

The Impact of Rapid Urbanisation on Public Transport Systems in the Gauteng Region of South Africa

J. Chakwizira, P. Bikam, T. A. Adeboyejo

Abstract—This paper seeks to illustrate the impact of rapid urbanization (in terms of both increase in people and vehicles) in the Gauteng region (which includes Johannesburg, Pretoria and Ekurhuleni). The impact that existing transport systems and options place on the capacity of residents from low income areas to travel and conduct various socio-economic activities is discussed. The findings are drawn from a 2013 analysis of a random transport household survey of 1550 households carried out in Gauteng province. 91.4% of the study respondents had access to public transport, while 8.6% had no access to public transport. Of the 91.4% who used public transport, the main reason used to explain this state of affairs was that it was affordable (54.3%), convenient (15.9%), Accessible (11.9%), lack of alternatives (6.4%) and reliable at 4.1%. Recommendations advanced revolve around the need to reverse land use and transportation effects of apartheid planning, growing and developing a sustainable critical mass of public transport interventions supported by appropriate transport systems that are environmentally sustainable through proper governance. 38.5% of the respondents indicated that developing compact, smart and integrated urban land spaces was key to reducing travel challenges in the study area. 23.4% indicated that the introduction and upgrading of BRT buses to cover all areas in the study area was a step in the right direction because it has great potential in shifting travel patterns to favor public modes of transport. 15.1% indicated that all open spaces should be developed so that fragmentation of land uses can be addressed. This would help to fight disconnected and fragmented space and trip making challenges in Gauteng. 13.4% indicated that improving the metro rail services was critical since this is a mass mover of commuters. 9.6% of the respondents highlighted that the bus subsidy policy has to be retained in the short to medium term since the spatial mismatches and challenges created by apartheid are yet to be fully reversed.

Keywords—Urbanisation, population, public, transport systems, Gauteng.

I. INTRODUCTION

URBANISATION is a major transformative phenomenon making and changing places globally. Urban areas and their populations are projected to experience substantial growth over the period to 2050. This growth in particular is expected to be most severe in the least developed countries which have constrained capacity to tackle the resulting problems [1]. The urban global tipping point was reached in 2007 when for the first time in history over half of the world's

population 3.3 billion people were living in urban areas. It is estimated that 60% of the world's population will be urbanised by 2030 and the majority of them will be from developing countries [2].

Spatial mismatches exist between where the poor reside and economic opportunities lie in many Sub-Saharan African cities particularly in Gauteng. This prevents many people from breaking out of the shackles of poverty, owing to restricted access to not only job destinations but also information networks about opportunities for training services and microloans [3]. The combination of rapid motorization, urban sprawl, under-developed road systems, and spatial mismatches has given rise to difficult traffic conditions in cities of the developing world. Time losses from traffic congestion are estimated to comprise 2 percent of GDP in Europe and 2 to 5 percent in Asia [4]. However, most countries in Europe and Asia can manage such congestion. The ability to manage and respond to escalating demands for urban travel is often limited in developing cities. Institutional shortcomings - such as an insufficiently trained and educated civil-service talent pool or absence of a transparent and corruption-free procurement process for providing transport infrastructure - abound [3], [5].

The last comprehensive investigation of travel patterns across South Africa was the National Household Travel Survey of 2003. It highlighted the dominance of private motor cars and minibus taxis in metropolitan and other urban areas, and the relative underperformance of bus and rail transport. With some variations, transport is the major source of energy consumption in urban areas (56 percent), followed distantly by industry (14 percent) and households (13 percent) [6]. In South Africa, taxis are the most commonly used form of public transport in South Africa. According to the General Household Survey of 2009, approximately 42.0% of the households had at least one household member who used a minibus/sedan taxi or bakkie taxi during the week preceding the survey. Provinces with the highest levels of use of minibus taxis were: Mpumalanga (50.9%), Gauteng (49.0%), KwaZulu-Natal (46.6%) and North West (44.7%). Nearly three-quarters (73.6%) of the individuals attend an educational institution walk to get there. A further 8% travel by private car and 8% use taxis. The most commonly used mode of transport to go to work is the private car (33.1%), followed by taxis (22.6%) and walking (19.9%). Nearly 12 per cent (i.e. 11.6%) of the working population work from home and therefore need no transport [7]. Given this background, it is therefore important to study and understand the impact that rapid urbanisation (in terms of increase in both people and vehicles) mean for transport circulation, business and society in the

J. Chakwizira is with the University of Venda, School of Environmental Sciences, P.Bag X5050, Thohoyandou, 0950, South Africa (phone: +27-(0)76 387 7814; fax: +27-(0)15 962 8587; e-mail: james.chakwizira@univen.ac.za).

P. Bikam is with the University of Venda, School of Environmental Sciences, P.Bag X5050, Thohoyandou, 0950, South Africa (phone: +27-(0)72 340 7451; fax: +27-(0)15 962 8587; e-mail: pbikam@yahoo.com).

T.A. Adeboyejo is with Ladoko Akintola University of Technology, PMB 4000, Ogbomosho, Nigeria (e-mail: thompsonadeboyejo@yahoo.com).

Gauteng region (which includes Johannesburg, Pretoria and Ekurhuleni).

A. Aims and Objectives

The study major aim was to unravel the impact that rapid population growth (of both people and vehicles) mean for transport circulation, business and society in the Gauteng region. The following specific research questions were generated, namely:

1. What are the socio-economic characteristics of urban commuters in Gauteng and in particular low income earners?
2. Which are the major modes of transport that urban commuters in Gauteng use in accessing socio-economic opportunities and why?
3. How can the urban commuting challenges in Gauteng province be addressed?

II. MATERIALS AND METHODS

A. Research Methodology

The study adopted a mixed research methodology to unravel the impact that rapid urbanisation (expressed both in terms of an increase in people and vehicles) mean for transport circulation and society in the Gauteng region (which includes Johannesburg, Pretoria and Ekurhuleni). Both secondary data sets such as the national household travel survey (NHTS) [8], 2003, general household survey (GHS), 2009, various official transport documents from the department of transport (DoT) and Gauteng Province, Johannesburg, Pretoria and Ekurhuleni municipalities were further analysed to understand important trends. The results and findings are further strengthened by including primary data findings from sample frame comprising randomized household sample size of 1550 units. This is made up of 150 (representing 9.6% of the total sample size) household apiece for Pretoria CBD, Mamelodi, Pretoria East, Mabopane, Hammanskraal and Midrand & Johannesburg CBD with 100 households (representing 6.4% of the total sample size each), Thembisa, Soweto, Alexandra and Sandton 150 (representing 9.6% of the total sample size each).

B. Case Study Approach

The study adopted the Gauteng region as a unit of analysis. This was informed by the fact that Gauteng is the most urbanized and vibrant region of South Africa. In addition, large cities of the developing world like Johannesburg, travel times are generally high and increasing, destinations accessible within limited time are decreasing [9]. Gauteng's province is the country's centre of trade with Southern Africa and beyond. In 2011 Gauteng produced 34.5% of the national GDP in current prices [10]. There is a widespread perception that better work and education opportunities are available in Gauteng. As such it is a growing pole of attraction for migrants from South Africa's rural areas and other urban centres, as well as immigrants from the continent. The entrance of newcomers gives it an increasingly cosmopolitan character and vibrant social and economic life.

