ACCESS AND MOBILITY IN GAUTENG'S PRIORITY TOWNSHIPS WHAT CAN THE 2011 QUALITY OF LIFE SURVEY TELL US?

C VENTER

Department of Civil Engineering, University of Pretoria, Pretoria, 0002,
Tel (012) 420-2184, Fax (012) 362-5218. Email: christo.venter@up.ac.za

ABSTRACT

The paper analyses the accessibility and mobility dimensions of travel together, in order to obtain a richer understanding of the quality of economic and social engagement afforded by particular locations. A four-quadrant plot of access and mobility indicators is presented that, together with an analysis of the wage gradient obtainable from a location, provides a useful way of differentiating between areas with distinctly different access-mobility characteristics. The method is applied to 27 priority township areas in Gauteng Province, using data from the 2011 Quality of Life Survey and other GIS sources. The analysis confirms that location along the core-periphery axis is very important to livelihood access. However several other factors such as rail access, the availability of local amenities and jobs, and proximity to several concentrations of job opportunities, can mitigate locational deficiencies. Implications for urban and transport planning are discussed.

1. INTRODUCTION

Mobility and accessibility are often considered conflicting objectives of transport. This carries through to debates about what the objectives of transport professionals should be, and what should be measured and evaluated in the course of setting these objectives (Litman, 2003; Cervero, 2005; Zegras, 2011). Mobility usually refers to the *amount* of travel undertaken, while accessibility captures a subtler notion of the *ability* to participate in activities, or the quality of access afforded by a land use-transport system. Partly as a counterpoint to what is seen as an historical over-emphasis of mobility in transport planning, much theoretical and applied research has lately been directed at the refinement of techniques to measure and analyse accessibility (e.g. Geurs and Ritsema van Eck, 2001; El-Geneidy and Levinson, 2006; Cheng and Agrawal, 2010).

There is little doubt that spatial (in)accessibility is a critical dimension of urban poverty and social exclusion. John Howe notes that 'it is the *accessibility* that a transport system provides which is of fundamental importance to the extremely poor' (Howe, 2000:12). A spatial understanding of poverty is increasingly informing research on economic access and desirable urban form in South Africa, and is finding expression in government policy such as Cabinet's Outcome 8, which calls for 400 000 shacks to be upgraded on 'well-located land' (Cross, 2013).

This paper contributes to this debate by examining accessibility across 27 townships in Gauteng, in relation to both local amenities and region-wide economic opportunity. The intention is to provide a high-level understanding of what constitutes good access, and of how it varies across localities. We take the view, however, that deeper insight can be obtained by considering *both* accessibility and mobility together, as their interaction can help explain patterns of economic and social engagement in ways that neither can do on its own.

DATA AND METHODOLOGY

2.1 Quality of Life surveys

In 2009 the Gauteng City Region Observatory (GCRO), a joint initiative of the Gauteng Provincial Government and the Universities of the Witwatersrand and Johannesburg, commissioned its first Quality of Life (QoL) survey. The survey was used to provide a holistic assessment of life in the Gauteng City-region that looks not just at Gross Domestic Product or similar economic measures, but includes the values and attitudes of citizens, their levels of social capital and engagement, and so on (GCRO, 2012). The survey was repeated in 2011-12, producing a sample of 16,729 respondents statistically sampled across Gauteng's wards.

This analysis focuses on a sub-sample of the 2011 data, corresponding to the major township areas in Gauteng. The Gauteng Provincial Government (GPG) has identified a set of priority townships as focal areas for infrastructure and social investment, and has refined the list several times over the last few years. Although the list does not include all former black townships in Gauteng, it represents most areas of major significance in terms of population, and provides sufficient variation in location and the present condition of infrastructure to be broadly representative of the variety of situations facing township dwellers in Gauteng.

The list of 26 priority townships used by the GPG was refined in one respect: Soweto contained a disproportionally large sample, so it was split into two sub-areas (named Soweto East and Soweto West) using a north-south boundary running along Elias Motsoaledi Road (M77). A final set of 27 township areas was used (see Figure 3 for their locations).

