely carpool participants enjoy about the emergency WITSIT service

Similar results were noted for the commuters most likely to carpool, however one more aspect ranked highly: almost 70% of the respondents feel that this service would give them time to relax during their commute, and if they were to share the journey with another, this would also share the responsibility of driving the vehicle.

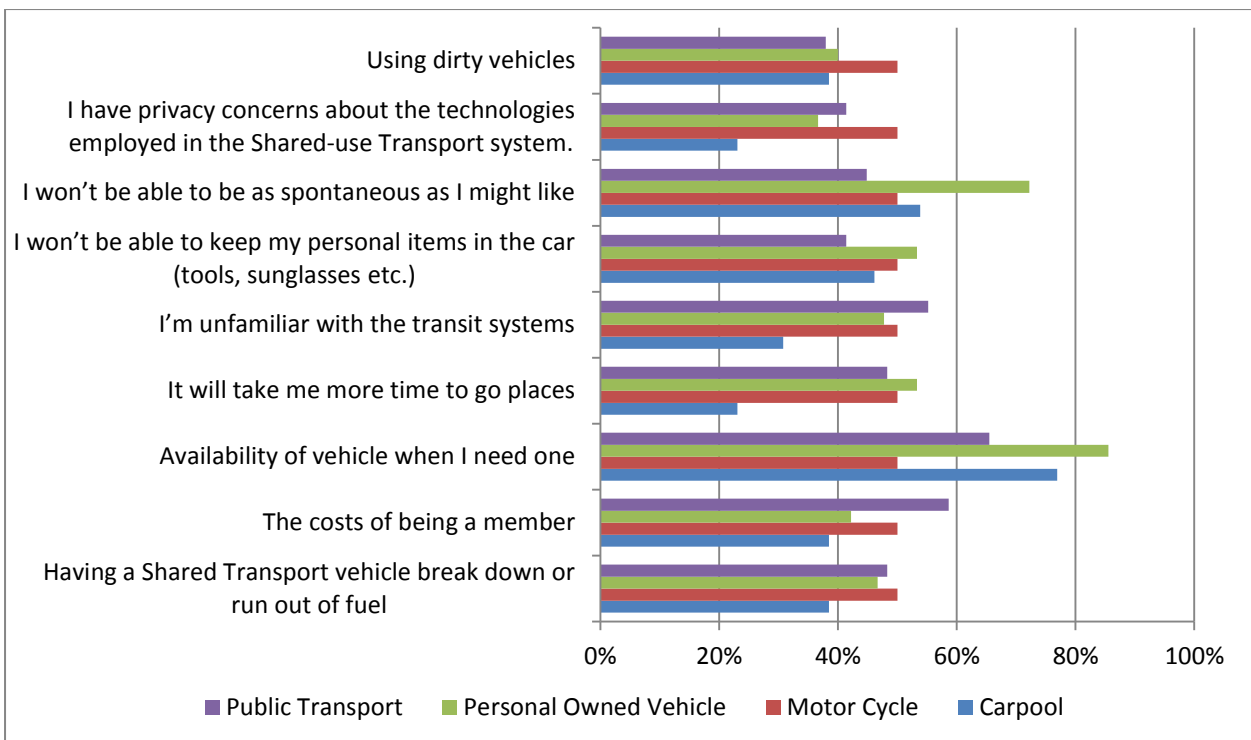


Figure 6.38: Aspect respondents dislike about the emergency WITSIT service (by current transport mode)

The analysis of the responses shown in Figure 6.39 reveals a key insight that what would deter private vehicle users the most from using the emergency WITSIT service is, the lost opportunity of being spontaneous, because the emergency WITSIT service will require some advanced planning.

The agility, flexibility and real time components of the service must be proved during the trial of the emergency service to improve buy-in from future members.

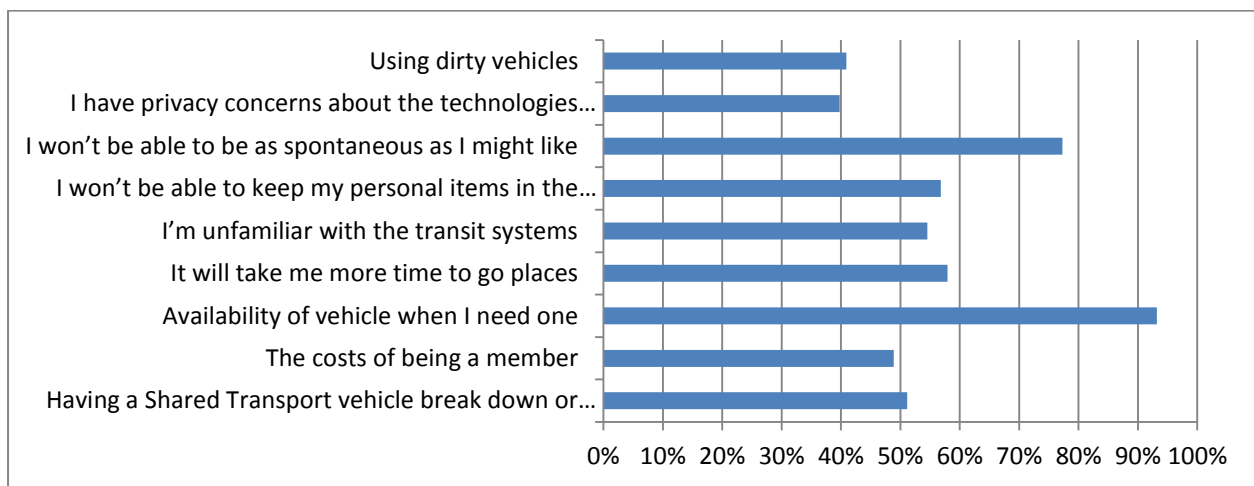


Figure 6.39: Aspects that likely carpool participants dislike about the emergency WITSIT service

Analysis of Figure 6.39 reveals very similar results as above; there is however one aspect to be aware of, namely that commuters who are likely to carpool in the future feel that a shared transport service might require more time to get to destinations.

This is a false concept that must be addressed when advertising the benefits of shared transport. The door to door time would take the same amount of time, except if all the fleet vehicles were not available and the member had to wait for a vehicle to be returned. This is a highly unlikely scenario and should be prevented at all costs. The key for the shared transport service to be adopted would be to put in place a well-planned and tested logistics system and a reliable real-time booking and tracking system.

7 CONCLUSION

There is large base of evidence that suggests that CO₂ emission will continue to rise as a result of combustion of fossil fuels for private vehicle transport. South Africa was rated the 12th most carbon intensive country by the USEIA in 2011. It has also been predicted that South Africa's GHG emissions will reach 850 MtCO₂ by 2025. IEA reported that in 2011 South Africa's emissions per capita, due to the combustion of fossil fuel, were 1.7 times larger than the global emission rate per capita which is linked to passenger vehicle transport. Private vehicle oriented transport systems are also proven to consume 3.1 times more impervious surface infrastructure than multi-modal transport systems In the USA on average traffic congestion leads to 46 hours of wasted productive time per person. The same is most probably true for South Africa; resulting in the population being unproductive and further hindering economic growth in South Africa The main driver to private vehicle oriented systems is urban sprawl, which is inherent in South Africa due to the legacy of Apartheid planning. As a result, lower income groups have been forced to settle on the periphery of Johannesburg, disproportionately affecting the poor through excluding them from work opportunities and access to reliable social services. Furthermore results from Statistics South Africa reveal that that 19.9% of the total annual household income is spent on transport, while the middle quintile population, which most closely represents the Wits commuter, spend at least 12% to 14% of their personal income on transport. The literature also reveals that air pollution due to traffic congestion has been associated with premature deaths from heart attacks, strokes, asthma attacks and other respiratory illnesses.

The adoption of *smart growth* in cities reduces reliance on private vehicles, while encouraging shared city space to support multiple activities, by reducing parking supply, increasing parking prices through mechanisms like congestion charges, improving alternative transit modes, reducing traffic speed and improving the streetscape to encourage increased pedestrian traffic. The concept of smart growth can further be supported by service oriented economies as opposed to product oriented economies resulting in sustainable business value-driven models and embodies concepts like shared space, shared knowledge and shared transport modes. This paradigm shift is evident in the body of literature that gives insights into aspects such as success factors and barriers experienced, which could facilitate a higher rate of adoption of carpooling at Wits University

Wits University is an ideal entity to implement an advanced carpooling scheme, as the population is a fairly homogeneous target group, due to clustering of localities, safe location for the pilot fleet to be accessed from, the existence of advanced IT infrastructures easily accessed via Wi-Fi and smart phones in most areas of the campus, the ability to easily create a service support team for low costs and introduction of concepts and practice of alternative transportation strategies to a cohort of young people, many of whom will be influential leaders and ambassadors of the University who can therefore spread the concept to the wider community, for advanced carpooling to take effect in wider communities. A conceptual model first needs to be introduced to possible users, while highlighting the benefits and then testing the likelihood of adoption.

This research study aimed to explore, through successful adoption of the shared transport solution WITSIT at Wits could lead to significant economic and environmental sustainability benefits could be achieved, with possibility of positive social spin-offs.

The concept of shared transport in the form of flexible and reliable, real-time carpooling system was presented to 137 survey participants, in order to establish the current carpooling trends that could be representative of the larger population. From this sample the likely outcomes could be extrapolated, in terms of carbon emission and land use reduction, if the entire Wits population were to participate in the carpooling system. Two distinct commuter groups were identified through the survey, which needed to be analysed separately as they travelled to Wits for different lengths of terms, namely staff and students, who commute for 48 weeks and 26 weeks to Wits per annum respectively. These outcomes were then compared to carbon emission reduction targets interpolated for Wits Transport sector based on the COP15 commitment targets for South Africa.

The target for Wits commuting staff is 195 T CO₂ eqt., while the student targets come to 1 509 T CO₂ eqt. for 2011, with the total target being 1 704 T CO₂ eqt. The amount of carbon dioxide equivalent emitted by typical Wits commuter vehicle types was calculated to be 196 grams per passenger-km. The typical emission for a staff journey based on the average distance travelled by a single occupant staff vehicle of 30.88km came to 1.453 CO₂ eqt, while the typical single occupant student journey emits 1.075 CO₂ eqt due to the average travel distance being 42.18km. To reach the respective mitigation targets the contribution from staff

journeys would have to reduce to 134 T CO₂ eqt. and that from student journeys would have to reduce to 1 405 T CO₂ eqt.

Due to limited data being made available from the parking office, specifically the current number of vehicles on the campus, this needed to be calculated by counting the number of bays on the university premises, assuming that each bay represents a single vehicle journey in order to calculate the worst case scenario, which could be reduced if that commuter were to carpool. There were 1 500 staff parking bays and 3 000 student parking bays. The number of single staff journeys would need to be reduced to 1 366 and 1 595 for single student vehicle journeys.

The base case represented the worst case scenario if all commuters continued to drive by themselves. Scenarios one to four represented driving with 1, 2, 3 and 4 people respectively. From the analysis it was assumed that current carpooling trends of the survey respondents reflected the most likely outcome of the rest of the Wits population following the same trends. This is represented in scenario 5. The Delhi case study reports the number of users likely to carpool with one, two or three passengers, which is a useful benchmark for this study. The Delhi carpooling survey responses indicate that 28.2% of people want to carpool with one person, 8.2% of people want to carpool with two people, and 15.4% would carpool with three people. This study showed that currently 47% staff and 67% of students carpool with one person, 23% staff and 17% students carpool with two people and 10% staff and 17% of students carpool with three people. Unfortunately due to technical difficulties the likely future carpooling trends with one, two, three and four people could not be determined because of the sample size, however only 15% of student participants indicated they would not participate in carpooling, and all staff responded that they would participate. The remaining students indicated that 59% would benefit from being a passenger in a carpool while 32% indicated they would offer up their private vehicle for carpooling.

The analysis revealed that if staff were to carpool with just one other passenger, the Wits staff target could be exceeded by 458% (750 single occupant vehicle journeys) and students could exceed their target by 7% (1 500 single occupant vehicles journeys). Travelling with two, three and four passenger resulted in even greater achievements. The most likely outcome based on the current sample carpooling trend, results in exceeding the target by

597% (936 single occupant vehicles journeys) for staff and 22% (1 708 single occupant vehicles journeys) for students.

Based on this parameter and the weeks over which staff and student travel to Wits during the year it was calculated that if all staff carpool with just one other passenger, the target of reducing carbon emissions of 195 T CO₂ eqt by 895 T CO₂ eqt in that year will be exceeded, while the 'most likely' outcome results in 1 165 T CO₂ eqt more carbon emission mitigated, than the required target. If a student carpools with one other passenger the target for mitigating carbon emissions of 1 509 T CO₂ eqt is exceeded by 103 T CO₂ eqt in a year. The effect is slightly less impressive than that of staff, as it was assumed that a student travels to Wits only 26 weeks per year, whereas staff are assumed to travel to Wits 48 weeks of the year. The added effect of both staff and student carpooling with just one passenger results in the Wits transport carbon emission mitigation target of 1 704 T CO₂ eqt could be exceeded 1.6 times while if the Wits population was to carpool with four other passengers, the target could be exceeded 2.5 times. Based on the current sample's carpooling trend, the likely outcome due to the most probable adoption rate would result in the mitigation target being exceeded by 1.9 times.

The parameter that 35m² is required for a parking bay, which includes associated internal access routes, was used in the analysis. Based on the counted parking bays, which came to 4 500, the land required for parking bays came to 157 500 m², which may be compared to the area measured on Google Earth Pro, which came to 156 811m², this was a close representation of the land currently required for the allotted parking bays. The resulting number of vehicles expected on the Wits premises due to the six carpooling scenarios was multiplied by this parameter to conduct the analysis. Staff carpooling with one to four passengers could result in reduced requirement in land for parking bays between 26 250m² and 42 000m² respectively. Students carpooling with between one and four passengers could result in reduced requirement in land for parking bays between 52 500m² and 84 000m². The total maximum reduction in land equates to 126 000m². The most likely achievable total reduction in land from staff and student carpooling based on the current sample carpooling trend is 92 546 m².

The carbon emission savings and reduction in land use for parking bays that can be achieved by carpooling with only one passenger indicate that, if the shared transport model

was adopted by the entire Wits commuting population, significant environmental improvements can be achieved for both the Wits commuter and the University.

Through historic land evaluation reports accessed from the deeds office, the property value for the suburbs around Wits University came to approximately R2 809 per m² at 2011 market values. Possible savings from the efforts of staff carpooling with just one passenger could free up land worth R73.74 million, and for students carpooling with one passenger could result in land worth R147.47 million. This land could be used for other facilities like new lecture halls, sport facilities or for trees to provide recreational areas. Land to the total value of R221.21 million could be made available for other uses. The most likely rand value in land savings based on the current sample carpooling trends is a total probably saving to the amount of R259.90 million that could be achieved if the entire Wits population followed the sample carpooling trend.

There are benefits the commuter as well. If they were take up carpooling it is unlikely that those staff and students who carpool will sell their vehicles; the fixed cost will therefore not be recovered through carpooling and will only be saved in a year if the vehicle is sold and not replaced. However the savings would be in the running costs per trip saved. A staff member who is the driver in a carpool could earn fares between R1 600 and R2 600 per month depending on the number of passengers, while student drivers would earn between R1 700 and R2 700 per month. If staff were to carpool with one, two, three or four passengers as a carpool group, they could save between ~R3 300 and ~R12 900 per month. If students were to carpool with one, two, three or four passengers as a carpool group, they could save between ~R3 300 to ~R13 300 a month. Although they might travel in slightly cheaper vehicles than staff, the average distance a student drives is further, therefore saving only slightly more than staff carpooling.

It is evident that carpooling provides economic advantage for both the University in the form of reduced funds required to build and maintain parking lots as well as reduced travel costs for those Wits commuters who carpool. With support from the University, even greater savings could result if carpoolers were further incentivised. The carpoolers would then also be paying less for parking fees with the security of knowing allocated parking would be available to them.

A large proportion of the staff (at 78%) do not carpool, while 72% of students do not currently carpool. This indicates that it may be difficult to entice the Wits commuters to adopt carpooling, The survey captured the respondents' likes and dislikes of their current transport modes. The responses were then cross analysed to the proposed carpooling system based on their current main transport modes to evaluate the likely adoption of carpooling, identify barriers and determine motivating factors.

The critical factors for Wits commuters was that the carpool would need to allow for carpoolers to change their carpool group at short notice if schedule changes occurred, and to provide the commuter with a sense of freedom through a certain level of control in planning their travelling schedule and mode. The carpooling would also need to be reliable to achieve high adoption rates. The savings that could be achieved would also clearly provide motivation for adopting carpooling, based on the responses analysed. This finding was similar to the insights provided by the other works reviewed in the literature survey, which also suggested that those that participate should not only receive monetary incentives but should also be recognised for the positive effect that their change in behaviour will have on the environment to further entice their peers to join.

Those that do carpool feel their transport mode does not reflect their social status. It was initially assumed that this could pose a barrier to carpool adoption, however this may not be the case. The results for carpoolers suggested that the survey participants are already cognisant of the fact that carpooling is a less destructive mode of transport towards the environment than driving alone, and already carpool as they are willing to change their behaviour to address environmental problems. A large portion of the carpoolers also indicated that, if they were not driving, carpooling provides time to relax during their commute. However it is not clear that those who do not carpool feel the same way and one cannot assume that appealing to their environmental consciences would result in the same outcome. It is these "non-participating" commuters whom the WITSIT service must target to ensure initial uptake of carpooling.

An issue that was identified that paralleled with the experience of a carpooling initiative at UCT was that a high percentage of the commuters have a problem finding parking. The UCT strategy of preferential parking would be a good incentive to adopt in the WITSIT solution. To ensure a more aggressive uptake of the WITSIT service, the transit schedules and routes

must be made easier to access than what is currently provided by Wits on the MyWits transport portal.

To address some of the concerns of the participants regarding flexibility, agility and reliability the emergency WITSIT service would be the next phase of a true shared transport system. The fleet availability for hourly use would provide the next level of flexibility if a commuter missed a carpool. The success of this emergency service would hinge on a well-planned and tested logistics system and a reliable real-time booking and tracking system to ensure that a vehicle would always be available to members. This is a viable solution for the next phase of shared transport: for example the rate of adoption in the US has been significant where over a four year period between 2000 and 2004, fleet-sharing membership increased by 820%

Sustainable business value-driven models are centred on a service economy where the business places focus on a multiplicity of stakeholders and moves beyond self-interest. Shared value is created by increasing the quality of life of those impacted by its activities, which in turn secures self-interested achievements. In this regard Wits has the opportunity to put in place a carpooling model which serves both its self-interest as well as enhancing the students' experience at Wits, enhancing the Wits brand as being cutting edge in addressing carbon emission proactively, while reducing the need for costly parking infrastructure. Carpooling has been proven to be a realistic solution to traffic congestion alleviation as well as a more affordable transport system, as established in the literature review.

Because Wits students represent the future business leaders in South Africa, if the students were exposed to varying level of shared transport modes, it is more likely that they will motivate for shared transport to be made available in the work space. Economies of scale will then take effect and significant benefits could be realized for all Johannesburg commuters. This change in behaviour would hopefully result in other social spin-offs that would demand the development of multi-modal transport systems.

8 RECOMMENDATIONS

In order to increase the number of participants, it would be recommended that Shaheen's survey be used only to influence aspects of the survey. The survey was too long and detailed and was the main reason for a low response rate. The questionnaire to be used in future research of this topic must be more focussed on specific aspects of shared transport in order to identify stronger patterns. These patterns could then also be evaluated across specific age groups and income groups to identify patterns of behaviour at a more granular level.

A consideration for future study would involve analysing of how to influence and measure the likely adoption of modal shifts by Johannesburg working commuters as planned by the Department of Transport reported in the Public Transport Action Plan. The first phase of this plan aimed "to achieve a mode shift of 20% of work journeys via cars to public transport networks" by 2020 (SAPTAP, 2007:14). SAPTAP documented that in 2003, 1.85m workers commuted to metropolitan cities in South Africa using a vehicle. It was assumed that this value would double to 3.7m in 2020: 20% of the estimate in 2020 equates to 750 000 workers in six of the metropolitan cities in South Africa.