III. LITERATURE REVIEW

Literature review confirmed the existence of differing land use and transport approaches, urban transport typologies and options for solving identified challenges. The growth of cities depends on different factors resulting in either a heterogeneous or homogeneous development related to jobs, housing and amenities among the population. Urban planning and transportation scholars in both developing and developed countries have for some time been exploring the connection between urban spatial structure and patterns of commuting. The major findings of these investigations have been that decentralization of urban employment and dispersed urban spatial structure has profound implications for people's commuting patterns [11]. The main ingredients of an urban spatial structure are the people's spatial distribution, socio-economic opportunities' spatial distribution, especially employment, and the people's commuting behaviour that links them to opportunities [12]-[15]. The section that follows reviews some of the mainstream city growth models of relevance to the study subject matter.

A. Monocentric City Model

In a monocentric city, there is a highly concentrated employment centre. Residents generally live in suburbs implying high commuting flows on radial routes into the centre. Consequently urban commuting has many origins for work trips but a concentrated destination. Although housing outside of the central business districts is less expensive than in the center, transportation costs (in money and time) away from the city centre are higher.

B. Poly and Multi-Centric City Model

In the mono-centric city model, people work in the central business center and reside in suburbs outside the main centre entailing daily commuting; the idea is slightly different in a poly and multi-centric city. The need to address the imbalance between job and housing markets as well as residential immobility creates a polycentric and multi-centric city. In this city people criss-cross the urban landscape commuting from one business district to another. Under this model the optimal commuting time is attained which is defined as the result of the average commuting distance required if individuals could exchange residences and workplaces to minimize the distance travelled. The proportion of the actual commuting distance above the optimum is defined as excess or wasteful commuting. In reality, a poly/multi centric city functions in a similar manner to a monocentric city – people are attracted by jobs from all over the city. But the commuting patterns are different [16]. There are two commuting models of poly/multi centric city. One model is that the city has some sub-centres of employment of a similar scale and in such a kind of polycentric city, each sub-centre generates trips from all over the city. The characteristics of commuting present a wide dispersion of origins and destinations, appearing almost random. Another model is that there are also different sub-centres of employment but one sub-centre is more concentrated and stronger than others. The urban commuting

flows would be composite of both random and radial patterns [11], [16]-[18].

Consequently, various city growth models that impact significantly on spatial structure have diverse implications in terms of influencing and affecting people's patterns of commuting particularly with regard to trip duration, distance as well as modal choice.

IV. SOCIO-ECONOMIC CHARACTERISTICS OF URBAN COMMUTERS IN GAUTENG PROVINCE

This section reviews the socio-economic characteristics of urban commuters in Gauteng province and in particular low income earners.

A. Population

According to the 2001 South African census, the continuous urban region within the borders of the Gauteng province (an area of 18 182 km²) housed 9 388 855 people. By the 2011 census this had grown to 12 272 263. Fig. 1 represents population density across the Gauteng province as a 3D map. The data was derived from the StatsSA Census 2011 Small Area Layer (SAL), by proportionally assigning the population to a randomly generated 1 km² grid. The highest density of 66 892 people per km² is located at the centre of the GR in the Johannesburg CBD, followed by Alexandra with 41 305 people per km². Pretoria CBD, Diepsloot and Tembisa are the next densest areas.

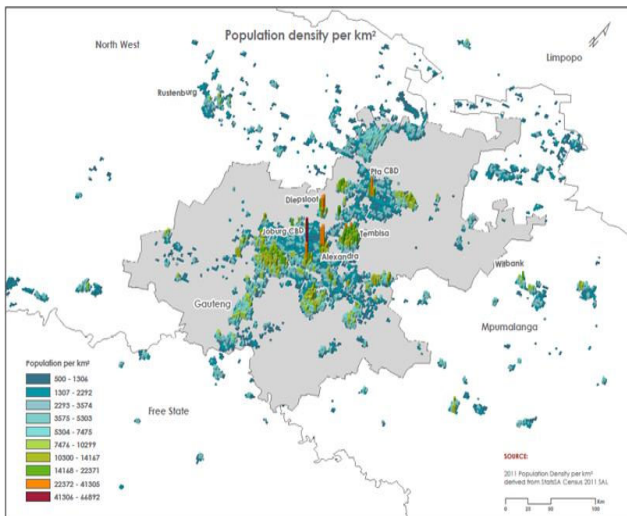


Fig. 1 Population density in Gauteng region (2011)

B. Gender

Fig. 2 presents the gender attributes of the study area by location. 60% (930) of the study respondents were male while 40% (620) were female. This is typical of migration and mining urban settlements in South Africa, which predominantly indicate male migration in search of employment. The detailed disaggregation by location follows the overall pattern with however few outliers with for example Midrand having the lowest female representation at 5.32%, Hammanskraal at 11.61% having the highest. Women find it

relatively easier to access and reside in the low income areas such as Hammanskraal compared to the much more affluent areas such as Midrand. The highest male concentration is in Sandton and Alexandra (11.18%), followed by Soweto (10.22%) and Thembisa (10.43%). These are traditional attraction areas for male migrants, low income earners as well as male dominated areas.

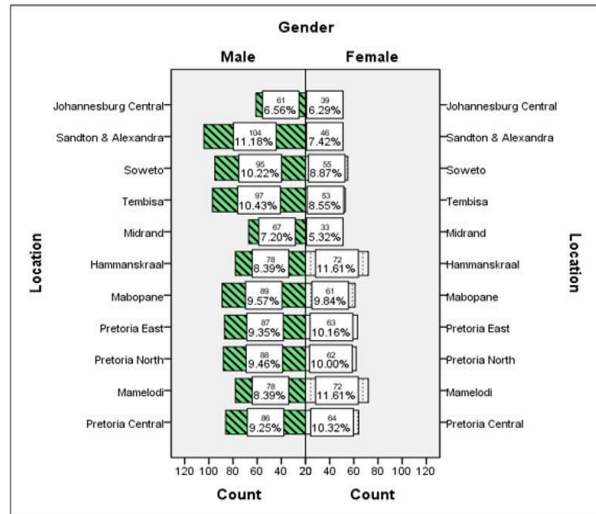


Fig. 2 Gender Attributes of Study Area

C. Race

Fig. 3 presents the attributes of the study area by race. 95.3% of the study respondents are African, which is the most dominant racial group in the study area. The remainder is constituted of the less dominant groups such as Indians, coloureds, whites and other nationalities from all over the World.

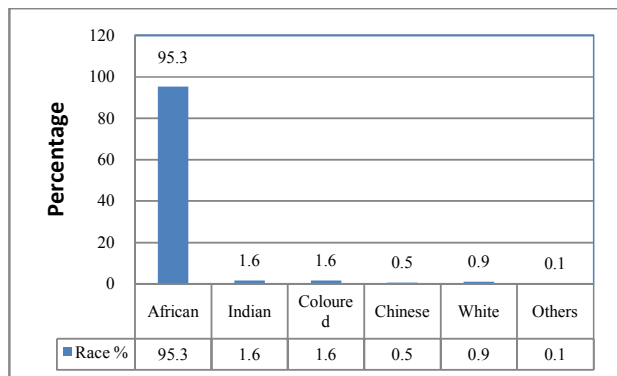


Fig. 3 Racial composition in the study area

D. Mother Tongue

Fig. 4 presents the mother tongues spoken in the study area. The main dominant mother language is IsiSepedi which was spoken by 21.3% of the respondents. This was followed by Venda at 13.4% and Tsonga at 13.0%. IsiTswana was spoken by 11%, while English at 3.4% and Afrikaans at 2.7% were among the least mother tongue languages in the area. The

results were expected given that the Whites and Afrikaans are a minority while IsiSepedi & isiTswana is the indigenous language of the study areas. The high prevalence of Venda and Tsonga is not only a reflection of the cosmopolitan nature of the study area but direct indicator of the strong migration dragnet of municipalities in the study area such as Johannesburg, Pretoria and Ekurhuleni.