Due to limitations stated upfront in this study in section 3, it is recommended for future researchers to refine the carbon emission reduction targets for the population being considered (Wits Staff and Students or even city work commuters), taking into account the skewed carbon load contribution, in order to provide more realistic targets.

Furthermore future researchers could consider investigating long-term health impacts of particular matter in more detail. This could include the negative impacts on quality of life even when it does not lead to directly loss of life. Economic implication of increase illness leading to absenteeism from school and work frequently could result in economic unproductivity. A separate area of interest would be to analyse additional reduction in carbon emission if carpooling were adopted by the majority of the city's work commuters as a result of the reduced vehicles travelling to the city and increasing the rate at which traffic is able to flow. Barth et al. (2008) conclude that direct reduction in carbon emissions is compounded due to easing of traffic and probable increased travelling speed.

For shared transport to be considered as an economically-viable option, service economy concepts would have to be adapted to the proposed Wits shared transport service. This is important for preventing high start-up capital costs that are associated with fleet procurement. The use of established fleet organisations such as rental companies must be explored and paired with available and affordable real-time information management technology, which could be applied to the existing Wits technology infrastructure to utilise the Wits commuters' vehicles as a virtually-managed fleet.

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APPENDIX A: SOUTH AFRICAN CARPOOLING WEBHOST EXAMPLES

RideLink (UCT, 2012)

The following text was copied from the Vula website (Vula, 2012) for ease of reference, as it is publically available data.

“What is Vula?

Vula is the University of Cape Town’s web-based content management system. It is home to many course sites, as well as a host of other sites including those used for administration, research and project groups, libraries and student societies. As a guest user, you have been invited to join a Vula site. On the site you will have rights to read content but you also may be able to create and/or edit content (depending on your assigned role).

What if I already have a Vula account?

If you have used Vula in the past then you already have a Vula account, in which case we strongly suggest that you accept the above invitation and then indicate which existing Vula account you wish to use to access the Ridelink site. This will avoid you having multiple accounts, each with a different set of associated sites. If you do not choose to associate this site (Ridelink) with an existing account, then a new account (a guest account) will be created for you using this email address, and in the future to access the Ridelink site you will need to login to Vula using this new guest account username and its associated password.”

I requested a guest account from Pallet (2011), the RideLink UCT Student Environmental Officer. I was provided with temporary access in order to investigate how the online system worked and was able to interview Pallet (2011) afterwards to gain further insight into the workings of the RideLink web portal. Approval was given to share the insights I gained from using the tempory login access in order to influence the WITSIT conceptual model, as shown in Figure A.1.

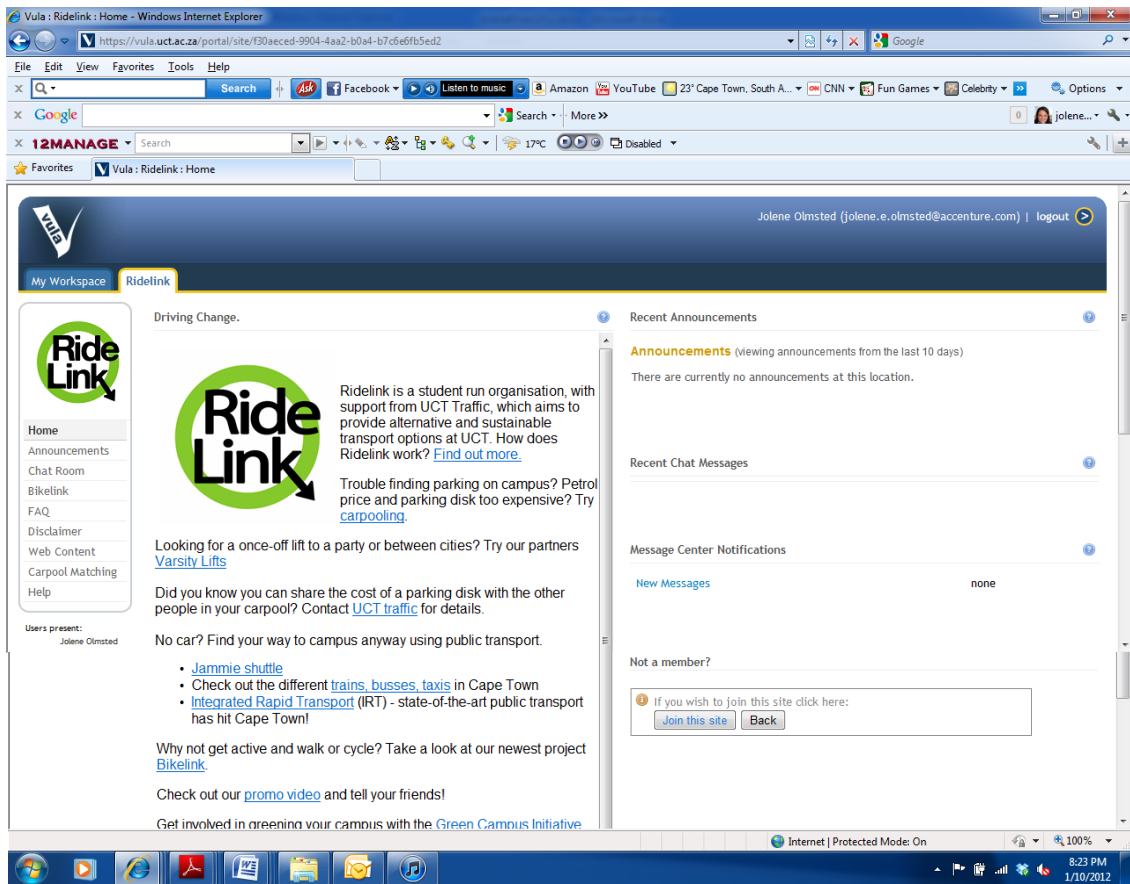


Figure A.1: RideLink User Profile Login (Vula, 2012)

Once I provide my personal details and created a travel schedule, Ridelink helped match me up with potential carpoolers. I was able to view their profiles to see whether they were suitable to share lifts. I was able to requests to join specific carpool I felt comfortable with. When requesting to join a carpooler I was prompted to add a short note to introduce myself. I was notified when I sent the request to carpool with somebody; they would receive an automatic email notification to confirm my request. Once they confirmed this request I received a confirmation email and was encouraged to phone the person to introduce myself and discuss any details that were unclear. One is encouraged to set up multiple carpools to match different schedules I might have on different days or times on that day, however being cognisant of not double booking for the same day, or for different times of that day. If I wanted to leave a carpool I would need to delete myself from that profile and set up a new carpool for that trip. The forum also provides suggestions as to where people should meet, how to split petrol costs, how to deal with carpool member that do not want to share costs or delay car trip frequently due to running late diplomatically, as well as suggested etiquette rules for informing carpool member if one is sick, smoking restrictions and music being

played in the vehicle. These steps have been capture in the screenshot referenced in Figure A.2, A.3, and A.4 below.

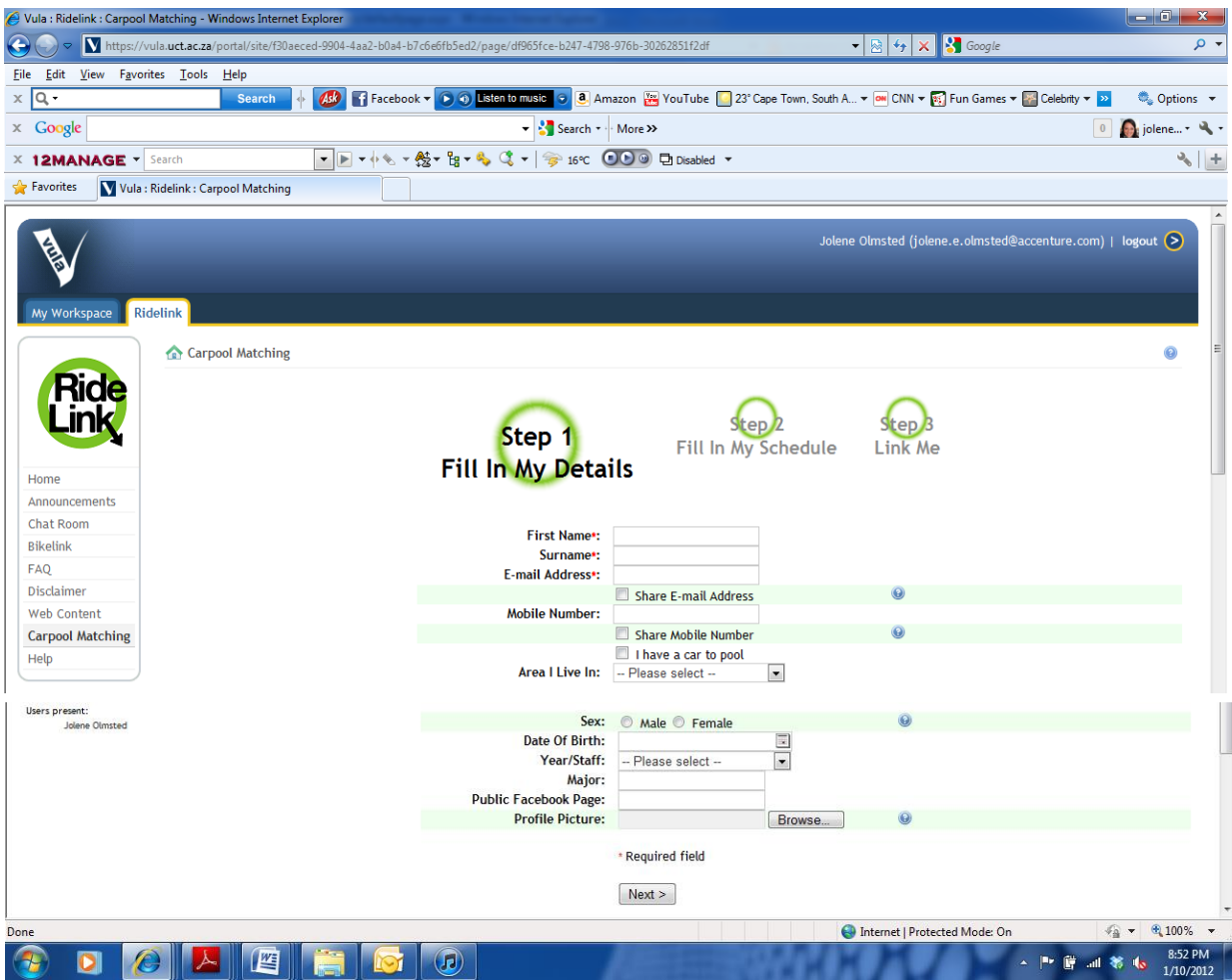


Figure A.2: RideLink Step 1- Fill in my Details (Vula, 2012)

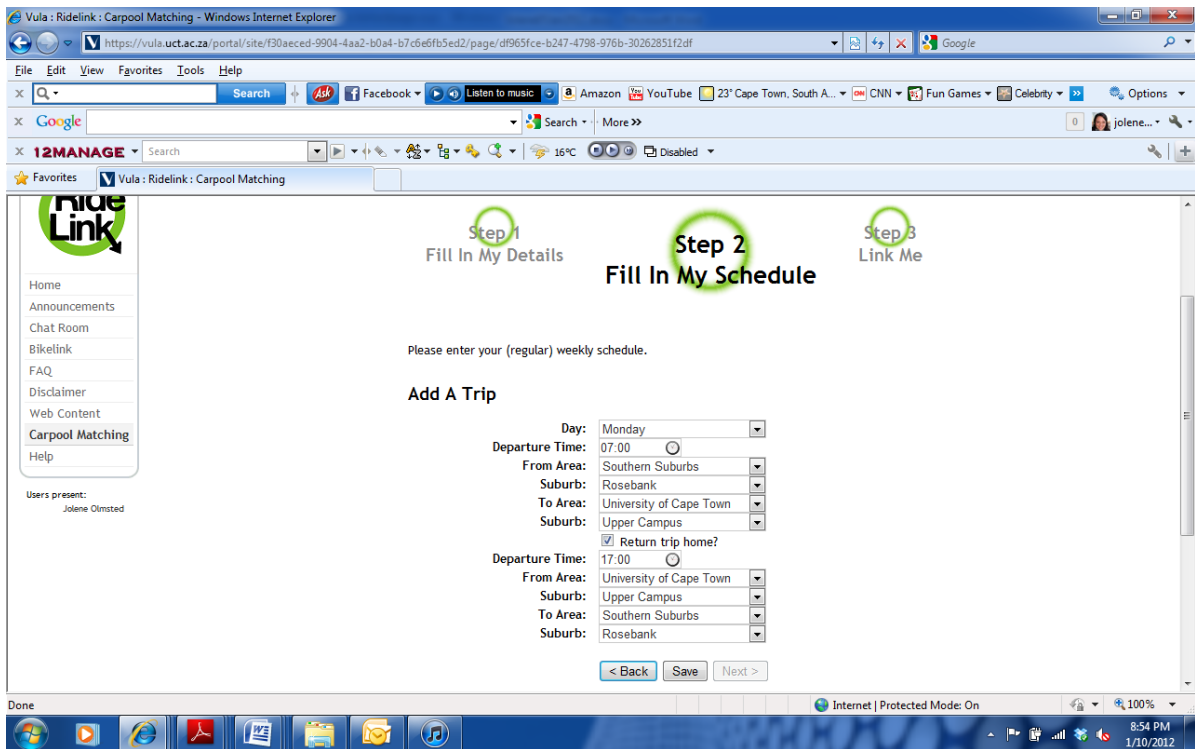


Figure A.3: RideLink Step 1- Fill in my Schedule (Vula, 2012)

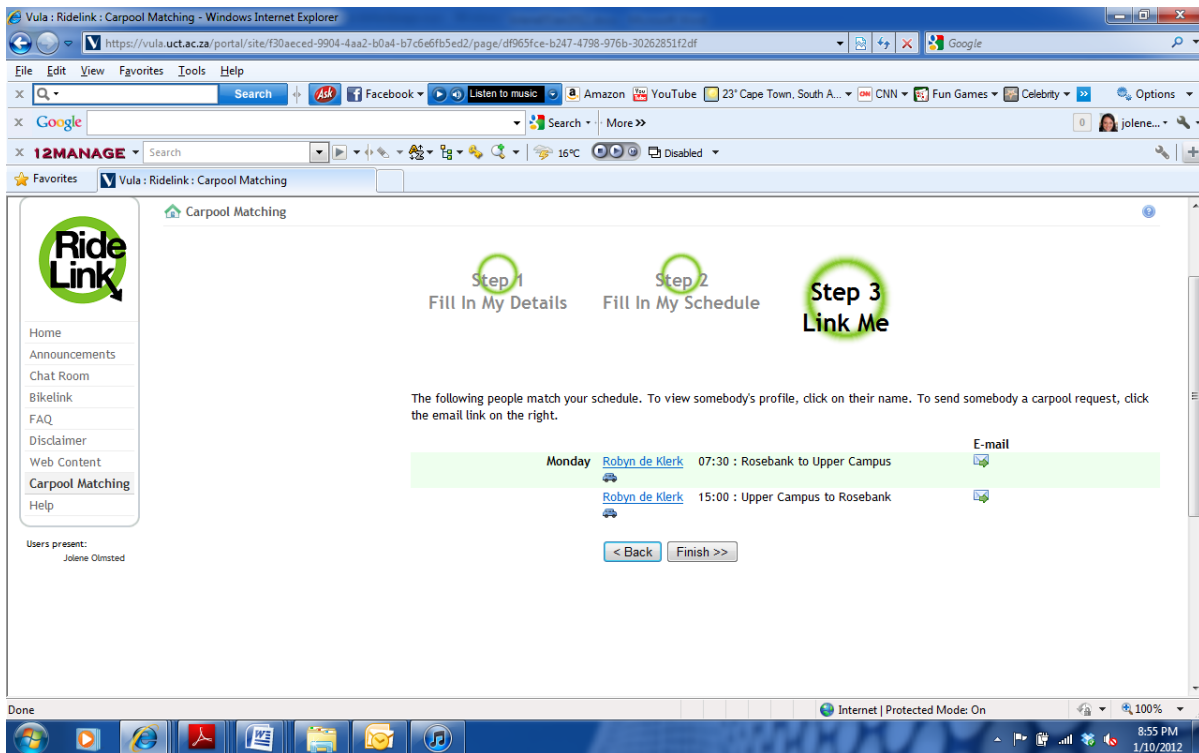


Figure A.4: RideLink Step 1- Link Me (Vula, 2012)

Due to confidentiality agreements I am unable to share the RideLink documents I was provided access with. This provided greater understanding of the existing University carpooling programme implemented by UCT, which influenced my proposed conceptual model for Wits.

Greenwheels (Rhodes, 2012)

Greenwheels is a carpooling system established in Rhodes university similar to RideLink of UCT. Greenwheels was established to firstly create awareness of the issues surrounding global warming, climate change and greenhouse gas emissions and encourage a shift in mindset of their students, who are accountable and should take responsibility.

Secondly, Greenwheels developed the website to post possible solutions the problem, by providing a more formal forum for people to meet and travel together, thereby reducing the cost of petrol and potentially half Rhode's collective carbon dioxide emissions while travelling over the vacation periods.

Because shared rides are encourages for students travelling back home over the vacation periods, joining a carpool is open to the public. I tested the system by creating my own profile. Figure A.5 to figure A.14 demonstrate how one creates your own profile, finds and selects appropriate carpools to join, carpooling tips as well as sharing and generating other useful ideas regarding possible solutions for environmental problems

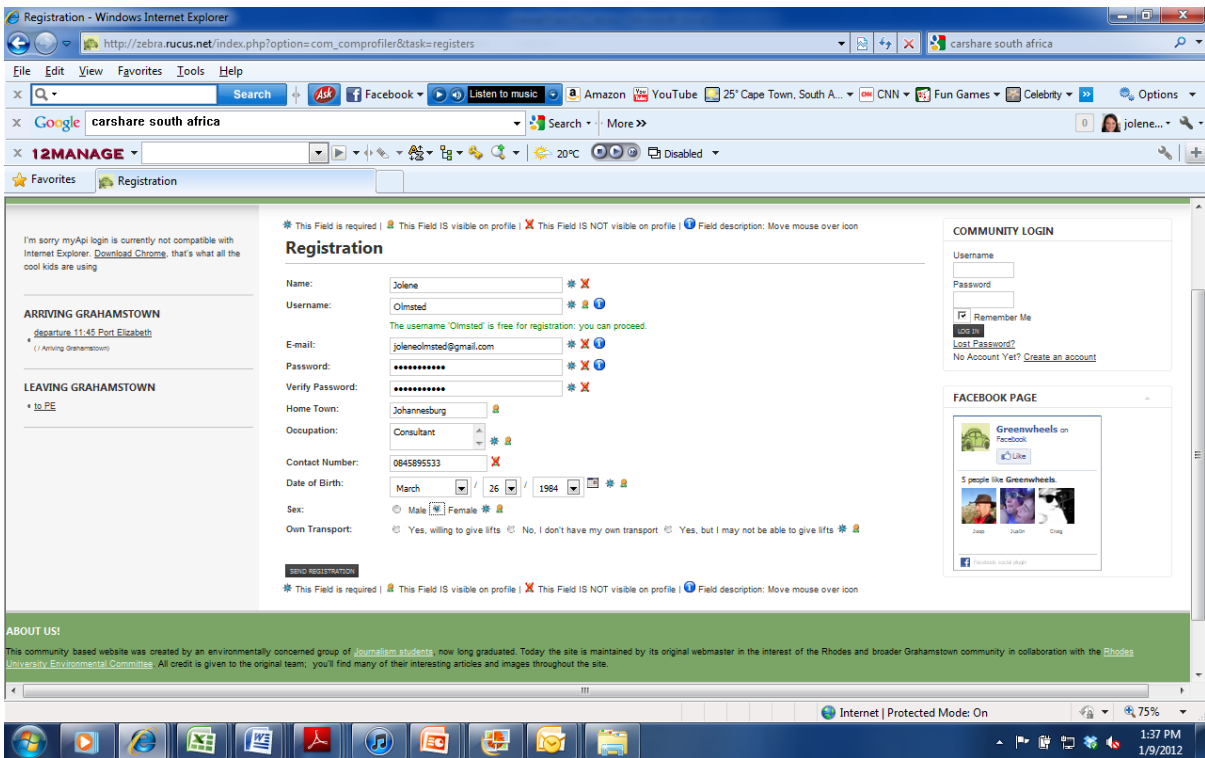


Figure A.5: Greenwheels Registration (Greenwheels, 2012)

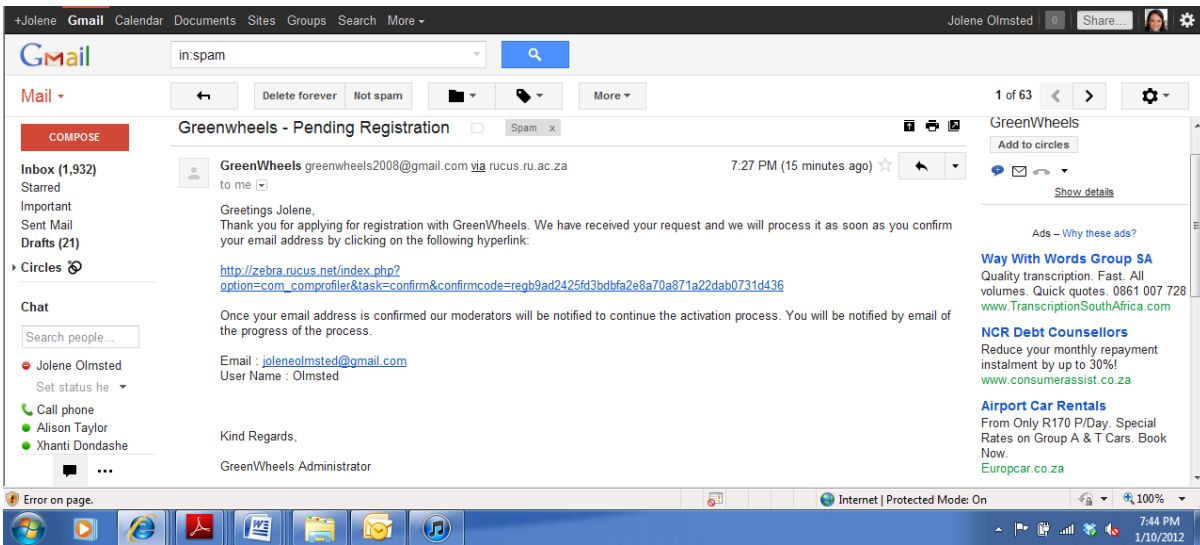


Figure A.6: Greenwheels Confirmation Email (Greenwheels, 2012)

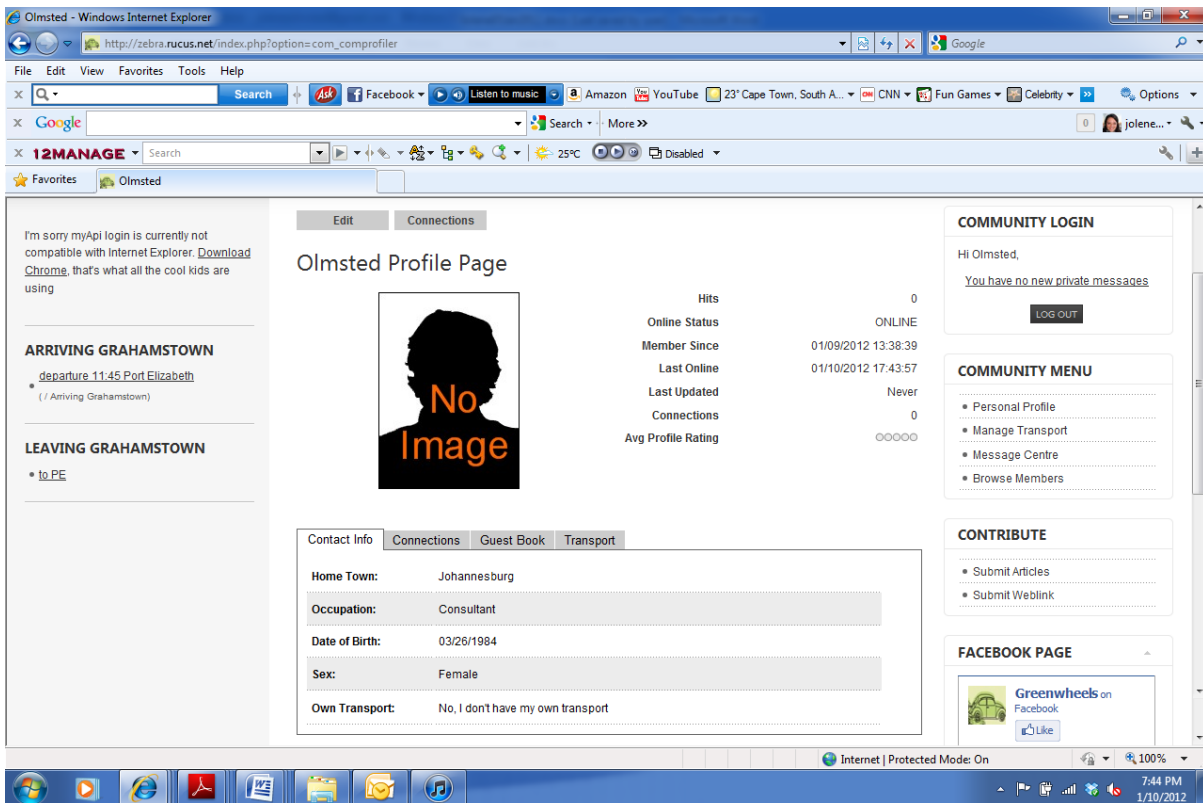


Figure A.7: Greenwheels Member Profile (Greenwheels, 2012)

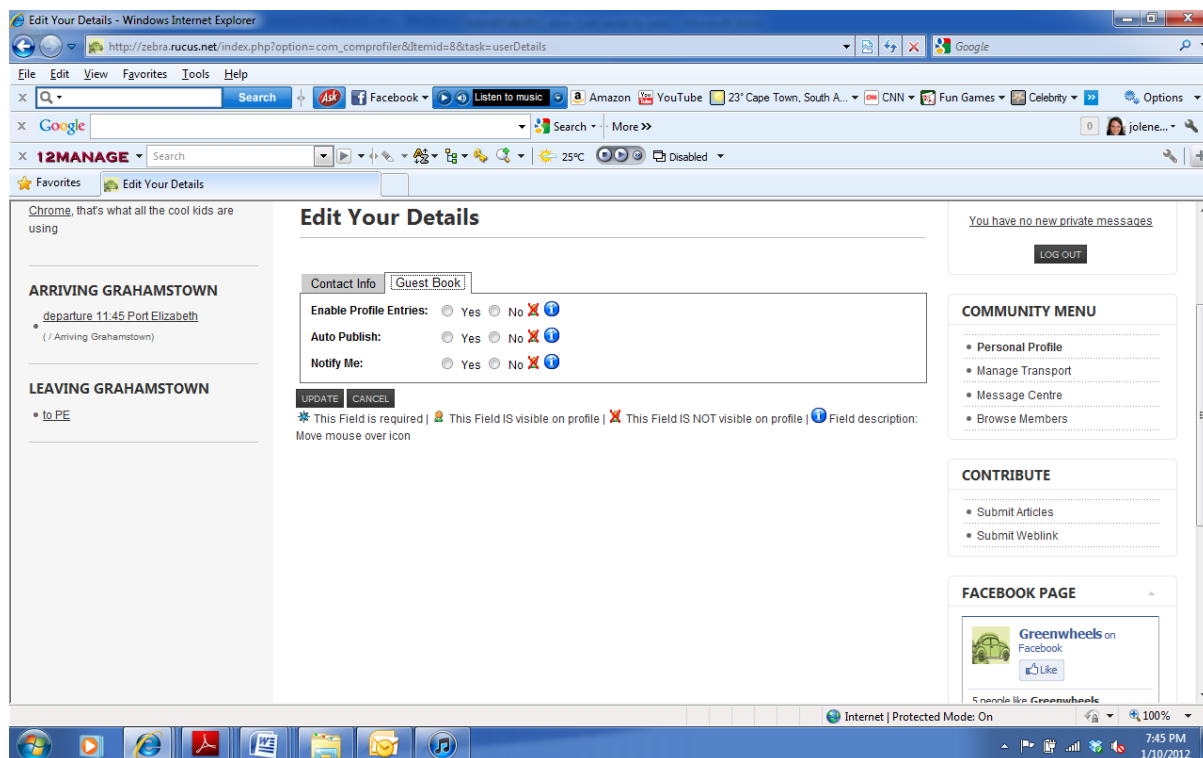


Figure A.8: Greenwheels Manage Notifications (Greenwheels, 2012)

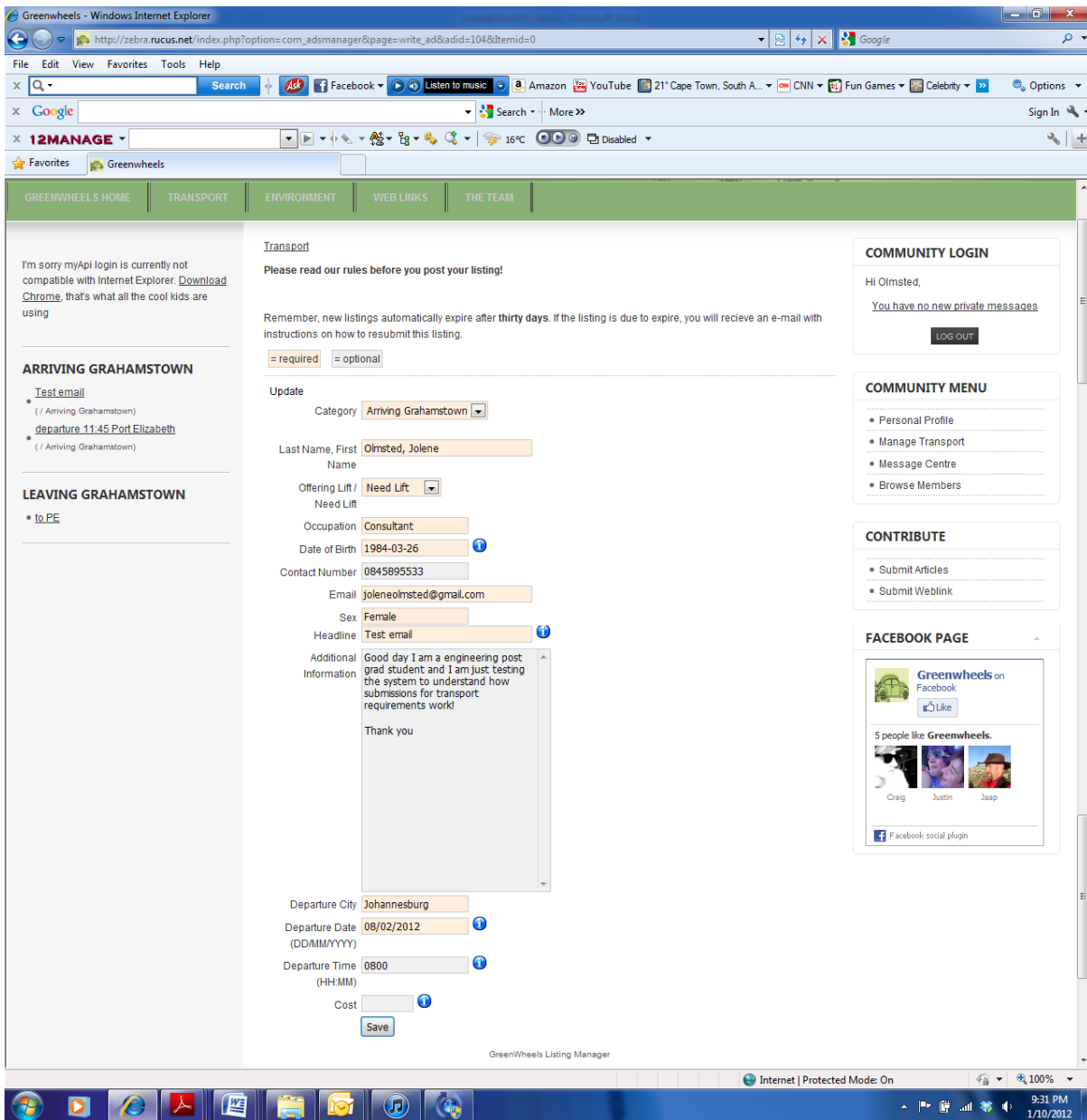


Figure A.9: Greenwheels Generate Transport Listings (Greenwheels, 2012)

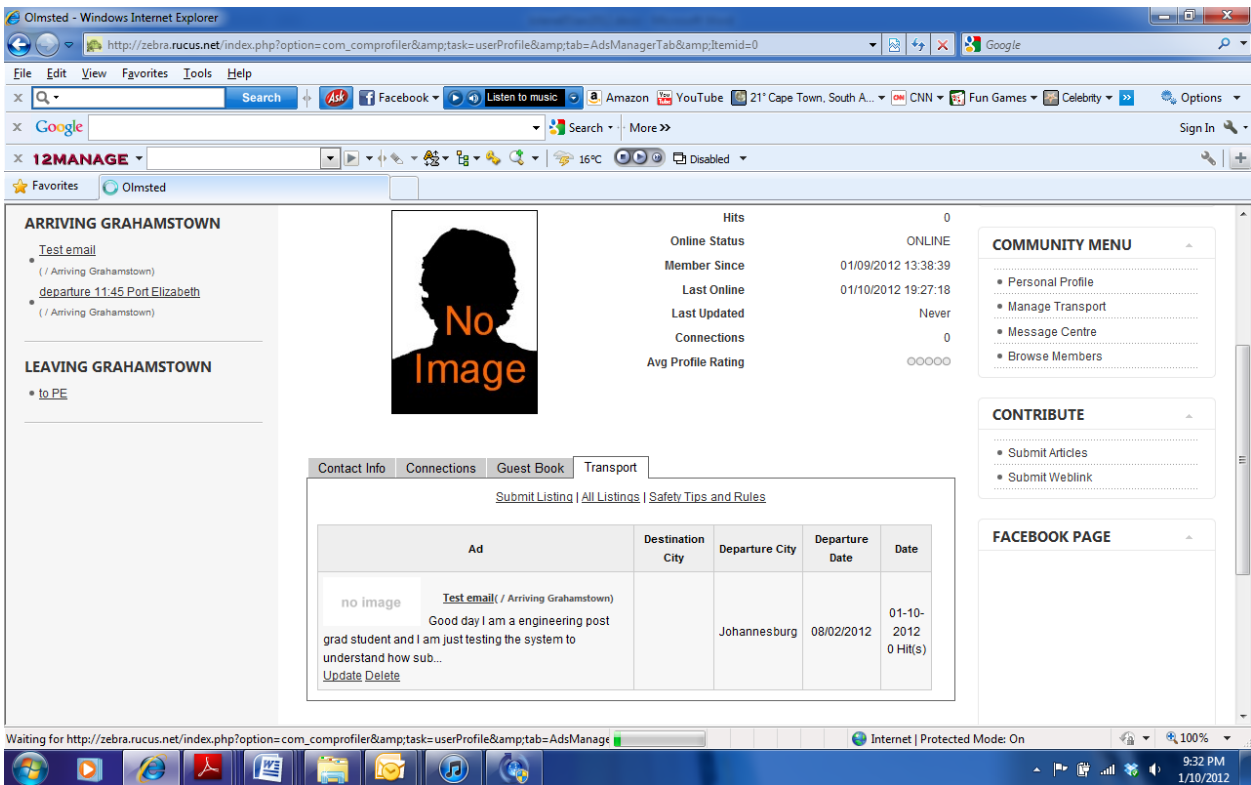


Figure A.10: Greenwheels Transport Listings Report (Greenwheels, 2012)

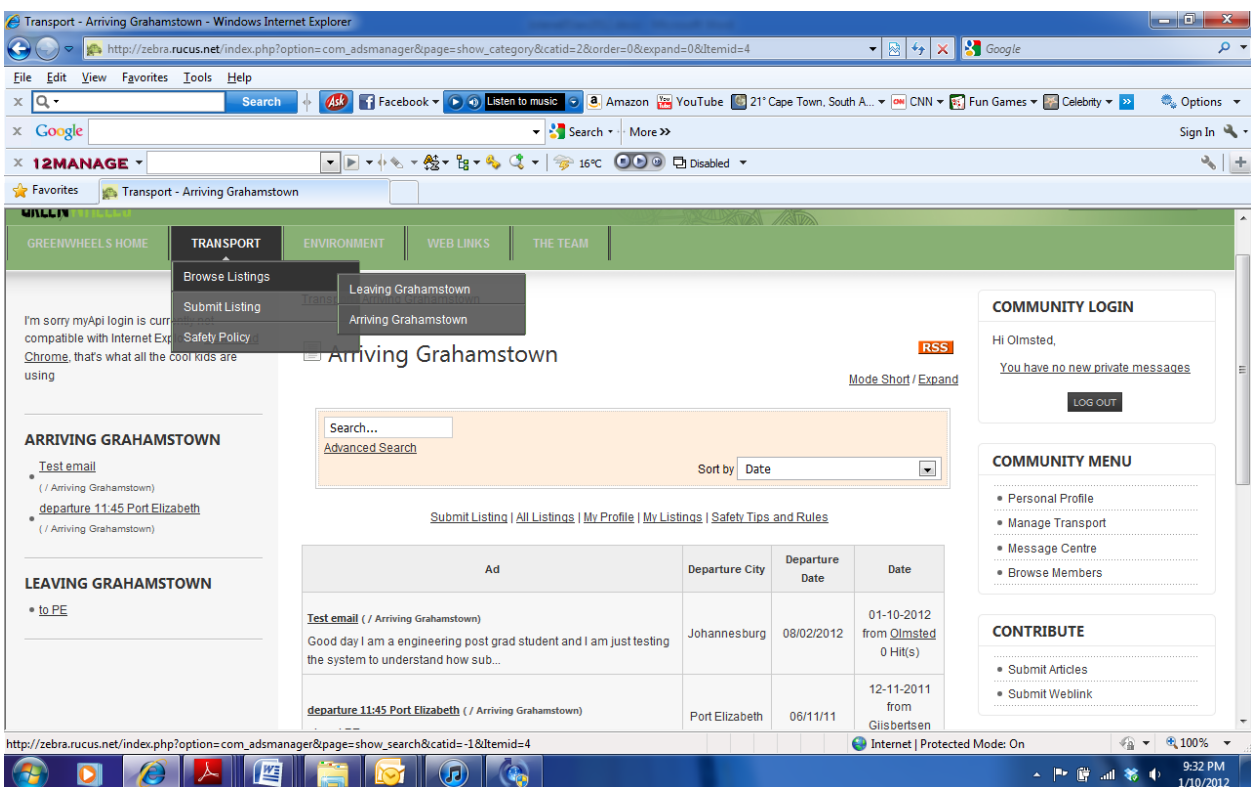


Figure A.11: Greenwheels Browse Transport Listings (Greenwheels, 2012)