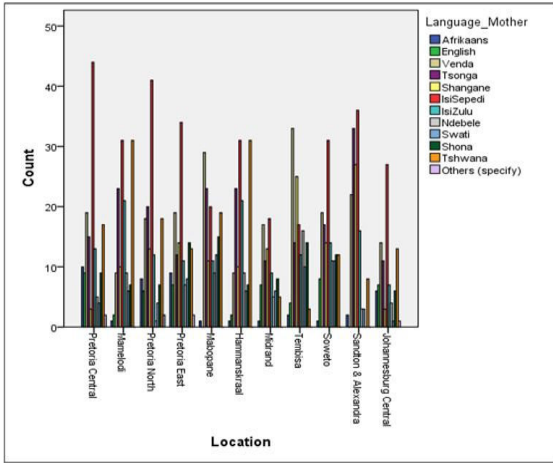


Fig. 4 Mother Tongue Languages Spoken in Study Area

E. Religion

Fig. 5 presents the religious composition of the study area. The majority of the respondents are Christians at 70.7%. This is expected since South Africa is a Christian state. Traditional religion at 22% follows while Islam at 1.3% is among the minor religion groups. The diversity of religion adds to the complexity and culture of the Gauteng region.

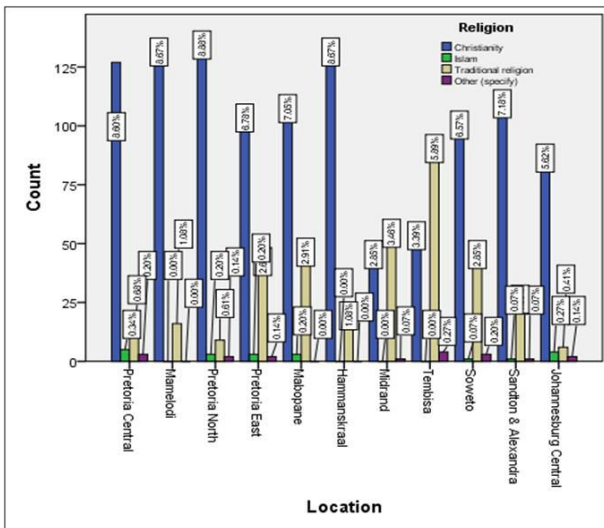


Fig. 5 Profile of Religion in the Study Area

F. Highest Education

Fig. 6 presents the educational profile in the study area. 42.5% of the respondents have vocation qualification. This is expected given that Gauteng is the commercial and industrial

hub of Southern Africa. 25.5% of the respondents have grade 12 qualification, while 21.1% have a Junior degree. 7.1% of the respondents have a Bachelor (honours) degree while those with postgraduate degrees at 1.8% and those with grade 6 at 1.2% are the lowest educated groups. The respondents on average have a basic literacy level to be useful in engaging in the urban transport research discussion.

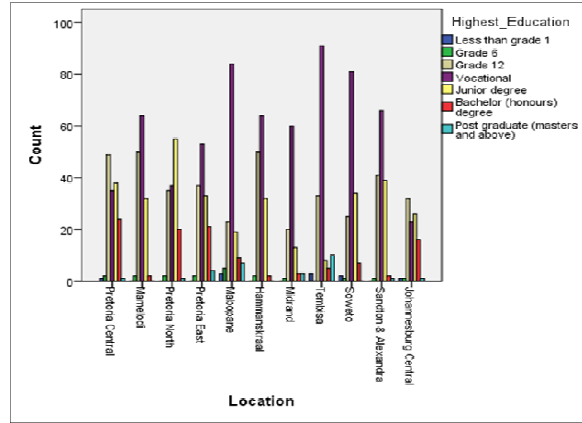


Fig. 6 Highest Education Level Attained by Respondents in the Study Area

G. Type of Suburb

The respondents were drawn from different segments in Gauteng province as depicted in Fig. 7. 9.6% of the respondents were drawn from Pretoria Central, Mamelodi, Pretoria North, Pretoria East, Mabopane, Hammanskraal, Thembisa, Soweto and Sandton and Alexandra. 6.4% apiece of the respondents came from Midrand and Johannesburg central. 21.4% of the respondents were drawn from middle income areas, while 52.1% were drawn from low income areas – formal. 10.4% were drawn from low income area – informal. 15.8% of the respondents live in mixed income housing (this includes middle and high income areas). The wide spatial distribution of respondents from different socio-economic backgrounds and neighbourhoods ensured a wide coverage and representation of public transport issues affecting the breadth and depth of Gauteng province.

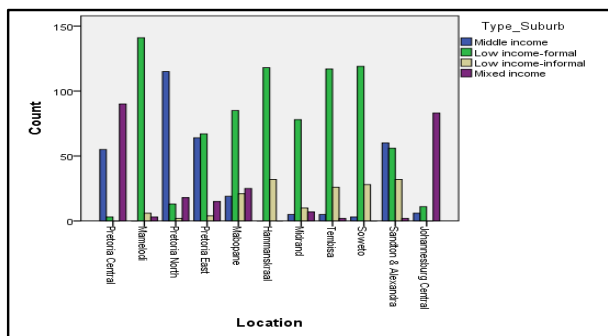


Fig. 7 Type of Suburb where Respondents in the Study Area Stay

H. Driving License

Fig. 8 presents the portrait of driving in the study area. 36.7% of the respondents have driving licenses to drive private cars. 54.1% of the respondents did not have any license and these were mainly from the low income areas. 4.5% have licenses to drive trucks while another 2.8% have licenses to drive buses. Driving licenses possession is higher in low income areas compared to high income areas. This is because of the perceived value and employment opportunities attached to it by employers.

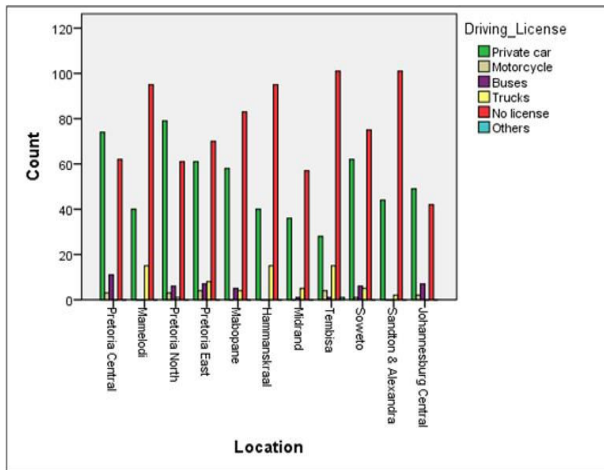


Fig. 8 Type of Suburb where Respondents in the Study Area Stay

I. Household Income

Fig. 9 presents the household income in the study area. The highest group of respondents earn between R 3001-R5000 at 22.4%. 21.3% of the respondents earn between R 5001-R7000. A paltry 2.5% earn greater than R 21 000 while 1.3% earn between R19000-R21000. The results are typical and were expected of a study that sought to find predominantly how low income earners commute in the Gauteng province.

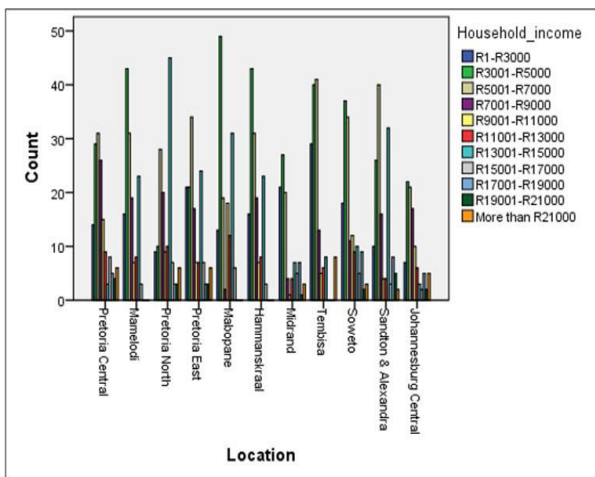


Fig. 9 Household Income in Study Area

V. TRANSPORT MODES USED BY URBAN COMMUTERS IN GAUTENG PROVINCE

This section presents an analysis of the major transport modes used by urban commuters in Gauteng province to access various socio-economic opportunities in the study area.