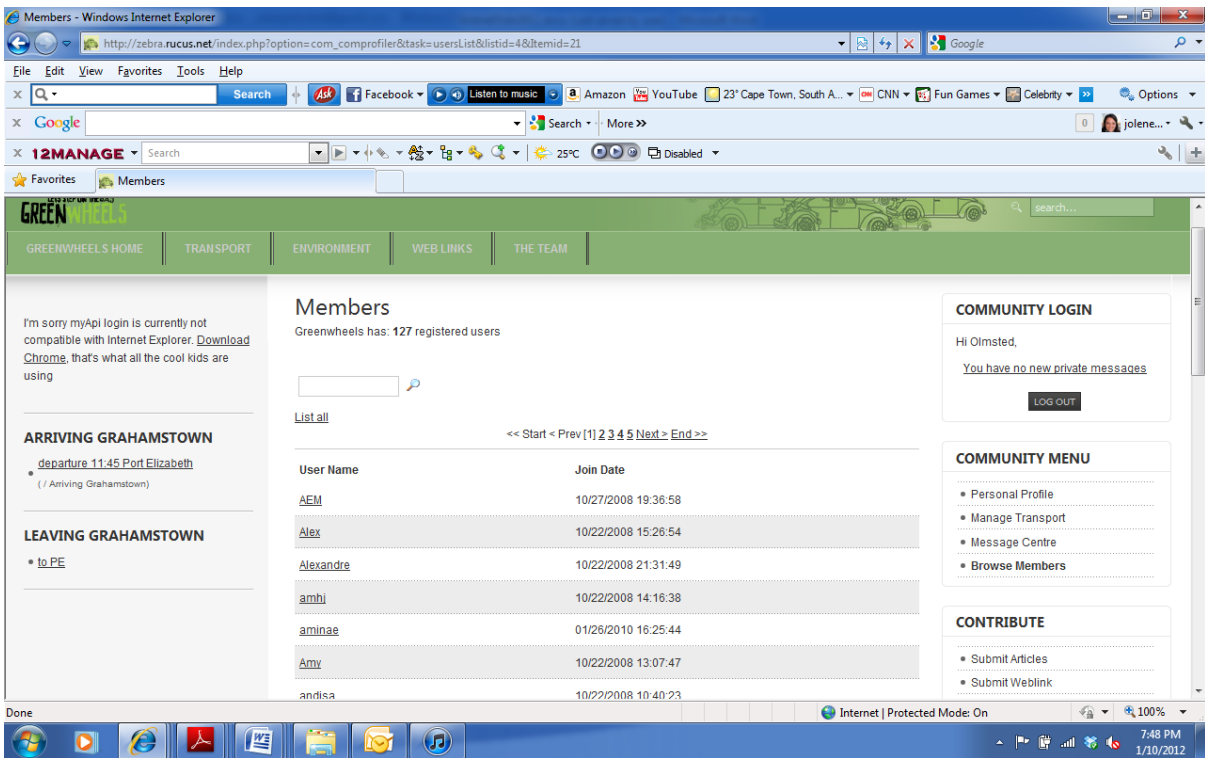


Figure A.12: Greenwheels Select Transport Listings (Greenwheels, 2012)

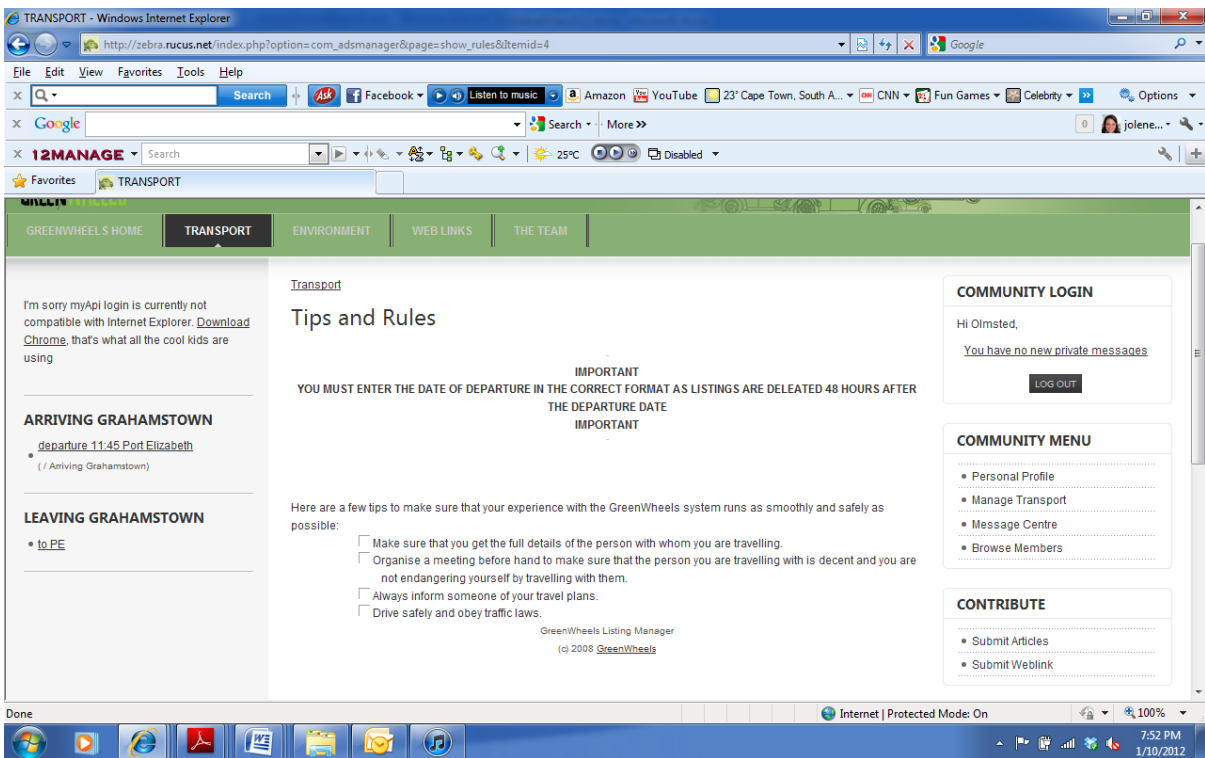


Figure A.13: Greenwheels Carpooling Tips (Greenwheels, 2012)

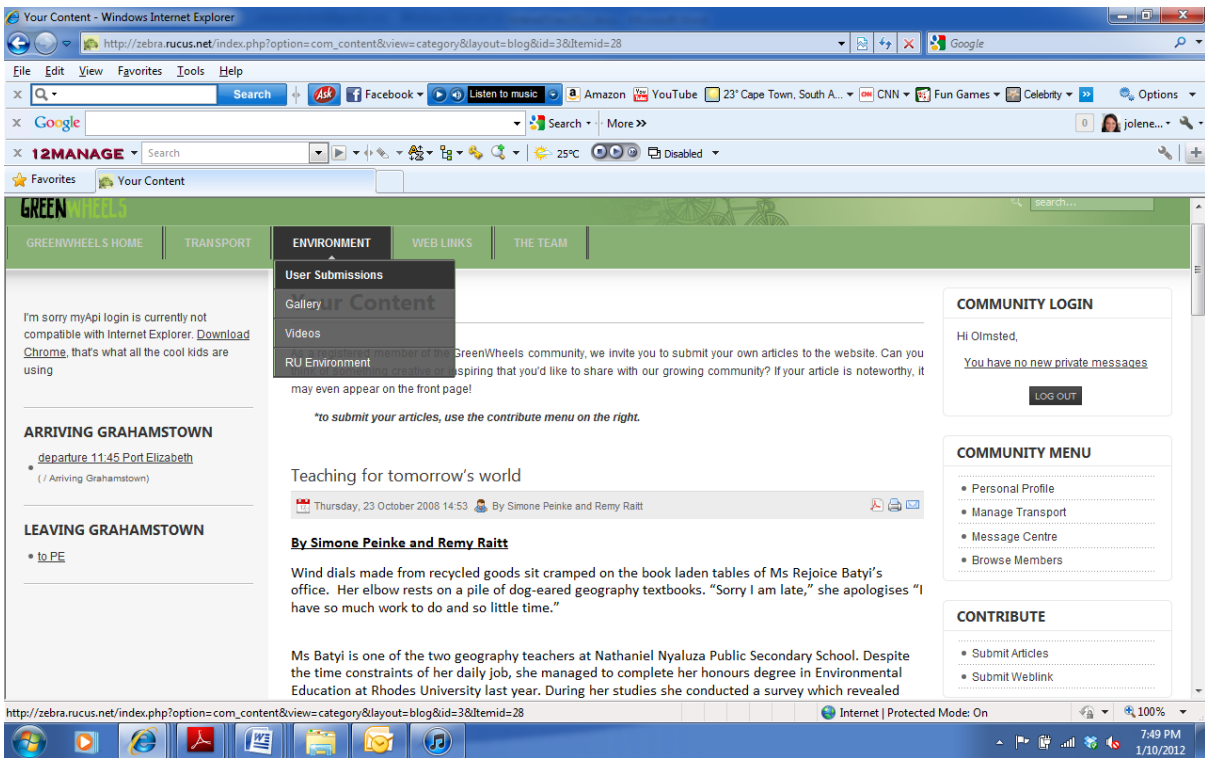


Figure A.14: Greenwheels Sharing Ideas & Solution Generation (Greenwheels, 2012)

eRideShare.com (2012)

eRideShare is less formalized than those carpooling systems implemented at Rhodes and UCT. These systems are completely open to the public and rely heavily on the number of members to work effectively.

Figure A.15 to figure A.18 show there is less sophistication to the carpooling system, where one simply joins, searches for possible drivers going to a specific destinations. One is provided with a report based on the listing you select and then emails or phones that carpool member to discuss further arrangements. The system clearly lacks any flexibility or real-time matching up of commuters.

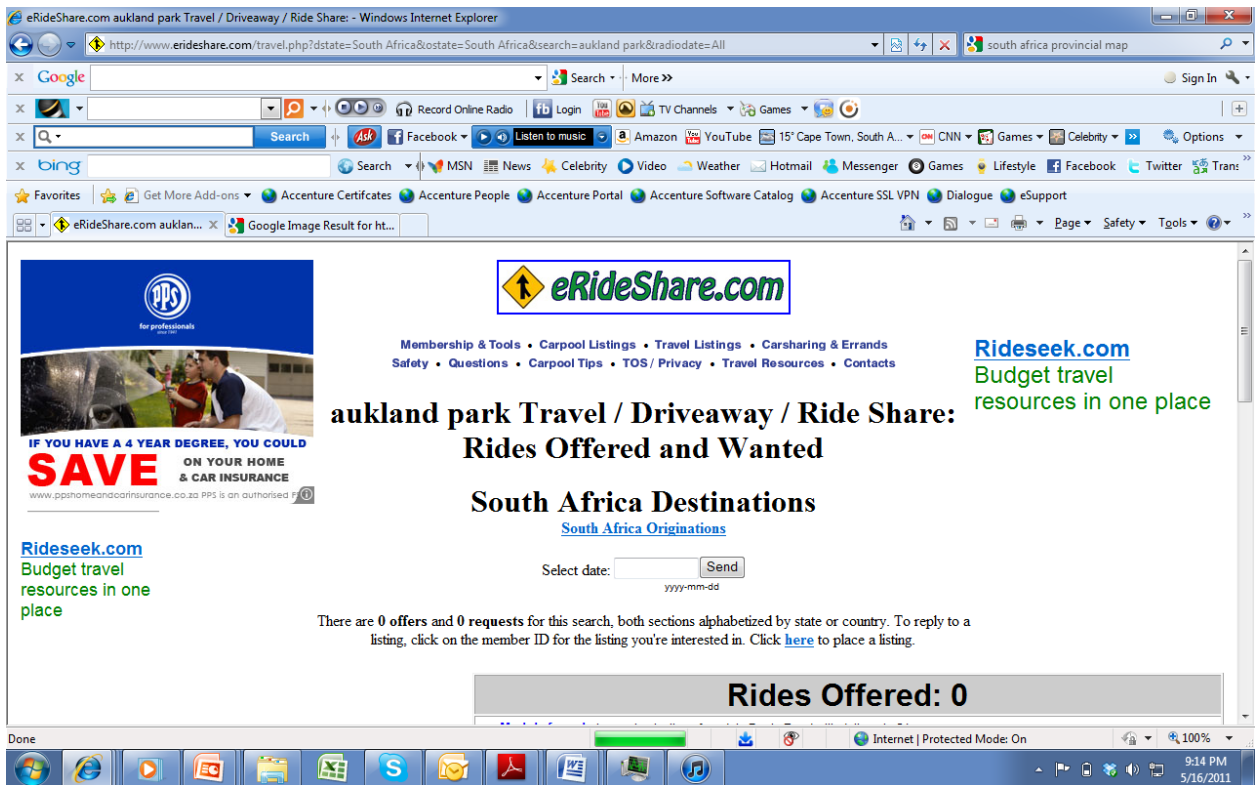


Figure A.15: eRidShare Registration (eRideShare.com, 2012)

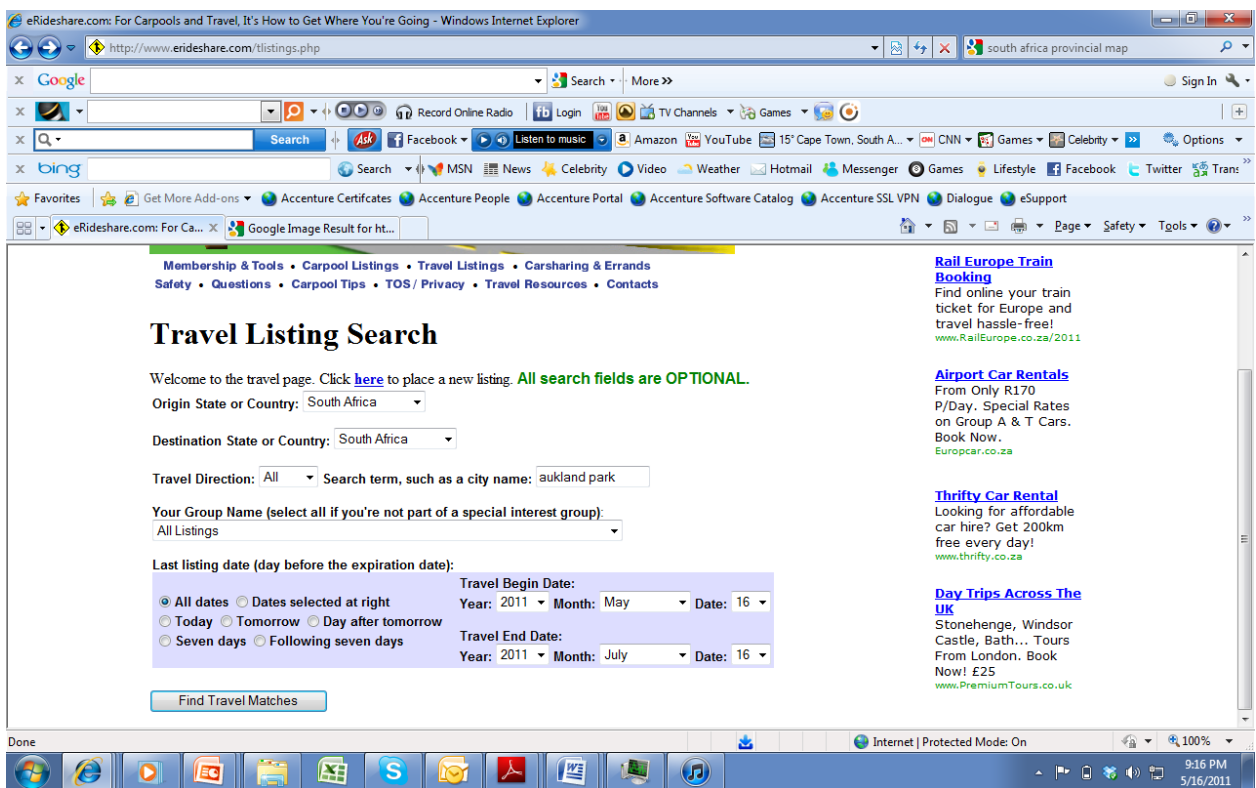


Figure A.16: eRidShare Listing Browser (eRideShare.com, 2012)

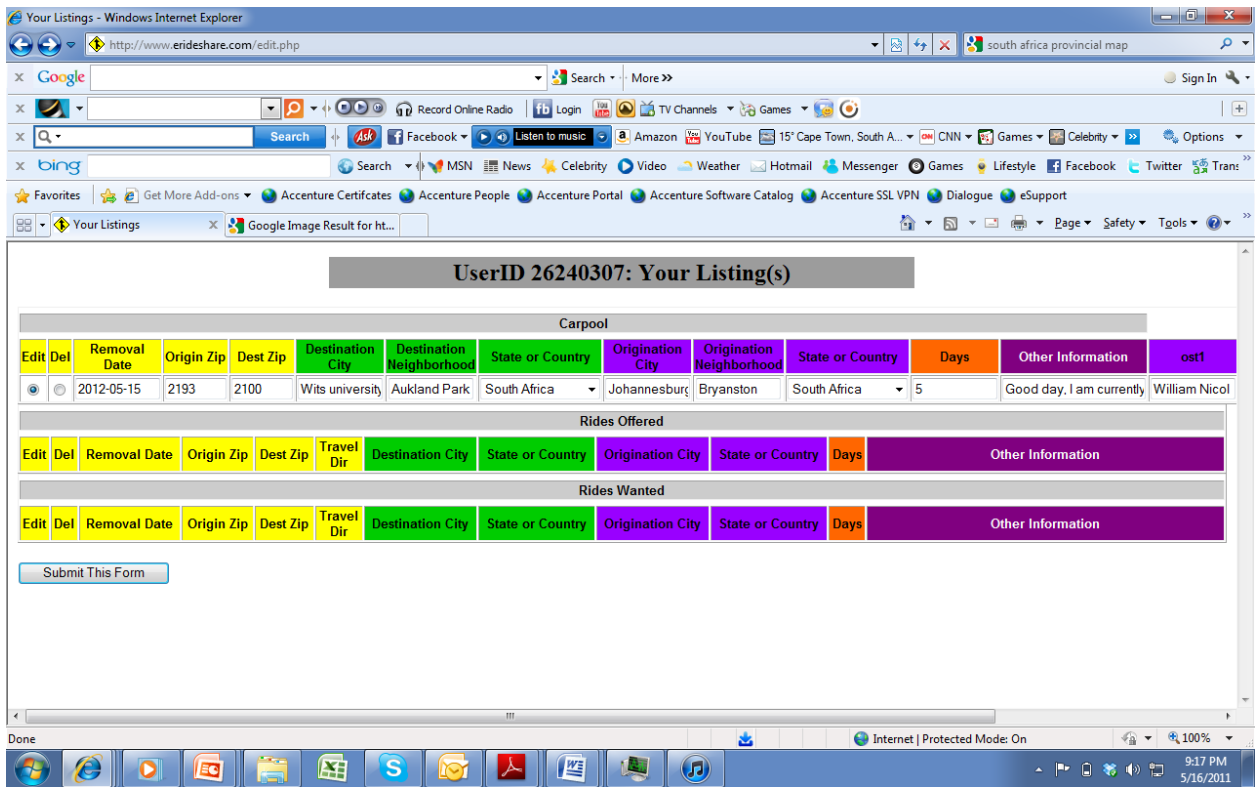


Figure A.17: eRidShare Listing Selection (eRideShare.com, 2012)

| | | | | | | |
|---|--------------|----------------------------|--------------|-------|---------------------------------|--|
| Braamfontein Johannesburg | South Africa | Centurion Highveld | South Africa | 5 | NomtieN | 5 am to 4.30pm type:request; entrydate:2011-05-03 |
| Johannesburg Rustenburg rd & Barry Hertzbog | South Africa | Johannesburg Monash side | South Africa | MTWTF | chricenice_1977 | ready to share cost and flexible with time call 073 177 6756 type:request; entrydate:2010-07-02 |

Figure A.18: eRidShare Listing Report (eRideShare.com, 2012)

Carpoolworld.com (2011)

Carpoolworld.com is also a less formalized carpooling system however it caters for carpooling members across the world. It provides a chat room environment to share ideas that have worked well for other carpool across the world.

It also provides a physical map of the carpool routes that have been established. One is able to plot your own travel route and seek other carpoolers in your city, who would like to travel that route with you, or join other carpool routes that have already been logged, as depicted in Figure A19.

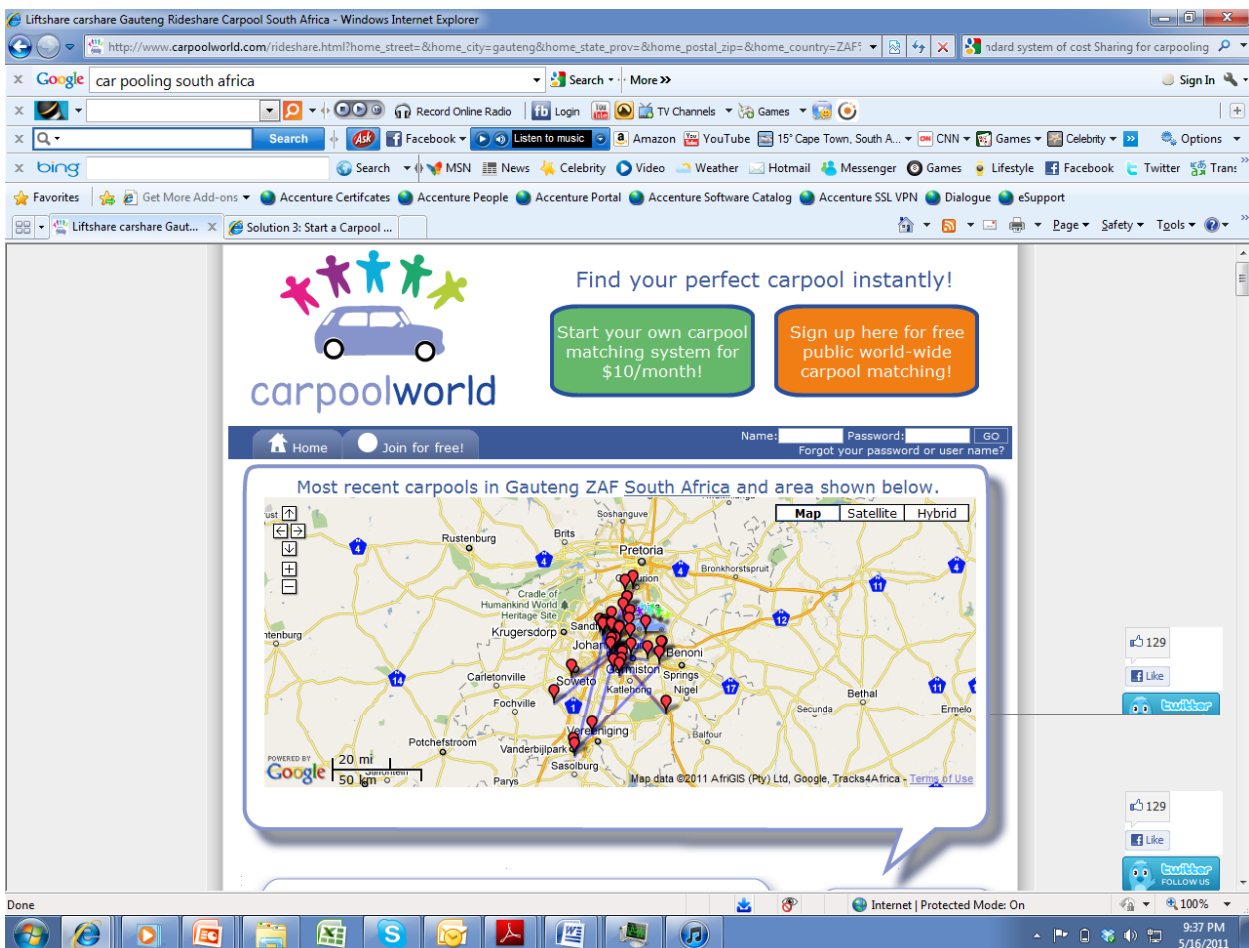


Figure A.19: Carpoolworld Listing Selection Level 1 (carpoolworld.com, 2011)

One can also filter by the next level of details, such as student carpools as depicted in Figure A.20.

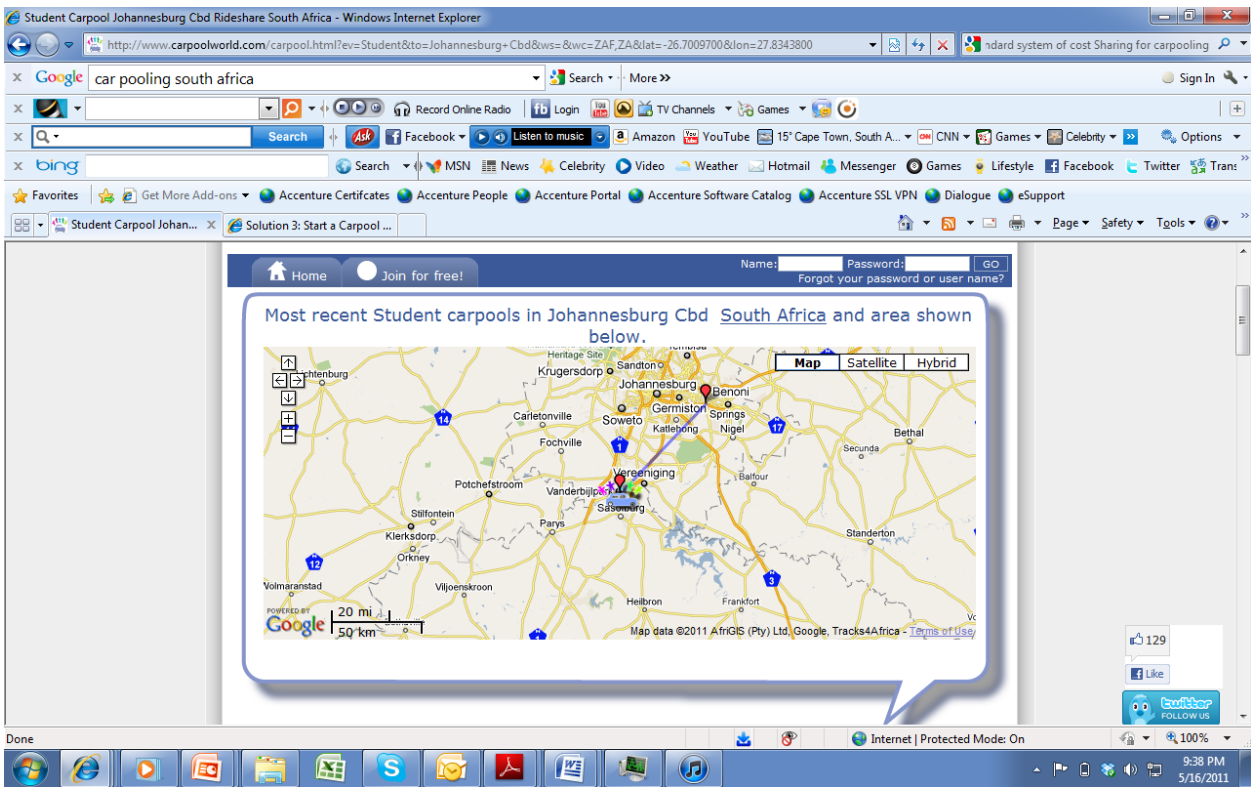


Figure A.20: Carpoolworld Listing Selection Level 2 (carpoolworld.com, 2011)

Orsi (2011) provides a high-level description of carpooling logistics, basic rules for passengers and drivers as well how to share expenses for carpools and structure the insurance for carpooling systems. Figure A.21 below is a sample of a possible carpooling agreement that could be set up between the members to maintain a certain level of etiquette.

Sample Carpool Agreement

This agreement is between the carpool riders ("riders") listed on the attached information sheets, all of whom agree as follows:

1. The purpose of the carpool is to transport us between our respective workplaces in downtown Boston and each of our respective homes.
2. Participation in the carpool is voluntary. Any rider may withdraw at any time, but we each agree to try to give as much notice as possible before ending our participation.
3. The carpool will begin on August 7, 20xx and will continue as long as there are riders willing to take part.
4. Any of the riders may volunteer to drive, and we will rotate drivers each week to ensure that driving responsibilities and expenses even out. Riders who do not ever drive will pay the driver \$2 per day, or \$10 per week, payable every Friday.
5. We will buy a quarterly parking pass for the downtown garage at Franklin and Hawley Streets. The cost is \$300 per quarter. We will divide the cost evenly among riders. Since the pass may be hung on the rearview mirror, at the end of each week the driver will give the parking pass to the designated driver for the following week.
6. In the morning, we intend be on the Massachusetts Turnpike heading for Boston by 7:45 a.m. We will determine an order for pick-up based on who is driving on that day. We will select specific pick-up times for each rider, and riders will try their best to be on time. The carpool won't wait more than 5 minutes.
7. The driver will make one stop at the corner of Water and Oliver Streets, a second stop at Federal and Franklin Streets, then park the vehicle.
8. At the end of each day, the driver will retrieve the car from the parking garage at 5:40 and make the stops in reverse order. It is imperative that everyone is waiting to be picked up by 5:40, to ensure that the driver does not have to circle back to pick up late riders.
9. We will let each other know if and when we are available to be back-up drivers, in the event that a driver is sick or for any other reason not available on a day that driver is designated to drive.

We all agree to maintain current insurance coverage on our vehicles as required by law, and each carry per-accident coverage of at least R160,000.

Signature: _____ Date: _____

Signature: _____ Date: _____

Information Sheet for Carpool Members

Name: _____

Address for pickup: _____

Phone numbers(please put a check mark by the best number to reach you)

Home: _____ Work: _____ Cell: _____

Other: _____ Email: _____

Emergency contact

Name: _____ Relationship: _____ Best number to reach: _____

Driver information

Drivers' license number: _____ Car make and model: _____

License plate: _____ Insurance co. and policy number: _____

Figure A.21: Sample Carpooling Agreement (Orsi, 2011)

APPENDIX B: WITS UNIVERSITY'S CURRENT TRANSPORT FACILITIES AND INFRASTRUCTURE

From personal experience, having been a student at Wits for the last eight years, parking availability has become an increasing issue. Over the past four years, Wits has increased their student intake, which, coupled with extensive capital works projects to support these numbers, would put pressure on land use. Parking availability would most likely remain a key issue unless alternative options are made available to students and staff. Transport modes that are available to students include the Wits Inter Campus Bus. Public transport services also only have designated collection and drop-off zones outside each of the University precincts. The Wits bus service is made available to students who require transportation from Wits Main Campus to the Wits Education Campus, Wits Health Science Campus and Wits Management Campus for academic activities, for students in residence and for Wits Health Science students who require transport to the teaching hospitals for academic activities. The bus departure times and routes are made available on the Wits website, under student services (Wits 2013).

The public transport sites themselves do not provide sufficient data: they may provide the routes but the ticket office points are not listed, so one would need to contact the customer care centre. More recently, an integrated Google map was created which provides an integrated public transport route map. Physical logistical issues have also been observed where accessibility of public transport between the Braamfontein Campus and Parktown Campus facilities is available but not as frequent, flexible and reliable as required. The public transport facilities on both campuses lack dedicated lanes and bus stops. Data is also not easily made available from the parking office; transparency is an issue which could lead to a lack of actual data for accurate future planning (Google, 2012), (Wits, Student Services, 2013).

The current process to acquire a parking permit at Wits is still largely paper-based when applying for the permit, although the data is then captured electronically by an administrative staff member. At registration, students are required to walk to the parking office, present their student card and proof of registration, and purchase a parking permit based on their student group and associated authorised parking areas. A permit token in the form of a sticker is issued to the student, who places the sticker in an easily visible place on the inside of their

vehicle windscreen. One permit is issued per person. Drivers are expected to follow all traffic rules as traffic infringements will be imposed with fines. The traffic rules can be referred to in the General Rules for Students' Conduct and General Information for Students. The permits are charged at between R458 and R690, which gives the student the right to park on the University campus for that year of study. If these permits are not visible on the vehicle, a fine of up to R500 may be imposed. The parking permit is displayed in Figure B.1, the process and rules are detailed in the permit application. Students are expected to park in designated areas, first years are provided with parking furthest from the main lecture halls, while postgraduates have been given preferred parking closer to the lecture halls (Wits, Student Services, 2013) Multi-car permits: can also be requested, however are issued at additional cost and with a single permit token and the parking bay is allocated only to the principle user,

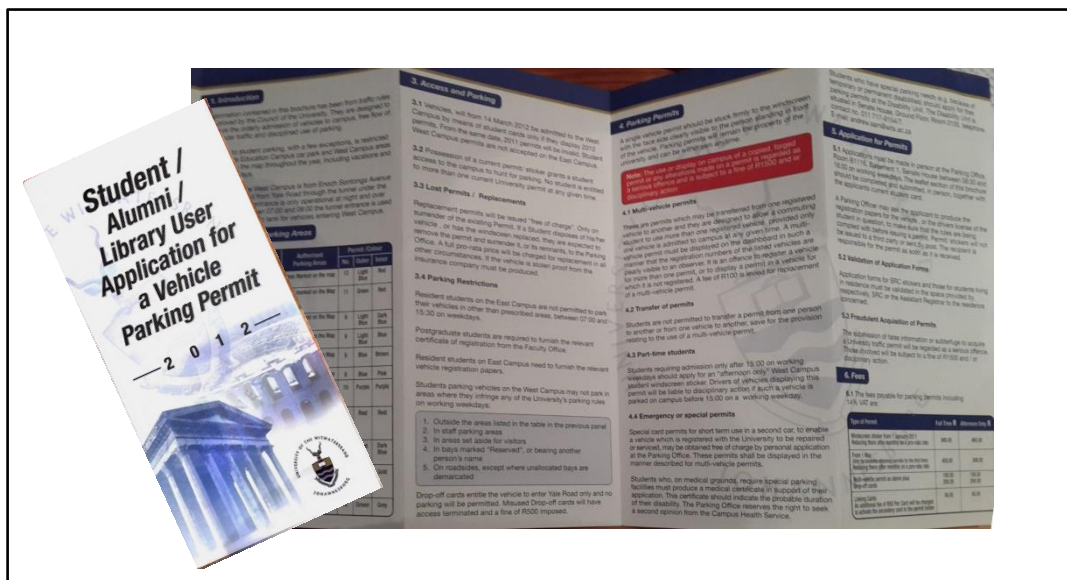


Figure B.1: Wits student application for a vehicle parking permit

This process could be supported online, reducing the paper applications and the manual processing of student data. Most of the data required is made available at registration and it is not necessary to duplicate this capturing of data. The department systems and information should be better integrated. The parking permit information is also not available online and there are no policies or incentives in place to encourage students to travel together to reduce parking bay demand, which could be easily managed through adapting the existing multi-car permits for Wits shared transport systems like carpooling. The additional cost for the multi-car permit would likely be a disincentive to a lift clubs and should not apply for carpools

unless only one car was used by all members of the club. If the card access to the parking area is given only to the principal user, so while a lift club could theoretically rotate cars on the single token, the principal user would always have to be in the car as it would be highly unlikely that the Wits traffic department would issue a multi-car token for cars with different owners, as this could be logistically difficult to administer.

MyWits is the official communication channel between the University and the students. It allows students to host a personal e-mail address, personal calendar facilities that integrate with academic calendars, and facilitates instant messaging with other Wits students. There are currently no forums, blogs or portals which provide carpooling organisations (Wits, MyWits, 2013).

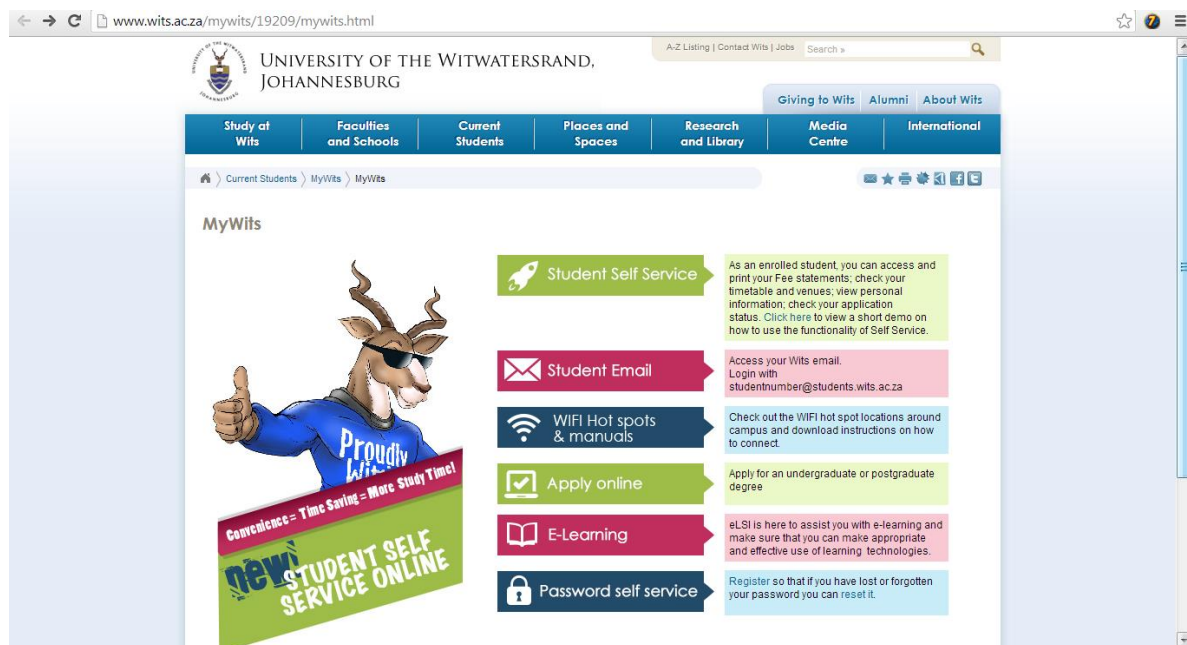


Figure B.2: MyWits homepage screenshot (Wits, MyWits, 2013)

APPENDIX C: CONCEPTUAL WITSIT SHARED TRANSPORT MODEL

WITSIT Conceptual Model: Governance Structure

An effective governance structure is critical in ensuring the maturity and sustainability of a car-sharing service at Wits University. This framework also aims to establish well-defined monitoring reports to shape the decisions regarding future transport solutions. The current lack of transparency can be addressed by a predetermined service commitment. The governance framework for the UCT Rideline system achieved transparency and accountability through effective policy that aims to influence the University commuters' current and future behaviour. Governance and performance management structures described by Greenpeace (2011), Deloitte (2012), Abile Group (2012) for business was reviewed and adapted for the WITSIT service.

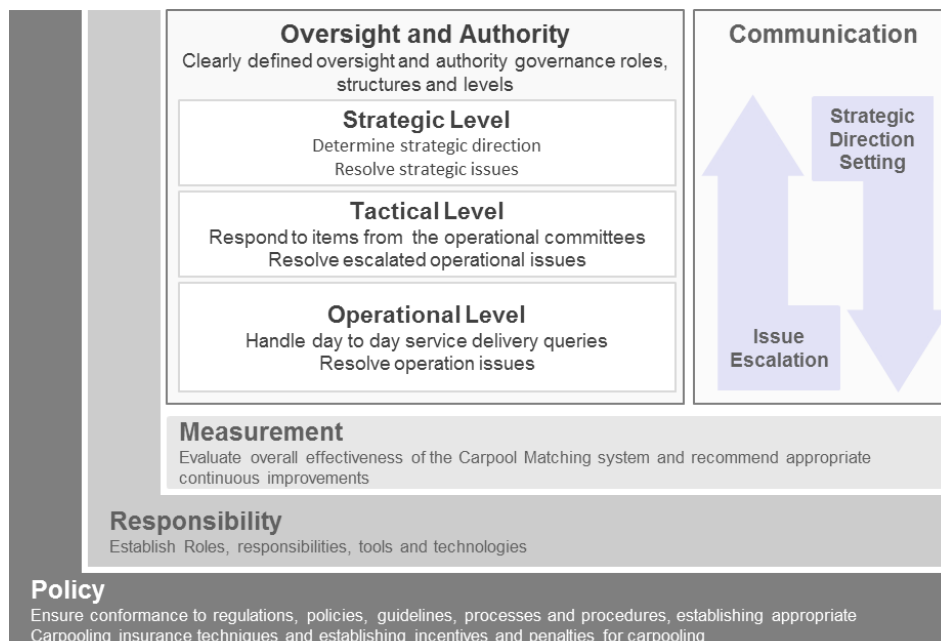


Figure C.1: WITSIT Governance Framework

The governance framework in Figure C.1 aims to ensure that all those involved in managing the carpooling service, would be integrated from operational to tactical and strategic levels. Operational levels pertain to the support administration roles such as the Logistics, IT Programming and Administration operators who are closest to the detail and are provided with a channel to escalate ('action' is not a noun) any issues, and recommended continuous

improvement initiatives. Tactical levels pertain to the Environment Management team in charge of managing any issues that are escalated and making decisions within predefined limits, so as to ensure a quick turnaround time in communicating solutions to the operational level and filtering more strategic issues to the strategic forum established with the Head of Wits Facilities Management. Strategic levels apply to the Head of Wits Facilities Management, who is required to provide oversight of a large programme such as a carpooling service. Decisions that could not be handled by the Environmental Management team must be dealt with here. At all times the Head of Wits Facilities Management must be able to align the carpooling initiatives to any policies of the University such as the Wits 2022 Vision.