A. Number Travelling

Fig. 10 presents the number of persons that travel daily from different residential areas to conduct various social-economic opportunities in the study area. The highest number of males travelling per household is three males representing 33.8% of the study population, while two males travelling represent 26.9% of the study population. 1 male who travel per household represent 16.5% of the total respondents. More males travel per household than females indicating that the society is still male work dominated. The highest number of females is 3 representing 8.3% of total respondents, while two females travelling per household represent 6.8% of the total respondents. 1 female travelling per household in the study area represents 6.0% of the total study sample respondents. Family clustering and concentration is an aspect of the living style in the study area as nuclear and extended families stay together. At the same time, people stay as networks of connection sharing costs of living such as accommodation, electricity etc. The spatial distribution of persons travelling differs from place to place with Mamelodi, Pretoria North, Hammanskraal and Sandton & Alexandra having 3 males travelling from the households daily. The lowest numbers of females travelling is found in Mabopane and Midrand. These study areas have a strong male footprint.

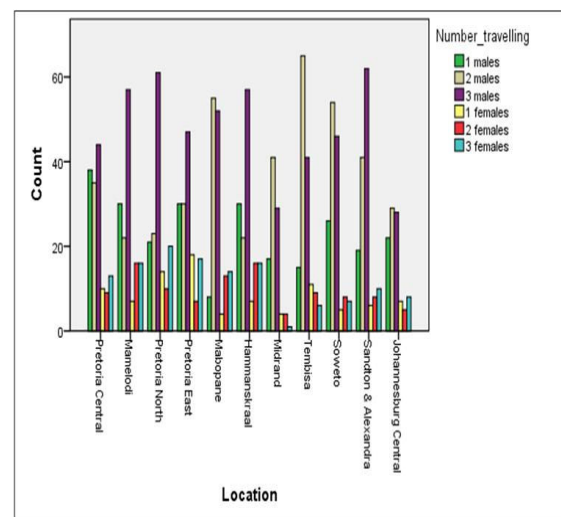


Fig. 10 Number of persons travelling daily from each household

B. Household Car Ownership

Fig. 11 presents household car ownership in study area. 64.8% of the total study respondents do not own a car. This is largely expected given that the focus of the study was to discover low income areas commuting patterns. 24.6% of the respondents owned a single car, while 7.7% of the respondents' households owned two cars. 1.7% of the

respondents owned three cars per household. 0.7% of the respondents' household had four cars while 0.9% owned more than four cars. The car ownership is unevenly spread with the low income areas such as Mamelodi, Mabopane, Hammanskraal, Thembisa, Soweto and Alexandra showing peaks. At the same time, Sandton and Alexandra, Mabopane and Pretoria East have high number of households that own 2 cars.

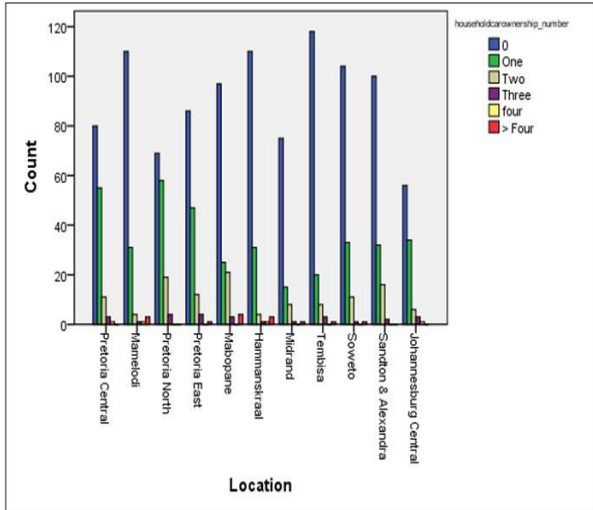


Fig. 11 Household Car Ownership in Study Area

C. Household Most Frequent Driver

Fig. 12 presents the most frequent driver per household. The father at 24.3% drives the household car most frequently, while the mother at 9.0% drives the household car more regularly. The son, daughter, relative (living at the same household) as well as helper at 0.9% and 0.1% respectively least drive the household cars in the study areas.

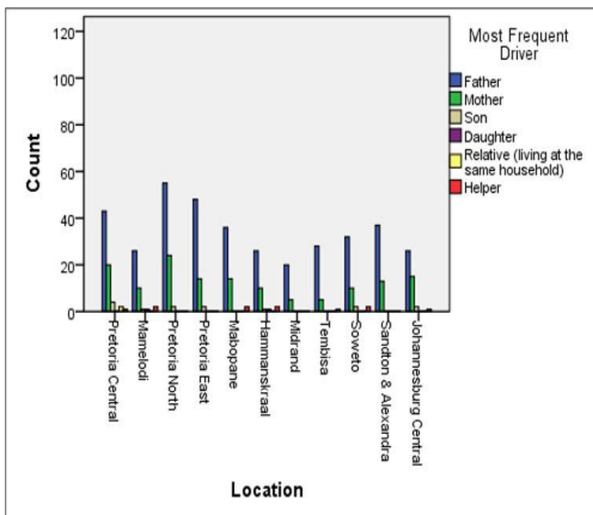


Fig. 12 Household Most Frequent Driver in the Study Area

D. Main Mode of Transport Used

Work trips at 82.1% are the highest trips that households in the study area make (refer to Fig. 13). This is followed by social and private business trips at 4.2% and 4.1% respectively. Residential trips constitute 2.4% while school and shopping trips are 1.9% and 1.8% respectively. The importance of work trips that are not discretionary in the study area cannot be disputed.

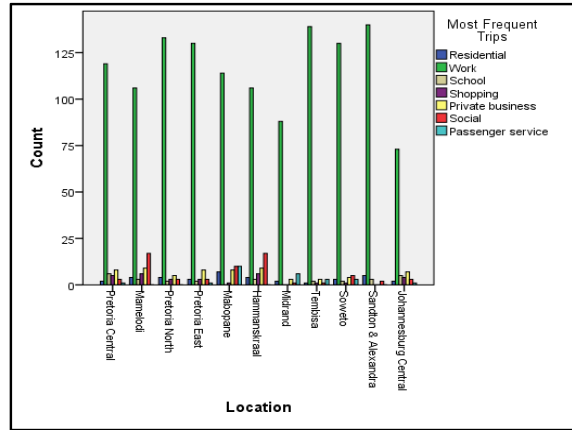


Fig. 13 Most Frequent Trips Undertaken in the Study Area

E. Main Mode of Transport Used

Table I presents the main modes of transport used in making most frequent trips.

31.4% use private cars, while 29.5% use Minibus taxi. The minibus taxi industry is an enormously important mode of transportation. The industry is well attuned to the fragmented form of South Africa's urban areas and has succeeded without the state subsidies that are provided to bus companies. However, interventions by government to improve conditions in the industry have been slow, with the Taxi Recapitalisation Programme achieving only about 25 percent of its stated objectives. The difficult question in relation to the taxi industry is how to create more stability through appropriate regulation, and through stronger partnerships between the industry and the state [19]. 20.7% use the metro-rail. 8.7% of the respondents walk, while 3.3% use the metro bus and 2.1% use private company cars. Cycling at 0.6% and School bus and Office vehicle at 0.1% are the lowest. Gautrain is used by 0.3% of the study respondents who are mainly middle to high income earners along the Hatfield – OR Tambo route. The last comprehensive investigation of travel patterns across South Africa was the National Household Travel Survey of 2003. It highlighted the importance of private motor cars and minibus taxis in metropolitan and other urban areas, and the relative underperformance of bus and rail transport. With some variations, transport is the major source of energy consumption in urban areas (56 percent), followed distantly by industry (14 percent) and households (13 percent) [6].

TABLE I
MAIN TRANSPORT MODE USED

Mode	Frequency	Valid Percent
Private Car Personal	487	31.4
Private Car Company	32	2.1
Motorcycle	15	1.0
School Bus	2	0.1
Office Vehicle	2	0.1
Metro Rail	322	20.8
Gautrain	5	0.3
Bus Rapid Transit	2	1.8
Minibus Taxi	459	29.6
Metro Bus	52	3.4
Walking	136	8.8
Cycling	10	0.6
Total	1550	100

91.4% of the study respondents had access to public transport, while 8.6% had no access to public transport. Of the 91.4% who used public transport, the main reason was that it was affordable (54.3%), convenient (15.9%), Accessible (11.9%), lack of alternatives (6.4%) and reliable at 4.1% (refer to Table II).

TABLE II

REASON WHY PUBLIC TRANSPORT IS THE PREFERRED CHOICE OF TRANSPORT

Mode	Frequency	Valid Percent
Affordable	841	54.3
Convenient	246	15.9
Accessible	184	11.8
Reliable	64	4.1
Lack of Alternatives	105	6.8
Others (Specify)	4	0.3
N/A	105	6.8
A Combination	1	0.1

F. Stated Public Transport Problems

Fig. 14 presents the stated public transport problems in the study area. High cost of fares at 21.3% and long waiting times at public transport bus stops (33%) were the major problems. Long walking distance to the nearest public transport stop/bus station/terminus at 14.7% was also noted as a key concern. Lack of reliability (9.4%), Insufficient service at night (2.8%), insufficient service during weekends (2.8%) and reckless driving behavior especially of Minibus taxi driver (3.0) were complaints at the lower rungs.

G. Waiting Times at Public Transport Bus Stops

In addition, respondents were asked to indicate issues regarding waiting times at public transport bus stops (refer to Fig. 15). 30% of the respondents indicated concern regarding increase in waiting period during peak periods especially for distant and peri-urban locations. 20% of the respondents indicated that the waiting periods for public transport were long during weekends and off-peak periods. At the same time, 20% indicated that there was a problem of late arrival at workplaces owing to public transport headway frequency service levels. 15% reported long queues during peak hours at bus stops or pick up points. 10% highlighted that businesses

do not open in time. This was especially true for the informal and self employed entrepreneurs.

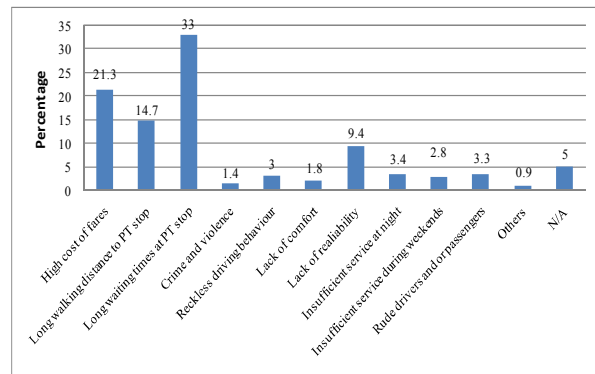


Fig. 14 Public Transport Problems as Stated by Respondents

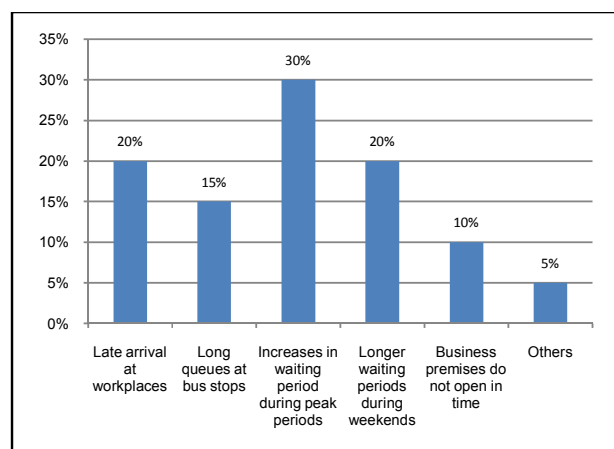


Fig. 15 Waiting times at Public Transport Bus Stops

H. Expenditure on Public Transport

Fig. 16 presents expenditure on public transport in the study area. 48.5% of the respondents spend less than R 500 on public transport. This is in terms of subsidized bus monthly tickets. 28.5% spend between R 501-R1000 and mostly this group is comprised of minibus taxi users. 2.3% spent between R2001-R2500 since the family has more than one member using either subsidized public transport or a minibus to go to school, college or work. For 13.8% of the respondents this was not applicable as they use own cars that provide them with better travel choice and freedom.

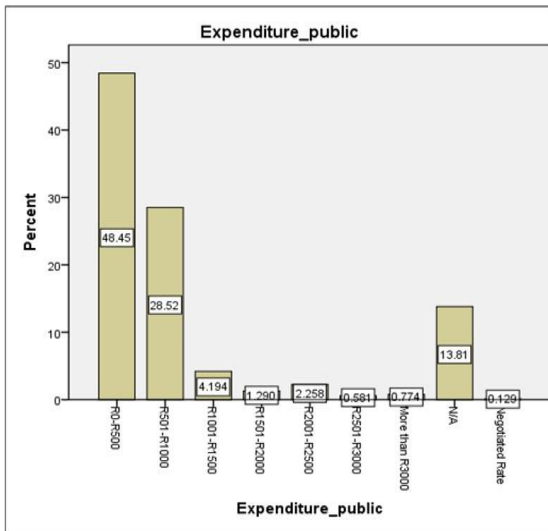


Fig. 16 Expenditure on Public Transport

I. Breadwinners Trip

Fig. 17 presents information regarding the trip that breadwinners make. 38.4% of the breadwinners in the study area use a Minibus taxi to go to work, while 28.6% use private cars. 14.1% use the metro train, 5.5 % (walk), 4.9% (bus), 3.5% a combination of modes and 2.7% (metro bus). This is typical of the trip modal distribution established by the NHTS, 2003 and the GHS, 2009. South Africa’s middle class is overwhelmingly dependent on the private motor car and so, despite comparatively low levels of affluence; private car ownership in South Africa’s big cities is relatively high. The result is congestion, high carbon emissions, and lengthy travel times. In the absence of adequate alternatives, those who cannot afford private transport are also vulnerable to social and economic exclusion. IBM’s 2010 *Commuter Pain Survey* [20], which analysed traffic patterns in 20 major cities internationally, rated Johannesburg as one of the most congested cities. The problem for South Africa is that car ownership levels are still relatively low and there is considerable scope for further growth of private vehicle ownership and use. In 2003, the car ownership level in metropolitan areas in South Africa was just 186 per 1 000 person. Over the past few years the number of passenger vehicles on South African roads has been increasing at about 3 percent a year, significantly in excess of population growth (and with a possible 7 percent a year increase in Gauteng) but still most people do not have access to a private car [7], [19]. As a result of this most breadwinners trips are undertaken through mini bus taxis. Although there has been a significant rise in passenger vehicles in Gauteng, this was due to the subsidy incentives given to minibus owners to purchase new buses during the 2010 World Cup.