Based on the Governance Framework requirements described above as well as personal views shared by the UCT environmental committee lead Kate Patell (2011) the governance structure in Figure C.2 is proposed to ensure the successful implementation of the WITSIT service. One qualified person could fulfil all roles highlighted below, but in most cases candidates will only be able to fulfil these roles part-time. Hence it would be advisable to have up to ten members; otherwise the span of control for the Chairperson is exceeded and could lead to ineffective governance. Finally the appropriate number of skilled logistic, IT and administration support staff must be established. This may require the creation of new positions for administration staff at Wits University.

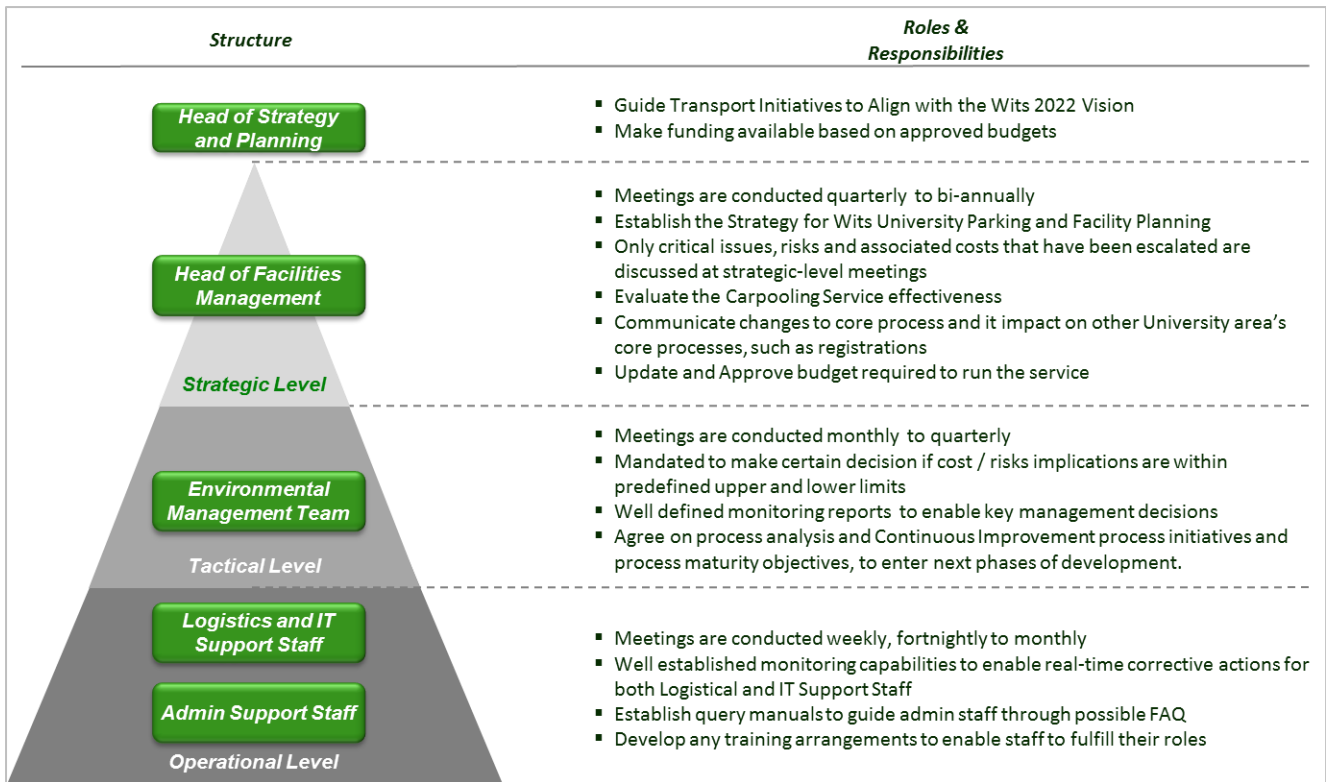


Figure C.2: Proposed WITSIT governance structure (influenced by Governance Framework paper published Deloitte, 2012)

The tactical and operational roles will play a pivotal role in developing and executing the WITSIT service.

Within the Environmental Management team, the following specific roles must be fulfilled, preferably by separate entities. The current Wits Student Council may choose to incorporate these roles or interconnect with a newly established group that will be led by a staff member to supervise supporting roles. The supporting roles must be fulfilled by student representatives to encourage stewardship amongst the students with regard to environmental initiatives. Some of these responsibilities similar to those of the UCT Rideline governance structure have been highlighted below:

- General Manager (Staff): Lead the strategic vision of the Environmental team and align this vision with the Wits Strategic Planning Division;
- Environmental Management Leader (Staff): A senior team member who understands the environmental issues Wits is facing: they will serve as a subject matter expert,

redirect the vision where required and ensure that strategy can be practically implemented and adjusted when required;

- Environmental Management Support (Student): This role will organise students to implement the plans developed by the strategic members in the team;
- Marketing Leader (Staff): Provide the rest of the team with research and databases to track the level of adoption of the WITSIT and other similar environmental programmes;
- Marketing Team (Students): Plan, direct and implement marketing campaigns to increase uptake of the proposed model;
- Financial Leader (Staff): Establish, secure and track funding for the model and associated activities;
- Financial Manager (Student): Support the Financial Leader in carrying out administrative tasks, track and report on the provided budget for the model development and implementation;
- Smart Application Programming Leader (Staff): Identify, appoint and oversee junior application programming members and ensure the quality of the webhosted car-sharing systems;
- Smart Application Programmer (Student): Develop the webhosted car-sharing system and scan for future development of application tools to ensure maximum exposure to commuters, while ensuring user-friendly and easily accessible systems. Establish a database to assist future transport planning;

WITSIT Conceptual Model: Strategy & Policy Planning

Orsi (2011) identifies that a legal entity is necessary to provide guidelines for determining the shared costs, best practices and equitable standards when establishing lift clubs. These guidelines facilitate the interaction between commuters who will share transport. It is expected that the commuters who participate will follow these rules and etiquette, which involve guidelines on agreeing on the shared cost of the transport, behaviour that will not be tolerated during the commute, and logistical arrangements that should be planned to ensure that commuters depart from convenient locations. An example of the guidelines developed by Orsi (2011) has been provided in Appendix A: South African Carpooling Webhost Examples.

Policies that could promote car-sharing have been discussed in Section 4.3.1. The policies could either provide incentives in reduced parking fees, or be driven by penalties to discourage single occupant private vehicle trips. In the UCT Ridelink programme, it was evident that these policies are mutually reinforcing (Patell - UCT, 2011). At UCT, preferential parking for those who carpool proved to be fairly successful. Emphasis was also placed on promoting the benefits and creating awareness of carpooling through interactive marketing tactics, which involved student volunteers. Although these tactics were successful at UCT the policies would need to be piloted and adapted throughout the implementation phases to respond to the Wits context. The details are further referenced in Appendix A: South African Carpooling Webhost Examples.

WITSIT Conceptual Model: Process Maps

The WITSIT conceptual service processes have been mapped out below, as a result of having analysed other carpooling processes and utilizing best practice where possible. The IT system function, system administrator tasks and environmental management team roles have been mapped in Figure C.3, in order to plan and maintain the car-sharing model. The IT system function, system administrator tasks and environmental management team roles and Wits University commuter actions have been mapped in Figure C.4, which forms part of the registration and access tasks. In Figure C.5 the actions that each of these functions takes to set up the online carpooling application, have been mapped. Finally Figure C.6 depicts the carpooling matching process that is followed by the IT system function, system administrator, environmental management team, driver and the passengers.

Plan and Maintain Carpooling Model

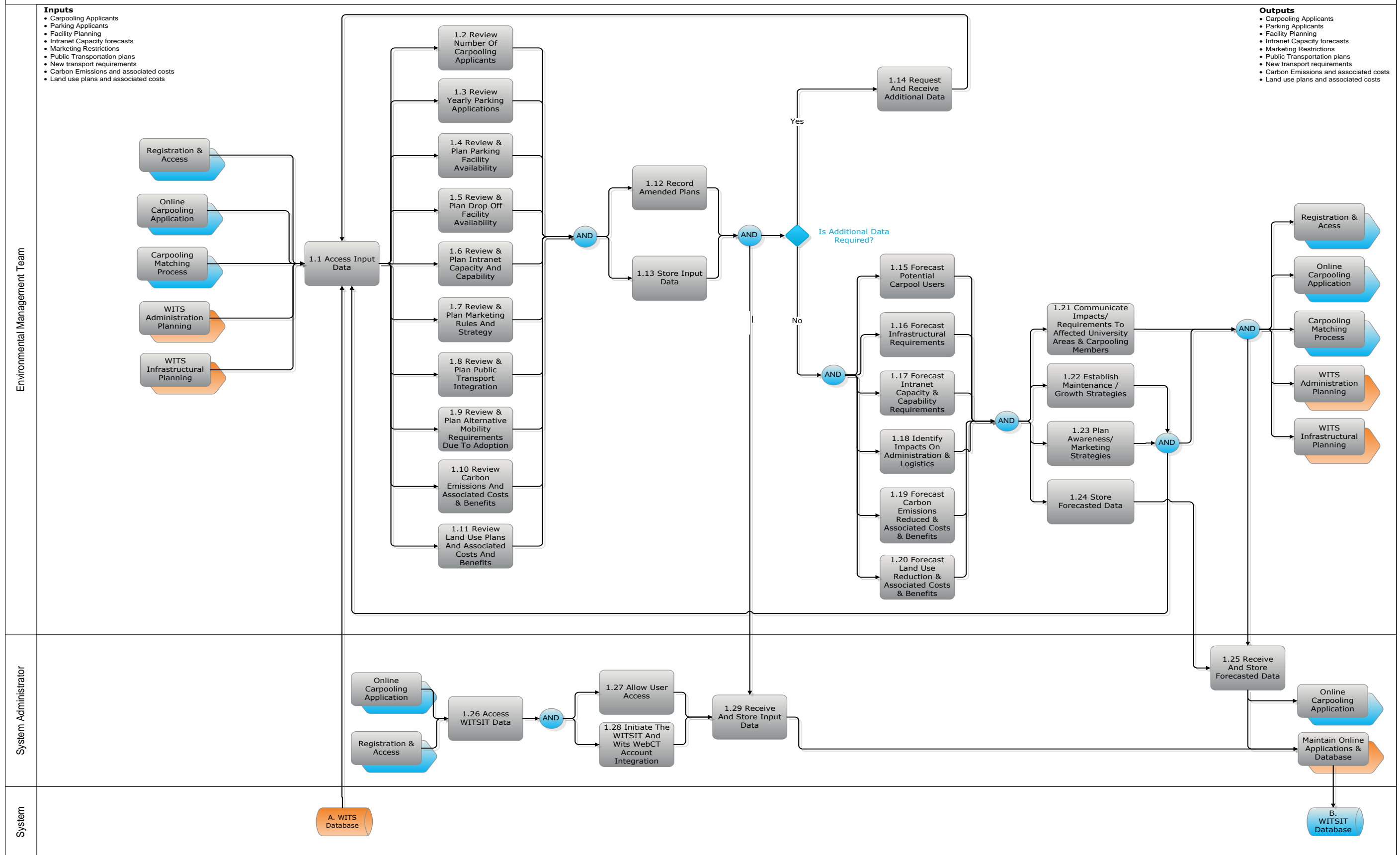


Figure C.3: Planning and maintaining the carpooling service model

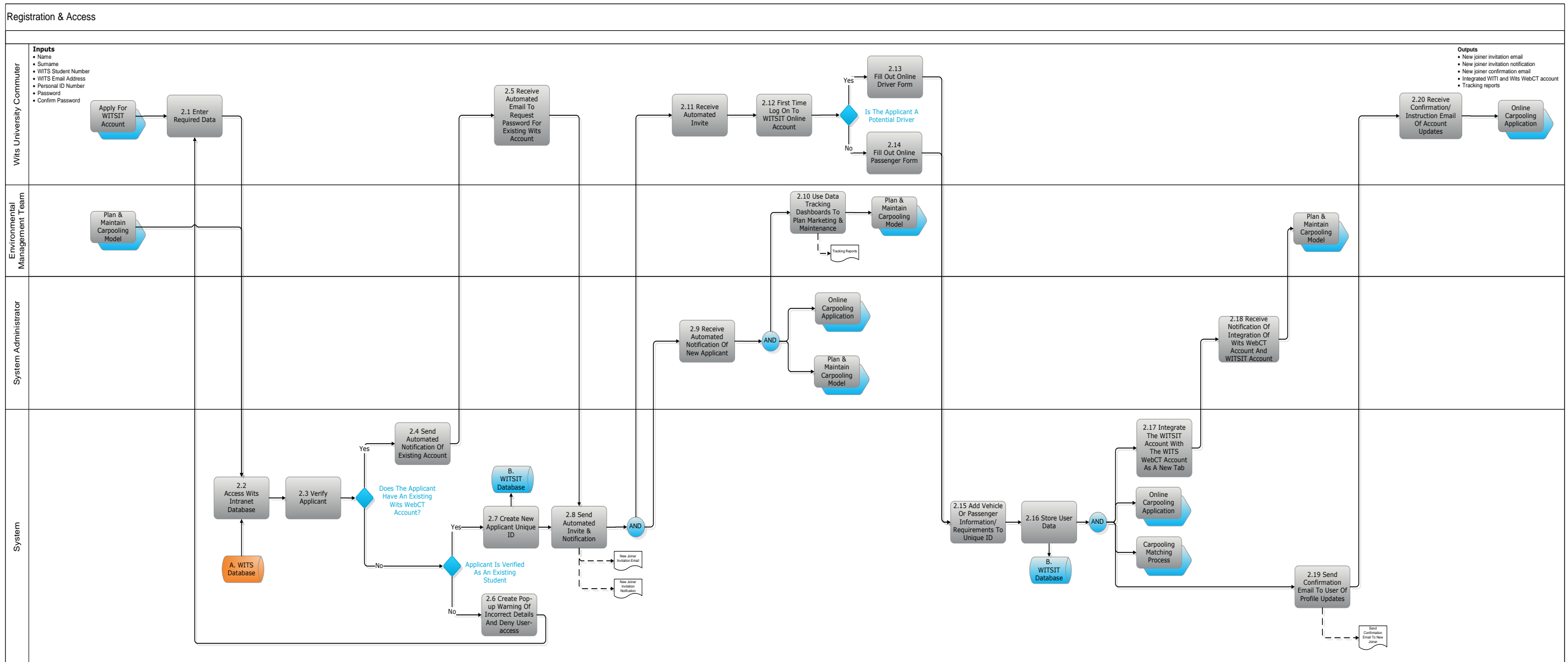


Figure C.4: Registration and access process

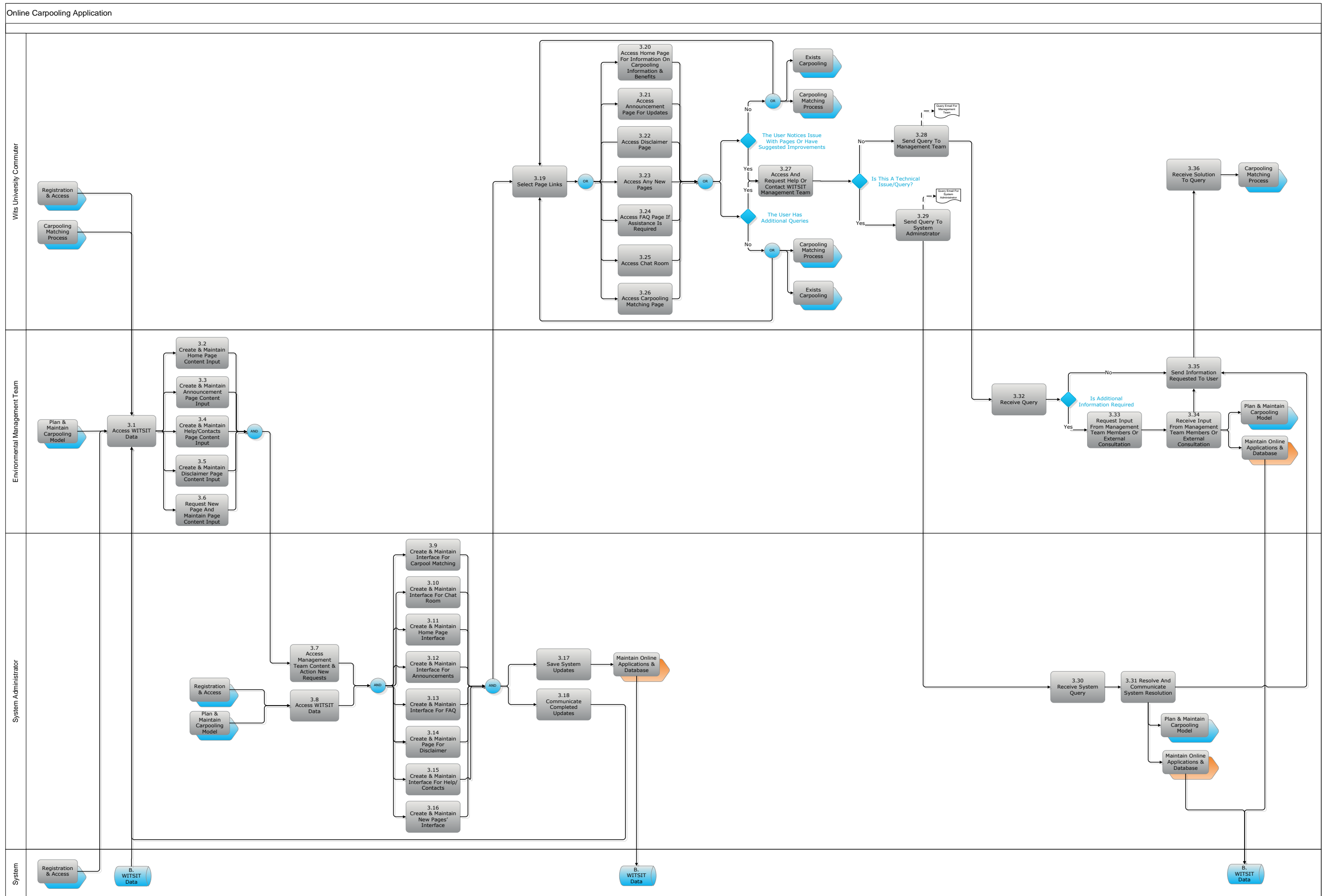


Figure C.5: Online carpooling application process

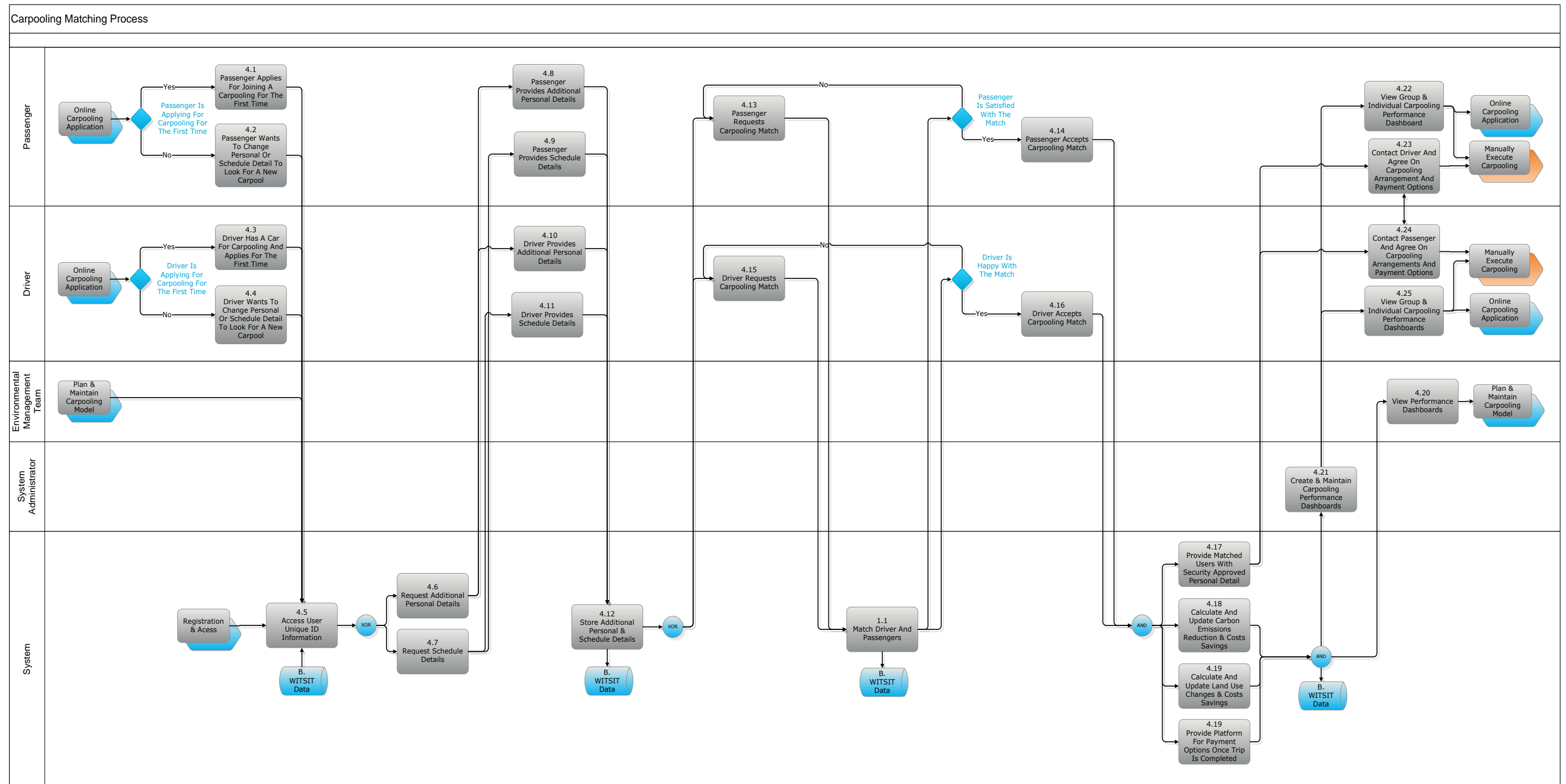


Figure C.6: Carpooling matching process

APPENDIX D: SURVEY QUESTIONS AND DISTRIBUTION SYSTEMS USED

Survey Questions Developed from Shaheen's Questionnaire

Information about Yourself

Finally, we would like a little more information about you for our records. All your answers will be kept completely confidential.