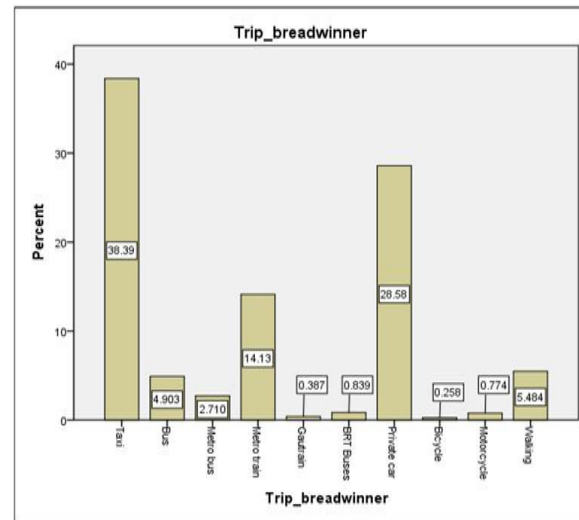


Fig. 17 Breadwinners Trip

J. Breadwinners Trip Approximate Distance Covered

Fig. 18 shows the approximate distance that the breadwinners trip on average cover. The majority of the respondents travel between 11-20km (46.77%), while 21.87% of the respondents travel between 21-30km. 16.32% of the respondents travel a distance less than 10km to their workplaces. Although 46.77% of the respondents travel shorter distances to their work places, the routes are often congested during peak hours particularly on the N1 road linking Pretoria and Johannesburg on Lynwood; Hans Strydom; Allendale; William Nicol, Rivonia, Elands, Buccleuch, John Vorster, Gilloolys etc.

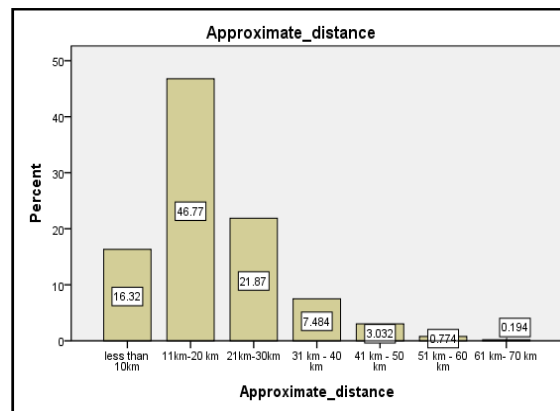


Fig. 18 Breadwinners Trip Approximate Distance Travelled

The Breadwinners trip has the following time implications, namely: 44.3% of the respondents spend between 21-30 minutes to access work places. 27.5% spend between 11-20 minutes. 10.1% spend less than 10 minutes while 11.6% spend between 31-40 minutes to access work places. Commuting times for black South Africans are longer than for white South Africans. The average travel time nationally for black commuters was 48 minutes in 2003, compared with

30 minutes for white commuters. The longest travel times are in metropolitan areas, where white commuters average 35 minutes and black commuters 59 minutes. Train and bus trips had the longest travel times with an average of 87 minutes and 68 minutes respectively for an average distance of 35km. [21].

57.2% of the respondents pay between R 10-20 per trip. 20.6% pay between R21-30 per trip. 7.4% pay between R31-40 per trip. For the lowest paid workers spending on average R 800 per month represents more than 20% of monthly income. This is way above the World Bank standard of 10%. Rapid urbanization coupled with inefficiencies in the movement of goods and people impose considerable costs on the economy and on individual households. In 2005/06 transport accounted for 20.8 percent of total annual household consumption expenditure in urban areas, compared with 19.9 percent nationally and 15.3 percent in rural areas [7]. The high cost of transportation is partly due to spatial form, and partly to do with modal splits and inefficiencies affecting particular types of transport. The introduction of Gautrain between Pretoria and Johannesburg has reduced the time of travel from 2 hours during peak hours on the N1 to under 1 hour. Although the Gautrain has helped in decongesting the N1 route, most ordinary poor commuters earning less than R 3000 per month cannot afford it hence only the affluent can access such services. The last comprehensive investigation of travel patterns across South Africa was the National Household Travel Survey of 2003.

K. Perceived Distance to Socio-Economic Centres

Fig. 19 presents the perceived distances to socio-economic opportunities by the study respondents. Over half of the respondents felt that the distances travelled are fair at 51.6%, while 38.9% felt that the distances are long. 8.8% of the respondents indicated that travel distances are short.

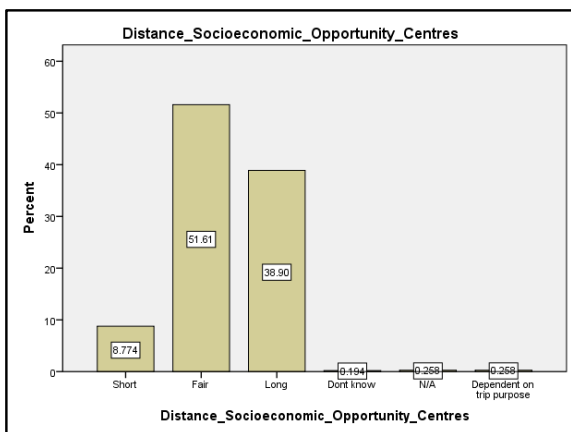


Fig. 19 Perceived Distance to Socio-Economic Centres

L. Summary of Findings in Gauteng Province

Fig. 20 presents a summary of the research findings. Reasons for increased urbanization are the post-apartheid free movement, higher economic growth in Gauteng which in turn attracted people in search of employment. Urbanisation is posed for an upward increase that is growing from 1.9%

(2001), 2.6 (2010) and is projected to 3% (2020). This is largely expected as by 2030 over 70% of South Africa is projected to be urbanized. Population growth rate increased from 2.6% in 2001 to a peak of 3.6% before starting to decline to 2.7% in 2010 and is projected to a low of 1.5% in 2020. The population growth is lower than urbanization indicating the strong in-migration growth element in Gauteng. Public transport has witnessed under-investment historically from the apartheid period. Despite efforts for taxi recapitalization, BRT Rea Vaya & Gautrain rapid rail which indicate the 12% increase that coincided with the 2010 World Cup, the level of investment required in public transport to catch up and reverse many years of fragmented public transport development backlog is inadequate. This is largely expected as developing countries generally invest little in the transport budget allocation and much less in public transport. Prior to 2000, a lot of investment into public transport was focused on the black population since over 80% of them relied on public transport. Part of this high investment was the local response in developing the taxi minibus industry as a way to overcome public transport deficits during the apartheid era.

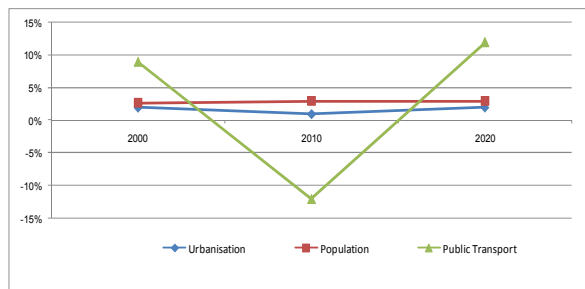


Fig. 20 Annual Percentage increase in urbanization, population growth and public transportation

M. Quality of Transport Index in Gauteng Province

Venter has developed four indicators used in the calculation of the quality of transport index (QoT) index which include: within-settlement transport conditions, area-wide accessibility levels, mobility expenditure and person-specific satisfaction [22]. In terms of worst performing low income areas, Refilwe and Hammanskraal significantly underperform other areas, largely as a consequence of their very low scores on the Within Settlement Index (refer to Fig. 21). In fact these areas are worse than the provincial average in all respects, except for the mobility expenditure which is at or below the average. This suggests that in both areas inaccessibility results in suppressed travel, which could significantly reduce welfare. Other bad performers are also in peripheral locations with poor or no rail service – including Ratanda, Rethabiseng, Garankuwa, Bophelong, and Khutsong. Most townships close to the economic core of Gauteng scored around the average QoT value, including many Ekurhuleni and Soweto townships. Best performers are Soweto (East), Tembisa, and Orlando, and finally Wattville. These are all areas with both high within-settlement access, good area-wide connections to job opportunities, and low to medium transport expenditures (in

terms of cost and time), indicating that residents benefit from their good location by being able to reduce the burden of travel.