1. Female Male

2. Household Composition (check one):

Self only

Self with spouse/partner

Self with spouse/partner and child(ren)

Self with child(ren)

Self with roommate(s)

Other, please specify:

3. What is your employment status? (Please select one)

Employed full-time Homemaker Other, please specify:

Employed part-time Retired

Currently unemployed Student

4. Which category best describes your occupation? (Please select one)

Day commuting student Resident Student

Lecturer/Professor

1. What suburb do you reside in _____

6. What is your age? (Please select one)

17-20 21-24 25-28 29-32 33-36 37 or older

7. How many individuals in your household are in each of the age groups below, including yourself? Please circle the number of people for each age category.

| Age category: | Number of people in household in each age category: | | | | | | | | | | | |
|-----------------------|---|---|---|---|---|---|---|---|---|---|----|---------|
| 0-5 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 6-15 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 16-18 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 19-23 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 24-30 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 31-40 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 41-50 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 51-60 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 61-70 years old | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |
| 71 years old or older | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | or more |

8. What is your household's annual income (please include all sources of income, not just personal salaries)?

- ____ Under R100,000
- ____ R100,000 to R190,999
- ____ R200,000 to R490,999
- ____ R500,000 to R790,999
- ____ R800,000 to R1,090,999
- ____ More than R,1100,000

9. Ethnic Background (check all that apply):

- ____ African
- ____ Asian
- ____ White/Caucasian
- ____ Coloured
- ____ Other, please specify:_____

Optional: How did you like taking this questionnaire on-line? Is there anything we should have done differently?_____

Optional: Are there any other comments you would like to share with us?_____

Thank you very much for taking the time to complete this

Current Travel Patterns

Instructions: Please read and answer each question. Unless otherwise noted, all questions refer to current travel modes

The questionnaire should take about 20 minutes to complete. The time you dedicate to this is extremely helpful to sustainable integrated shared vehicle research. Thank you for your participation!

Your Current Travel Patterns

In this section is to record information on your current transportation patterns.

1. How many persons (including yourself) are in your household?
2. How many university commuters, including yourself, are in your household? (A commuter is an adult who travels three to five days per week to and from university/work.)

3. How do you usually commute to university/work?

Estimate how many km's you travel and how much time you spend one-way going to work using any of the following modes. Please check the appropriate box(es) and provide the time and mileage for each mode for your most common way of commuting. For instance, if five days a week, you drive to a parking lot and meet a carpool, you should check "Drive by myself" and "Carpool." Next, enter the times and km's for both modes. Please include any waiting times (e.g., for BRT, a carpool, etc.) in your estimate.

Usual Commute to University/Work: I use this combination _____ days a week:

| Mode | Yes | Minutes | KM's |
|------------------|------------|----------------|-------------|
| Drive by myself | | | |
| Carpool | | | |
| Rea Vaya Bus | | | |
| Taxi | | | |
| BRT/Gautrain Bus | | | |
| Bicycle | | | |
| Walk | | | |

| | | | |
|------------------------|--|--|--|
| Work at home | | | |
| Other, please specify: | | | |

4. Do you sometimes commute to university/work by a different method? If yes, please complete the following table for your *other most-common commute method*. (If no, proceed to question 6).

Estimate how many km's you travel and how much time you spend commuting to work one way using each of the following modes. Please provide the time and mileage for each of the modes you use. Please include any waiting times (e.g., for RBT, for a carpool, etc.) in your time estimate for the trip.

Other Most Common Commute Method: I use this combination _____ days a week:

| Mode | Yes | Minutes | Km's |
|------------------------|------------|----------------|-------------|
| Drive by myself | | | |
| Carpool | | | |
| Rea Vaya Bus | | | |
| Taxi | | | |
| BRT/Gautrain Bus | | | |
| Bicycle | | | |
| Walk | | | |
| Work at home | | | |
| Other, please specify: | | | |

5. Is it difficult to find parking at your university/workplace? ____ Yes ____ No

6. How much do you estimate it costs you, on average, for your entire round-trip commute each day? Please calculate costs for each transportation mode used. Please also estimate how much it will cost you each day to commute using WITS Integrated Shared Transport Model using the table below/interactive calculator

Driving Alone R_____

(Including car payments, insurance, registration, parking, gas, tolls, wear and tear, etc.)

Carpooling R_____

(Including car payments, insurance, registration, parking, tolls, etc.)

Riding Public Transit R_____

(Including transit tickets, driving to the station, parking, etc.)

WITS Integrated Shared Transport R_____

(How much do you estimate it will cost each day to commute with Shared Transport?)

Optional: Do you have any comments on your current travel patterns that you would like to share with us? _____

Travel and Work

In this section, we hope to learn more about the trips you make during the workday.

1. How many days a week do you leave your workplace and return during the day for personal or company business via a vehicle or public transportation? (Indicate the number of days per week you make these trips.)

____ Not Applicable (I almost never leave my workplace during the day.)

____ Personal Business (lunch, errands, appointments, etc.) _____ days per week

____ Company Business (meetings, sales calls, etc.) _____ days per week

2. How do you usually complete these personal and company business trips? (Check all that apply)

| MODE | PERSONAL BUSINESS | COMPANY BUSINESS |
|----------------------------------|-------------------|------------------|
| My car | | |
| Company vehicle | | |
| Friend/carpool partner's vehicle | | |
| Bus | | |
| Taxi | | |
| Walking | | |
| Biking | | |

Other, please specify: _____

3. How long do these workday trips usually take on average? _____

4. How often do you choose to drive your vehicle to work because you will need it for errands on the way to work or home (e.g., shopping, picking up passengers, etc.)? (Select one)

- Never, I always drive my car anyway.
- Never, I never do errands during my commute.
- Once a month
- Once a week
- A couple of times a week
- Every day, I always bring my car to make errands.

5. How often do you drive your vehicle to work because you know you will need it during the workday? (Select one)

- Never, I always drive my car anyway.
- Never, I never need a car during the day.
- Once a month
- Once a week
- A couple of times a week
- Every day, I always need my car at work.

Optional: Do you have any comments on your work travel patterns that you would like to share with us?

Household Vehicles

The next few questions focus on the motor vehicles in your household. Please consult with your guardian to provide accurate answers if they are the main income holder and finance your vehicle.

1. How many operational motor vehicles (including cars, trucks, minivans, and motorcycles) does your household own or lease?

2. How do you usually pay for your vehicles?

Buy Lease Both

3. Approximately how much does your commute vehicle (the vehicle you most often use to get to university/work) cost you per month to operate, including purchase/lease cost, depreciation, petrol, registration, insurance, maintenance, parking, cleaning, and auto clubs (e.g., AAA)? Please use the AAA cost table provided below /interactive calculator to estimate your costs based on your demographic profile.

R_____ per month

4. Consider the next vehicle your household might acquire. How soon do you think your

household might buy or lease your next vehicle? _____

5. What do you plan to do with your personal vehicle(s) once you are in WITS Integrated Shared Transport? Will you keep all the vehicles or will you sell one, lend one to someone (such as a licensed child), or put one into storage? (Select one)

____ I will still use all the cars.

____ Someone in my immediate family will be using a car more frequently.

____ I plan to loan a vehicle to someone outside my immediate family.

____ I plan to sell or store one or more of my personal vehicles.

Optional: Do you have any comments on your household vehicles that you would like to share with us? _____

Your Attitudes and Opinions

Here we ask for your views on various transportation issues.

1. For each of the following statements, please check the one response that best expresses how strongly you disagree or agree. "My current transportation methods (that is, all the different transportation modes I currently use) ...

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|--|--------------------------|-----------------|----------------|--------------|-----------------------|
| "Are enjoyable to me." | | | | | |
| "Allow me to visit friends when I want." | | | | | |
| "Fit my budget." | | | | | |
| "Allow me to be spontaneous." | | | | | |
| "Help me go everywhere." | | | | | |
| "Say a lot about who I am." | | | | | |
| "Do not make me feel safe." | | | | | |

| | | | | | |
|--|--|--|--|--|--|
| "Give me a sense of independence." | | | | | |
| "Are great for my lifestyle needs." | | | | | |
| "Allow me to quickly respond to an emergency." | | | | | |
| "Are comfortable." | | | | | |
| "Give me a sense of freedom." | | | | | |

2. Please rank the three things you like least about your current transportation methods (for all your trips) in the following table: (Rank 1-3 where 1 is the least favourite aspect, 2, second least and 3 third least favourite aspect)

- _____ It's too expensive.
- _____ Parking is a hassle.
- _____ I waste too much time in traffic.
- _____ Vehicle maintenance is a hassle.
- _____ It's not reliable enough.
- _____ It takes too long to get places.
- _____ It's not environmentally-friendly.
- _____ It's not flexible enough.
- _____ Other, please specify:

3. For each of the following statements, please check the one response that best expresses how strongly you disagree or agree.

"I like to experiment with new ways of doing things."

- Strongly Disagree Disagree Neutral Agree Agree Strongly

"I sometimes don't drive because finding a parking space is difficult and frustrating."

- Strongly Disagree Disagree Neutral Agree Agree Strongly

"Transit is too expensive, so I don't use it much."

- Strongly Disagree Disagree Neutral Agree Agree Strongly

"I would like to reduce my auto use to reduce congestion and improve air quality."

Strongly Disagree Disagree Neutral Agree Agree Strongly

“Once I’m happy with something, I don’t want to change it.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“I spend too much time dealing with car maintenance.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“Keeping licenses and smog checks current is relatively easy.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“I usually do not wait too long for buses and trains.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“I am willing to drive an electric or other clean-fuel vehicle to improve air quality if I can afford one

Strongly Disagree Disagree Neutral Agree Agree Strongly

“I use transit (e.g., buses, BRT, Gautrain, etc.) when it goes where I want to go.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“I’d be willing to ride a bicycle or take transit to help to improve air quality.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“If friends and neighbours reduced their driving, I would follow their example.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“I know transit schedules and routes relatively well.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“It is time to change the way we live to help address environmental problems.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“The benefits of owning a car are higher than the costs.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“I would like a job that doesn’t require that I continue learning new skills.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“Traffic fumes are a major contributor to global warming, smog, and other environmental problems.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

“I sometimes do not feel safe while using public transportation.”

Strongly Disagree Disagree Neutral Agree Agree Strongly

4. How long have you wanted to try a different way to commute?

5. Was there a particular event or life change that influenced you to try a different way to commute? (Select one)

___ No, there was no particular event or life change.

___ Finding out about Shared Transport put the idea into my head.

___ Since I changed jobs

___ Since I moved

___ Since our family changed (e.g., childbirth, marriage)

___ Since our car broke down/got rid of a car

___ I have always been looking for a different way to commute.

6. Rank the three greatest strengths of WITS Integrated Shared Transport, by numbering 3 of the following options 1-3:

___ Shared Transport reduces the time I sit in traffic.

___ With Shared Transport, parking is easier and less expensive.

___ Shared Transport fits with my schedule better than buses/shuttles.

___ Shared Transport will let me run errands during the day.

___ Shared Transport gives me time to work or relax during my commute.

___ Shared Transport will save me money.

___ Shared Transport means I will not have to buy another car.

___ Shared Transport includes maintenance and licensing.

___ Shared Transport helps me do my part to reduce congestion and air pollution.

___ Other, please specify:

7. Rank your three most significant concerns regarding WITS Integrated Shared Transport, by numbering 3 of the following options 1-3:

___ Having a Shared Transport vehicle break down or run out of fuel

___ The costs of being a member

___ Availability of vehicle when I need one

___ It will take me more time to go places.

___ I'm unfamiliar with the transit systems.

___ I won't be able to keep my personal items in the car (tools, sunglasses etc.).

___ I won't be able to be as spontaneous as I might like.

___ I have privacy concerns about the technologies employed in the Shared Transport system.

_____ Dirty vehicles

_____ Other, please specify:

8. In a few sentences, could you tell us why you would be willing joining or have joined Shared Transport Model?

Optional: Do you have any other comments that you would like to share with us?

Cost Issues

An important part of the WITS Integrated Shared Transport program Emergency Vehicle Options is determining the appropriate level of fees. Your answers here are not intended to affect the price you pay while using WITS Integrated Shared Transport.

1. How important are the following WITS Integrated Shared Transport Emergency Vehicle services in your choice to join the program?

| <i>Services</i> | <i>Extremely Important</i> | <i>Important</i> | <i>Somewhat Important</i> | <i>Not Important</i> |
|-------------------|----------------------------|------------------|---------------------------|----------------------|
| Cleaning | | | | |
| Insurance | | | | |
| Maintenance | | | | |
| Credit Facilities | | | | |

2. If the Shared Transport Emergency Vehicle program employs 2001 Honda Civics as its vehicles. If we used each of the following vehicles instead how much more or less would you be willing to pay per month? (Circle an amount)

Ford Focus

| | | | | | | | | | | |
|--------|-------|-------|-------|------|----|-----|------|------|------|-------|
| LESS | | SAME | | MORE | | | | | | |
| -R1000 | -R500 | -R250 | -R100 | -R50 | R0 | R50 | R100 | R250 | R500 | R1000 |

Honda Accord

| | | | | | | | | | | |
|--------|-------|-------|-------|------|----|-----|------|------|------|-------|
| LESS | | SAME | | MORE | | | | | | |
| -R1000 | -R500 | -R250 | -R100 | -R50 | R0 | R50 | R100 | R250 | R500 | R1000 |

Toyota Prius (Hybrid-Electric Vehicle)

| | | | | | | | | | | |
|--------|-------|-------|-------|------|----|-----|------|------|------|-------|
| LESS | | SAME | | MORE | | | | | | |
| -R1000 | -R500 | -R250 | -R100 | -R50 | R0 | R50 | R100 | R250 | R500 | R1000 |

Used Honda Civics (identical to current vehicles but two years older)

| | | | | | | | | | | |
|--------|-------|-------|-------|------|----|------|------|------|------|-------|
| LESS | SAME | | | | | MORE | | | | |
| -R1000 | -R500 | -R250 | -R100 | -R50 | R0 | R50 | R100 | R250 | R500 | R1000 |

3. How much more per month would you be willing to pay if there were one sport utility vehicle, one minivan, and one pickup truck, in addition to the current fleet of Honda Civics? (Circle an amount)

| | | | | | | |
|------|-----|------|------|------|-------|--|
| SAME | | | | | MORE | |
| R0 | R50 | R100 | R250 | R500 | R1000 | |

4. Assuming your monthly cost remains the same, how much would you be willing to pay on a per use basis to use a specialty vehicle? (Select one)

| | |
|--|---------------------------------------|
| <input type="checkbox"/> R5 per hour | <input type="checkbox"/> R100 per day |
| <input type="checkbox"/> R10 per hour | <input type="checkbox"/> R200 per day |
| <input type="checkbox"/> R20 per hour | <input type="checkbox"/> R450 per day |
| <input type="checkbox"/> R 30 per hour | <input type="checkbox"/> R850 per day |

5. Which method of payment would you prefer?

Higher monthly rates for a limited number of hours
 Pay per day

6. What do you think the monthly km limit should be for Home/University based Users? (Select one)

500 km's per month
 750 km's per month
 1,000 km's per month
 1,200 km's per month
 There should be no limit
 There should be a charge for every km driven

7. If the home-based/ University users are allowed 1,000 km's per month. How much would you be willing to pay per km if you exceeded the 1,000 km monthly limit? (Select one)

There should be no extra charge.
 R.2 per km
 R.4 per km
 R.6 per km
 R.8 per km

8. Suppose you are a satisfied WITS Integrated Shared Transport Emergency Vehicle user after one year and you want to continue using the service to travel to university as your preferred options instead carpooling. Do you think you would dispose of one of your personal vehicles at that time? (Select one)

I think I would still keep all my vehicles.

I would probably put a car into storage.

I would sell one of my cars.

I would loan a vehicle to a friend or family member long-term.

Other, please specify:

9. Keeping in mind your response to the last question, what would you be willing to pay per month for access to WITS Integrated Shared Transport Emergency Vehicle Option?

R_____

Optional: Do you have any comments on carsharing costs that you would like to share with us? _____

Questionnaire Distribution System Used

Step 1: Set up a Google form with relevant questions in order to collect all critical variables for the feasibility study.