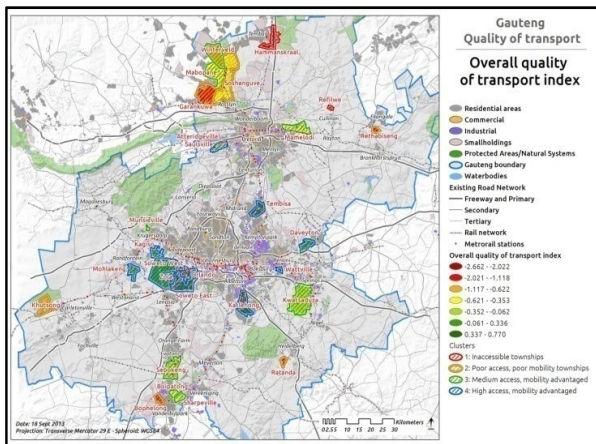


Fig. 21 Overall Quality of Transport Index

VI. ADDRESSING URBAN COMMUTING CHALLENGES IN GAUTENG PROVINCE

This section presents potential measures and actions that can be implemented to solve urban commuting challenges in the Gauteng Province.

A. Transport Commuting Affordability Solutions

Fig. 22 presents stated urban commuting solutions to addressing identified transport commuting affordability challenges. 38.5% of the respondents indicated that developing compact, smart and integrated urban land spaces was key to reducing travel challenges in the study area. 23.4% indicated that the introduction and upgrading of BRT buses to cover all areas in the study area was a step in the right direction which has great potential in shifting travel patterns to favor public modes of transport. 15.1% indicated that all open spaces should be developed so that fragmentation of land uses can be addressed. This would help to fight disconnected and fragmented space and trip making challenges in the study area. 13.4% indicated that improving the metro rail services was critical since this is a mass mover of commuters. 9.6% of the respondents highlighted that the bus subsidy policy has to be retained at least for now since the spatial mismatches and challenges created by apartheid are yet to be fully reversed.

TABLE III
INGREDIENTS OF ADDRESSING DISTANCES TO SOCIOECONOMIC OPPORTUNITIES

Solution	Frequency	Valid Percent
Compact city design	516	33.3
Transit orientated development	423	27.3
Infilling and densification	183	11.8
Mixed use zoning	248	16.0
BRT Rea Vaya	157	10.1
Gautrain	11	0.7
Light Rail	12	0.8
Total	1550	100

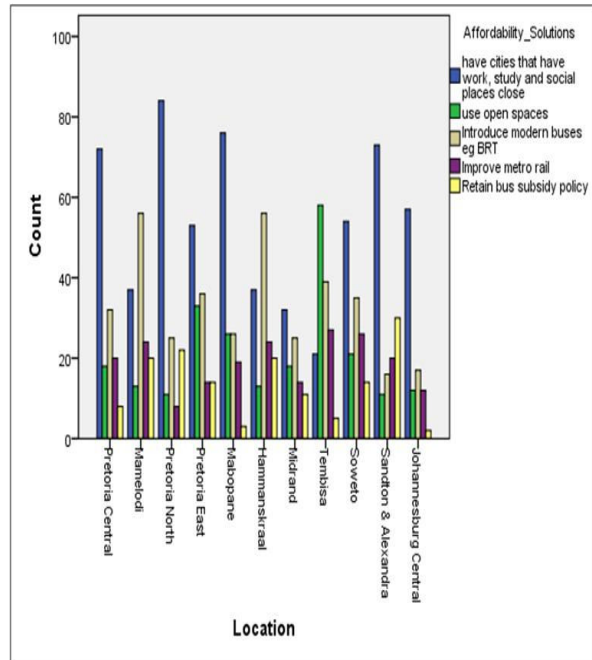


Fig. 22 Transport Commuting Affordability Solutions

B. Addressing Fragmented Urbanisation and Distances to Socio-economic Opportunities

Table III presents suggested solutions to address the fragmented city structure of the study area.

33.1% of the respondents indicated that a compact design was the solution. 27.3% of the respondents highlighted that transit orientated developments have to be fostered and promoted in the major transport corridors in Gauteng. 16% noted that there was room for mixed use zoning to contribute regarding minimizing trip making. The BRT at 10.1% was the highest public transport intervention viewed as having potential to address the problem of separated socio-economic developments in the study area. Gautrain and light rail at 0.7% and 0.8% were seen as least initiatives to assist in reducing the problems. The fact that Johannesburg CBD acts as a monocentric as well as multi-centric network (given dispersion and clustering effects of major urban centers such as Benoni, Sandton as well as Pretoria) including the multiplicity of shopping malls throughout fundamentally explains the challenges to addressing urban commuting issues in the study area.

C. Travelling Time Solutions

One of the major identified commuting challenges was that commuters are spending a lot of time travelling. Respondents were asked to indicate which travelling time solutions they thought if implemented can address this matter (refer to Fig. 23). 44% indicated that dedicated BRT busways was the solution. It was argued that international cases existed to support this notion. 26.9% indicated that employers needed to explore and use the concept of flexi hours much more as with Information Technology it is now possible to work from home and have virtual offices rather than be office bound. At 6.1%

respondents felt that scope for the light rail needed further thought as it can be a cue for the travelling time challenges. 3.3% of the respondents indicated that an underground transport system for Johannesburg needed to be constructed. This was the case in all developed countries. 2.8% indicated that if Gautrain is fully developed and extended to all parts of the Province it can play a significant role in addressing the challenge. This raises the question of the need to either consider reducing the fares of Gautrain or subsidising the fares. Alternatively more public bus fleet investment is necessary.

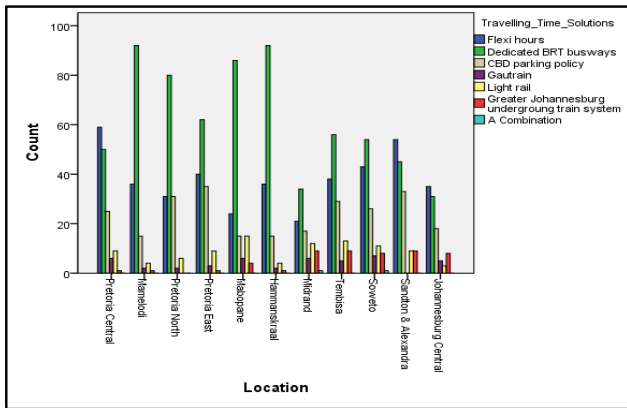


Fig. 23 Travelling Time Solutions

D. Traffic Congestion Solutions

One of the identified problems that commuters are facing is traffic congestion. Respondents indicated a range of options and strategies that could be implemented to address this challenge (refer to Fig. 24). 22.3% indicated that a compact city development form would go a long way in addressing this challenge. This would reduce the need for motor based trips as people could easily walk to various socio-economic areas. BRT systems at 19.9% were a prime improvement target area. Mixed use developments at 16.2% were also an integral part of solutions advanced. Introduction of a car retirement policy at 15.2% was seen as an important policy area. The Johannesburg underground transport system at 7.1% was also seen as a serious contender. Car ownership policy with capping was viewed as important at 5.1%. Improving the Gauteng freeways at 8.1% featured as a prominent priority intervention area. Implementing a wide suite of measures is what will make a lasting impression in addressing traffic congestion in the study area.