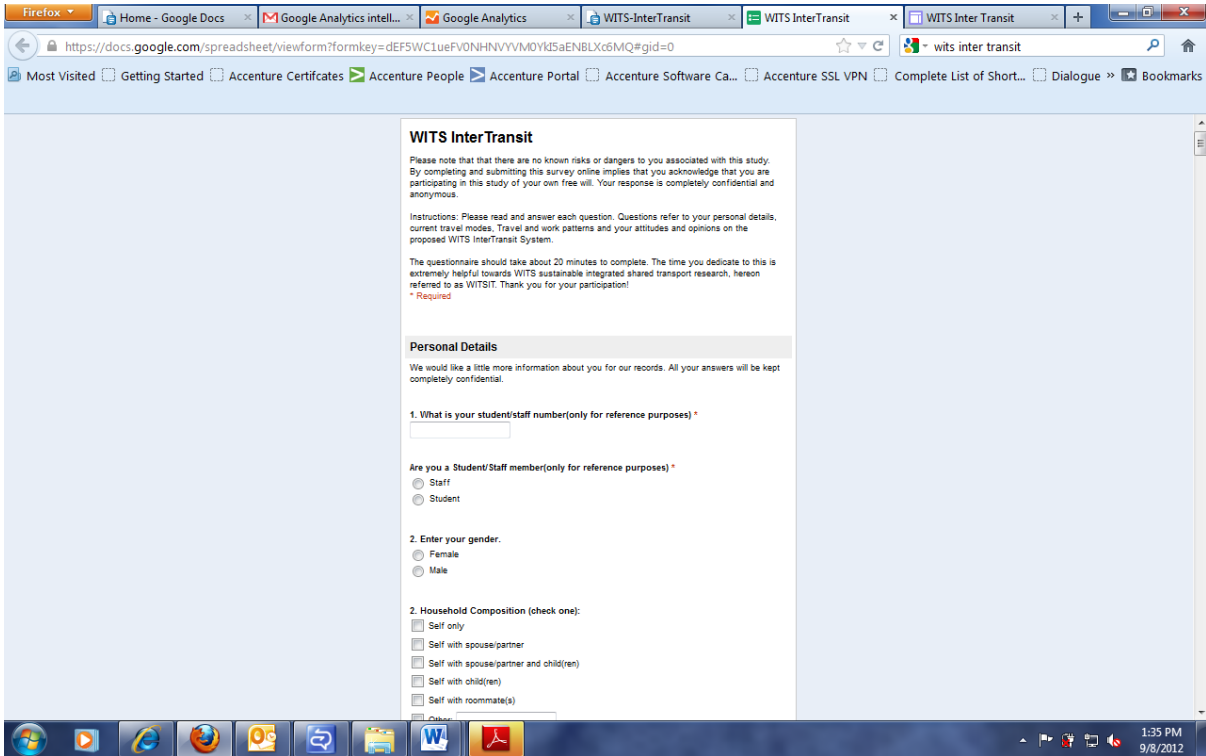


Figure D.1: Online Questionnaire

Step 2: Test exports of data to the Google WITS Inter-transit Spreadsheet.

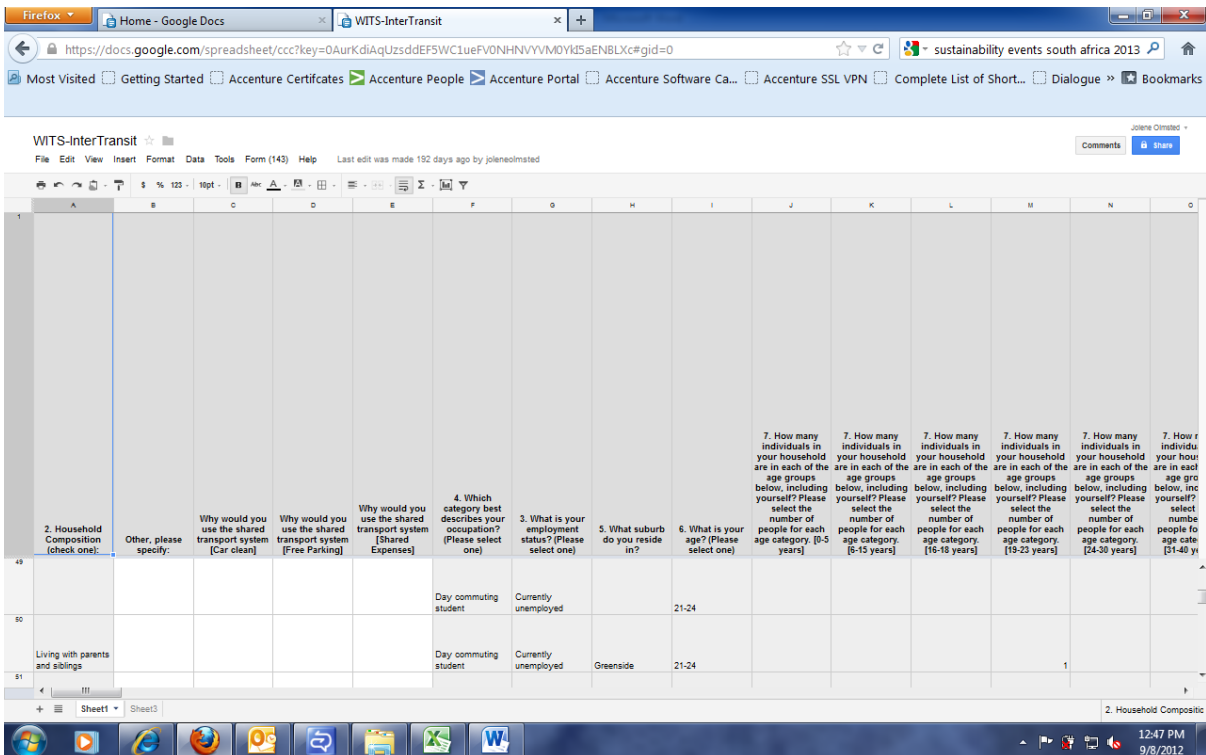


Figure D.2: Link to Google Spreadsheet

Step 3: Create an interactive Website to ensure positive first time interaction with the concept, as the survey participant will most likely be the end users of the model.

The survey is embedded in the website. Select the [link](#) to view the website

In order to gain responses from WITS students we had:

- Communicated with the Faculty registrars to request the students to complete the survey online
- Distributed a request for response via both the Student and Staff wits emails
- Placed posters up around WITS requesting Students to respond to the survey online
- Attended the WITS Orientation week and personally approached both new and registered students with flyers to take part in the survey online

Firefox Home - Google Docs WITS-InterTransit WITS Inter Transit

https://sites.google.com/site/witsintertransit/home

WITS Inter Transit

Home WITS Inter Transit Influences Sitemap

Home

What is WITS Inter Transit?

Research is currently taking place to propose the development and implementation of a WITS shared transport and dynamic real-time carpooling system.

WITS Inter Transit will provide financial benefits by reducing the funds needed for building future parking facilities, as well as providing benefits to the financially strained commuting students who will share the travelling and parking cost. The transport model will also reduce greenhouse gas emissions per commuter, lastly it is expected that there will be numerous social spin offs.

This website is designed as a social interactive tool to expose you to alternative, innovative and socially responsible travel models as well as collecting valuable data from future users of the proposed transport model.

YOU could be making a significant contribution to this research, all you have to do is:

1. Please complete the survey below,
2. Learn about the travel models that have influenced this research,
3. Lastly monitor the graphs related to your responses to reveal CO₂ emissions you could be reducing if were to carpool.

You could also be a lucky participant to **WIN a Nikon Coolpix S5100 Camera***

*A minimum of 200 participants and submission by **29 February 2012** is required to validate a prize winning-142 responses submitted, **1 DAY** left to complete submissions **so spread the word**

How will it work?

The **WITS Inter Transit System** aims to provide an integrated Shared Transport system which will provide WITS commuters with alternative economical, social and environmentally beneficial travelling options. The ideal system aims to provide users with flexible options:

- You join a carpool group as facilitated by a Wits social online network. This allows you to find commuters that travel from similar areas and have similar schedules;
- Your schedule is unpredictable and you are not able to commit to a regular carpool group. You would therefore join the smart phone application group and in real-time are able to find a driver who passes by your home on route. Log your requirements 30 min before the driver passes your home. They are directed via GPS coordinates, you both receive a verification code on meeting. If you accept the ride, you will share the cost of the ride for only the distance you travelled with that driver;
- As an emergency option, if you were unable to organise a carpool or share a lift use one of the emergency vehicles on campus, you will only be charged for time and distance the car was actually used to travel your home and back to the university the next day (if you are unable to return the car to the university you will be able to contact a sweeper unit to collect the vehicle for a reasonable fee)

If you select the second tab above you will be routed to a new page which provides details of these options as made available by existing service providers. Initially the WITS Inter Transit System will be managed very similarly to the current UC Ridelink Carpooling Model.

Ongoing WITS Inter Transit Research will provide insight as to how these three options can be best integrated and suited to the Wits Commuter needs, possibly to be made available to future users.

Potential Financial Savings per WITS commuter, who currently travels alone in a private vehicle, carpools with 4 other people instead.

| Savings Type | Commuter NOT Carpooling (R) | Commuter Carpooling (R) |
|-----------------|-----------------------------|-------------------------|
| Weekly Savings | ~1000 | ~100 |
| Monthly Savings | ~4000 | ~1000 |

Save R830 (Weekly), Save R3321 (Monthly)

Calculated using AA-Vehicle-Operating-Cost-Calculator
 ** The savings are based on commuters travelling a total of 40km's to and back from Wits per day

For any related questions contact the researcher at witsintertransit11@gmail.com

Please Complete the Survey

WITS InterTransit

Please note that that there are no known risks or dangers to you associated with this study. By completing and submitting this survey online implies that you acknowledge that you are participating in this study of your own free will. Your response is completely confidential and anonymous.

Instructions: Please read and answer each question. Questions refer to your personal details, current travel modes, Travel and work patterns and your attitudes and opinions on the proposed WITS InterTransit System.

The questionnaire should take about 20 minutes to complete. The time you dedicate to this is extremely helpful towards WITS sustainable integrated shared transport research, hereon referred to as WITSIT. Thank you for your participation!

* Required

Personal Details

We would like a little more information about you for our records. All your answers will be kept completely confidential.

1. What is your student/staff number(only for reference purposes) *

Are you a Student/Staff member(only for reference purposes) *

Staff
 Student

2. Enter your gender.

Female
 Male

Potential Carbon Emission Reduced

Gauge

Monthly Accumulative Emissions
 for WITS survey respondents commuting in a private vehicle alone: 5129.52 CO₂ kg's

Monthly Accumulative Emissions
 as a result of WITS survey respondents switching to carpool: 385.8624 CO₂ kg's

Sign in | Report Abuse | Print Page | Remove Access | Powered by Google Sites

12:52 PM 9/8/2012

Figure D.3: Online WITSIT Website

WITS Inter Transit

WITS Inter Transit Influences

The following videos have been sourced from YouTube. It aims to educate the survey participants of the travel modes that form the basis of the proposed WITS Inter Transit through providing information on current available Shared Transport models, made publically available by the service providers.

Online Carpool Network

Smart Phone App Assisted Carshare

Emergency Onsite Shared Transport

Online Carpool Network

Smart Phone App Assisted Car Share

Emergency Onsite Shared Transport

DriveNow - the unique and innovative car sharing venture

12:59 PM 9/8/2012

Figure D.4: Online WITSIT Media links

Step 3: The final results are exported to the Google WITS Inter-transit Spread sheet

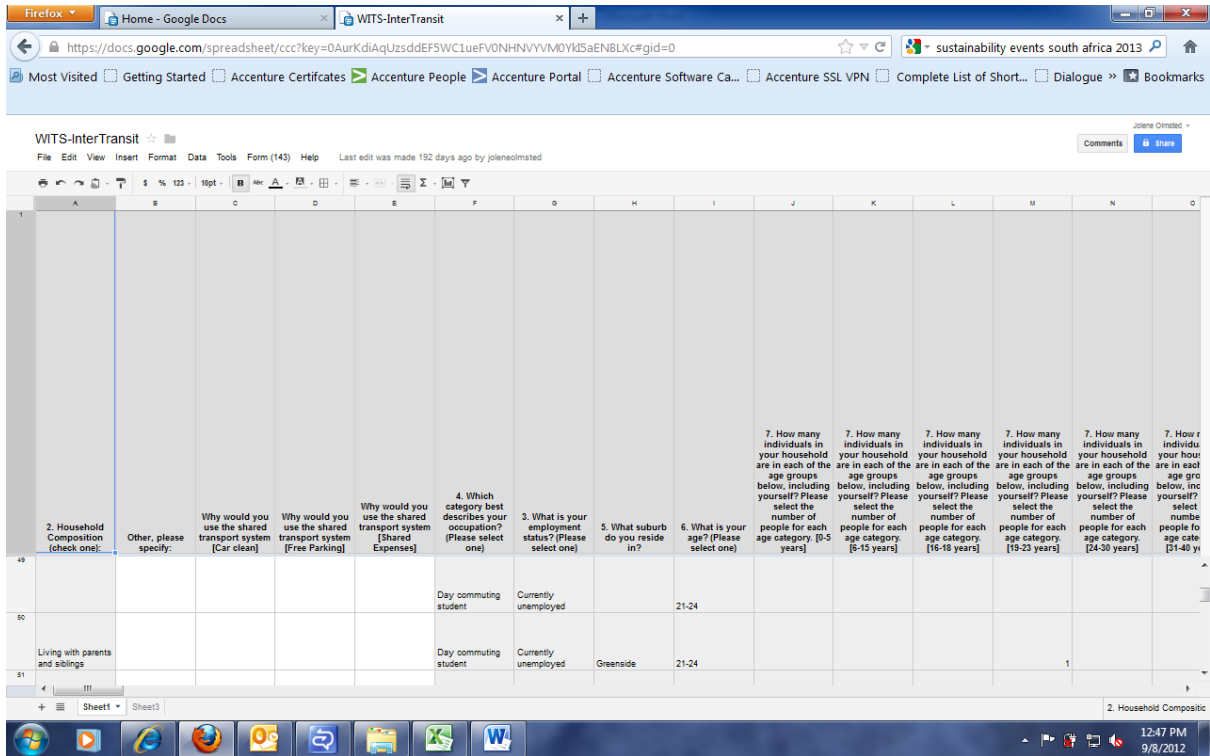


Figure D.5: Updated link to Google Spreadsheet

Step 4: This could be exported to a summary view to graphically interpret the responses and detect trends without any manual manipulation.

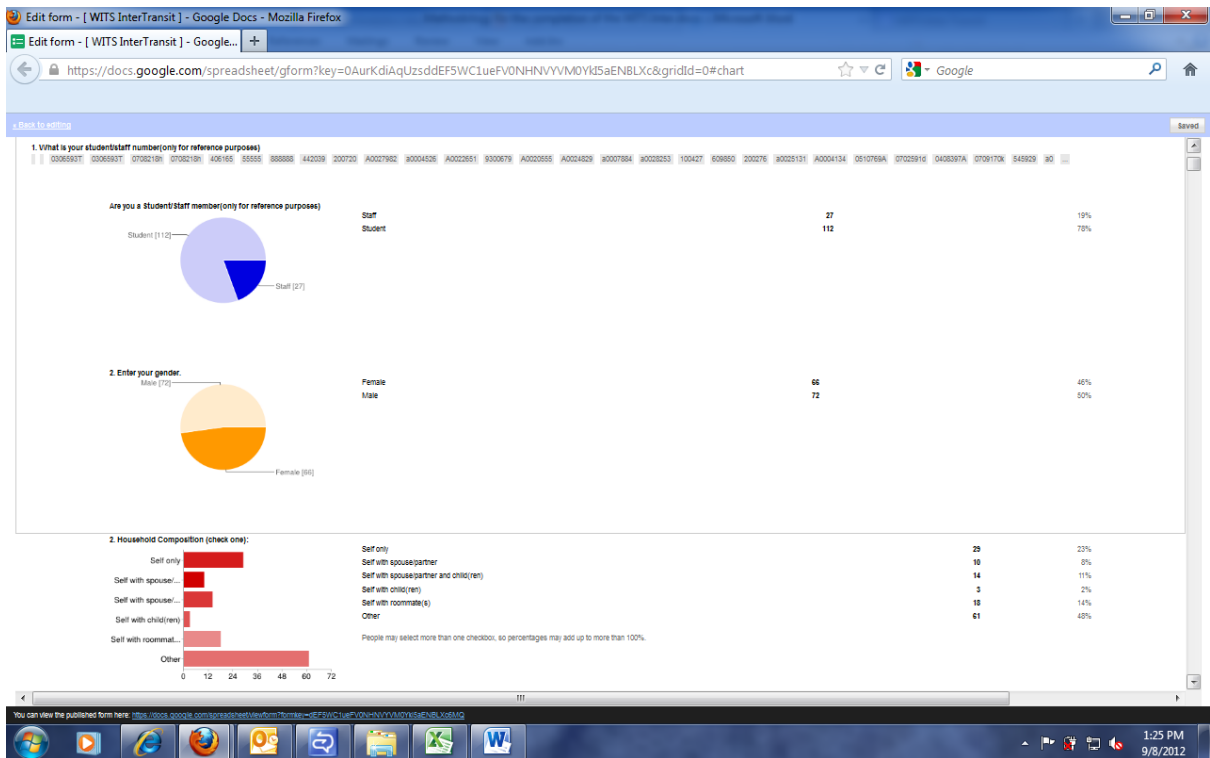


Figure D.6: Google Spreadsheet Graphical Summary

Step 5: The responses had been tracked on Google Analytics, which provided frequent reports of activity on the site. An initial report could also be requested from the Google Analytics, which depicted the responses in graphical form, enabling the researcher to establish trends in the responses without any manual interpretation.

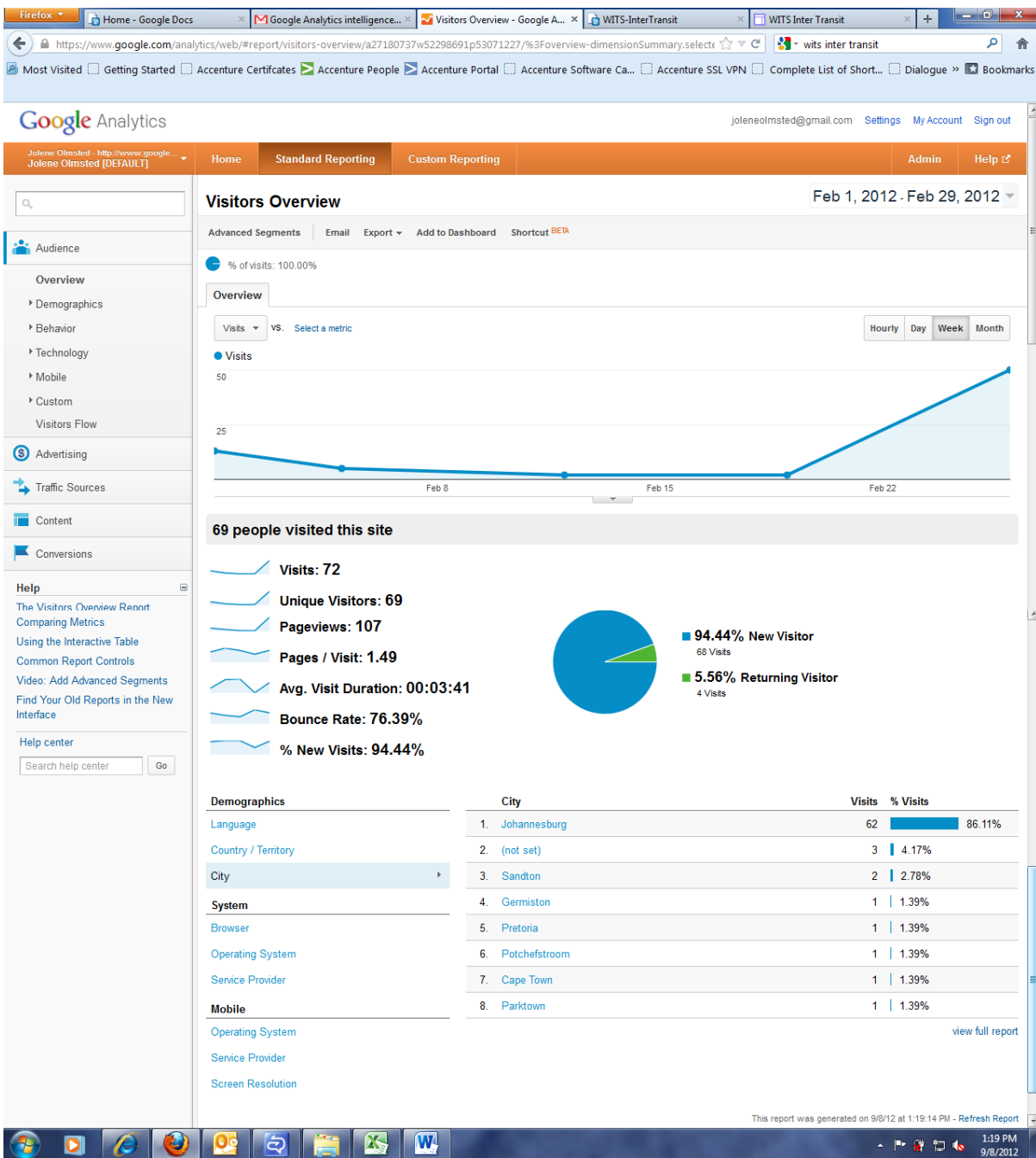


Figure D.7: Google Analytics Dashboard-Visitor's Overview