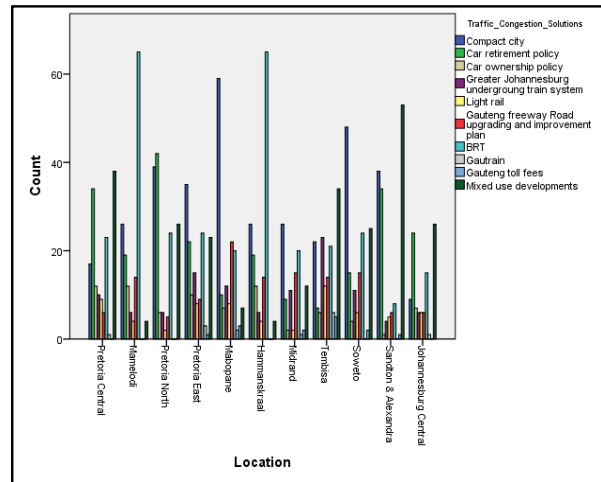


Fig. 24 Traffic Congestion Solutions

E. Implementation Challenges of Suggested Solutions

While the indicated solutions are attractive caution should be taken that implementing the solutions will not be an easy assignment. The complexity of the Gauteng region in terms of structure, culture and spatial interactions and dynamics add to the layers of challenges involved. For example, fragmented spaces are costly to reverse. However, forward planning should consider mix land use development, where residential, commercial and industrial areas are inter-linked with the shortest possible commuting distances. A shift towards public transport will meet with resistance from private car owners. However a clear integrated public transport strategy supported by a clear car ownership, capping and retirement policy will go a long way in promoting more efficient urban transport modes in Gauteng province.

VII. CONCLUSION

The development of packages of policy measures, including new urban mass transport technologies and new and existing transport policy instruments, will be of increasing importance in the pursuit to addressing urban commuting challenges in the Gauteng province. More effort is needed to understand the design of effective policy packages in different municipal contexts in the Gauteng region, both through underpinning research and through the collection of empirical evidence as leading cities apply such packages [1]. The pace of change and lack of resources and institutional capacity at these levels pose different but still significant challenges [1], [5], [11], [13]. Consequently, much stronger integration of transport and land-use planning needs to be elevated in importance in the Gauteng area before it is too late. As more and more growth happens in the Gauteng cities, opportunities for linking better land development and transport infrastructure should not be squandered [3], [23]. While it is acknowledged that integrated transport and land development can relieve congestion, contribute in cleansing the air, and conserve energy, its potential to reduce what remains the gravest problem facing the Gauteng province - extreme and persistent poverty - is

every bit if not more important [24]. All that is done in the Gauteng region must pass the litmus test of poverty reduction. Designing cities and transport systems to enhance accessibility and affordability is pro-poor and so are initiatives that strengthen non-motorized and public transport, keep fares affordable, and protect vulnerable populations from the hazards of motorized travel. Mass transit needs to be pro-poor across the board.

ACKNOWLEDGMENT

The authors wish to acknowledge the following institutions for financial support that enable the research project: University of Venda; Council for Scientific and Industrial Research (CSIR); South African Cities Network (SACN), Department of Transport (DoT); Gauteng Department of Roads and Transport; Johannesburg, Tshwane & Ekurhuleni Metropolitan Municipalities as well as public and private transportation companies, organizations, institutions and individuals who willingly participated and provided financial and non-financial support throughout the project duration.

REFERENCES

- [1] A. May and Marsden S, *Urban Transport and Mobility*, International Transport Forum, Leipzig, Germany, 2010 pp. 3 & 5
- [2] Cortright J. *Driven Apart*, 2010, Rockefeller Foundation, USA
- [3] R. Cervero. "Linking urban transport and land use in developing countries", *The Journal of Transport and Land use*, Vol. 6 no. 1, 2013 pp. 7-24
- [4] European Commission, "Roadmap to a single European transport area: Towards a competitive and resource efficient transport system". Technical report, European Commission, European Partnership for Transport, Brussels, 2011.
- [5] J. Chakwizira J, M. Mashiri M, The contribution of transport governance in socio-economic development in South Africa, *In Sustainable Transport: 28th Annual Southern African Transport Conference (SATC) 2009, Pretoria, South Africa, 6-9 July 2009*, pp 1-18 ISBN: 9781920017392
- [6] Sustainable Energy Africa, The state of energy in South African cities, Sustainable energy Africa, Cape Town, South Africa, 2006
- [7] StatsSA, *General Household Survey*, Pretoria, 2009 pp. 6
- [8] DoT, National Household Transport Surveys, 2003, Pretoria
- [9] R. Gakenheimer, *Mobility Issues in the Developing World*, Massachusetts Institute of Technology, USA, 1997 pp. 1
- [10] StatsSA, *Census 2011*, Pretoria, 2011
- [11] G.K. Ingram, Patterns of metropolitan development: What we have learnt? World Bank – Operations Evaluation Department (OED), Washington, USA, 1997
- [12] P. Alpkokin, C. Cheung, J. Black & Y. Hayashi, 'Dynamics of Clustered Employment Growth and Its Impacts on Commuting Patterns in Rapidly Developing Cities', Transportation Research Part A: Policy and Practice, 2008 vol. 42, no. 3, pp. 427–444.
- [13] N. Buchanan, R. Barnett, S. Kingham & D. Johnston, 'The Effect of Urban Growth on Commuting Patterns in Christchurch, New Zealand', Journal of Transport Geography, 2006 vol. 14, no. 5, pp. 342-354.
- [14] R.N. Buliung, & P.S. Kanaroglou, 'Urban Form and Household Activity-Travel Behavior', Growth and Change, 2006 vol. 37, no. 2, pp. 172-199.
- [15] Q. Ma, W. Zhang & X. Wang, 'Review on Spatial Structure of The Metropolis Affecting Its Traffic', Economic Geography, 2004 vol. 24, no. 2, pp. 215-220.
- [16] Bertaud, A, *The Spatial Organization of Cities: Deliberate Outcome or Unforeseen Consequence?*, World Development Report 2003: Dynamic Development in a Sustainable World, World Bank.
- [17] P. Veneri, 'Urban Polycentricity and the Costs of Commuting: Evidence from Italian Metropolitan Areas', Growth and Change, 2010, vol. 41, no. 3, pp. 403–429.
- [18] Bertaud, A, *Urban Spatial Structures, Mobility and The Environment*, 2009, World Bank, Washington DC.
- [19] J. Chakwizira, "The Question of Road Traffic congestion and Decongestion in the Greater Johannesburg Region", in *Proceedings of the 26th Southern African Transport Conference (SATC 2007)*, 9-12 July 2007, Pretoria, South Africa, ISBN: 1-920-01702x pages 499 – 511
- [20] IBM Corporation. *The globalization of traffic congestion: IBM 2010 commuter pain survey. Technical report*, 2010, IBM Corporation, Armonk, New York.
- [21] DoT, Key results of the national household travel survey, Pretoria, 2005 pp. 8
- [22] C. Venter, Quality of Transport in the Priority Townships, October 2013 (unpublished).
- [23] J. Pourbaix, *Towards a smart future for cities: Urban transport scenarios for 2025. Public Transport International*, 2011 vol. 60(3):8–10.
- [24] Chakwizira J, Bikam P, Dayomi M & Adeboyejo A. T, "Some missing dimensions of urban public transport in Africa: insights and perspectives from South Africa", *The Built and Human Environment Review, Volume 4, Special Issue, 2, 2011* pages 56 -84