2.2 Definition of mobility and access indicators

In line with the paper's interest in the quality of life, we defined indicators that reflect the quality of travel conditions and opportunities experienced by residents in each township[1]. The indicators are purposely wide-ranging – covering all modes, a variety of trip purposes (not just the traditional trip to work), and geographical scales (including both local and commute travel). This necessitates the use of multiple data sources, including the Quality of Life survey data, supplemented by other data layers obtained from other GIS databases.

[1] Other reports published by the GCRO examine the travel behaviour and perceptions of Gauteng residents, based on the QOL surveys, in more detail. See www.gcro.ac.za.

Three types of indicators were developed as discussed below:

1. Indicators of within-settlement transport conditions
2. Indicators of area-wide accessibility levels
3. Indicators of mobility expenditure

2.2.1 *Within-settlement transport conditions:* At the local geographical scale, the quality of life is shaped, first and foremost, by the feasibility of walking to everyday activities. Walking is a key livelihood strategy for low-income households, as it avoids the expense of making a motorised trip for activities like shopping and school attendance. Four indicators were selected to represent aspects of the local travel environment within the settlement:

- **Access to social services within walking distance of the home**: Two indicators were used to reflect the availability of destinations within walking distance of the home, namely:

  - % of dwellings that are further than 5km from a primary health care facility
  - % of population aged 0-18 that is further than 3km from a public school

  These data were originally sourced from Eskom, Lightstone, and the Departments of Health and Education, and calculated at the ward level.

- **Walk time to closest taxi service:** This indicator reflects the proximity of taxi transport to the home. Shorter walking times to taxi routes indicate both a more prolific supply of public transport in an area, and better location of public transport routes relative to households.

  Data for this indicator came from the QoL survey question that asked respondents to estimate the walking time to the nearest public transport (usually taxi) route to their home.

- **Satisfaction with road quality**: The quality of roads around a person's home affects the difficulty of getting around – especially under wet conditions, when unpaved roads become difficult to use. Unpaved or insufficiently maintained roads also raise travel costs and reduce the likelihood that public transport vehicles like minibus-taxis will operate routes close to the home (Venter and Cross, 2011).

  The QoL survey asked respondents to rate their satisfaction with the roads they use every day. There is reason to think that the quality of roads in the immediate vicinity of respondents' dwellings features strongest in their minds when answering this question. For instance, among the sample of township residents, the percentage of people who responded 'satisfied' or 'very satisfied' to this question was 64% for people living in formal dwellings, versus 28% in informal dwellings. Both sets face largely the same roads in the larger area, but different roads in their immediate vicinity.

For ease of analysis the four indicators were combined into a single within-settlement index (SETINDEX). Weights were determined through a principal component analysis, with the objective of weighing the indicators in such a way that the combined index maximises the differences between priority townships – in other words to maximise its ability to discriminate between areas with different internal access characteristics.

2.2.2 *Wider-area accessibility afforded by the transport system to participate in urban activities*: In terms of gaining access to wider urban opportunities such as jobs, services, and social networks outside the immediate neighbourhood, a particular residential area may be more or less suitable depending in three factors: (i) the location of the area; (ii) the spatial distribution of relevant activities across the urban space; and (iii) the quality and cost of connectivity provided by the transport network.

Area-wide accessibility was measured using a standard gravity-type accessibility indicator:

$$AI_i = \sum_{all\ j} \exp\left(-0.01 * t_{ij}\right) * A_j$$

Where AI_i = Access Index for origin area *i*
t_{ij} = Travel time (in minutes) between origin *i* and destination area *j*
A_j = Number of job opportunities in destination zone *j*

The indicator, in essence, takes each origin zone in turn, and counts the aggregate number of job opportunities in the entire Gauteng that can be accessed from that origin using the existing transport system. However each job opportunity is discounted by a factor

($exp(-0.01*t_{ij})$) that reflects how difficult it is to reach from the origin[2]. Thus an origin area that is located close to large employment areas will score a higher index than an area more isolated from job locations.

Note that this index measures the *opportunity* afforded by living in a particular location. It is not driven by the actual locations of jobs selected by residents. Opportunities are represented by *job* opportunities, the data for which came from the recently updated Gauteng Transport Study transport model. The access indices were calculated for each respondent in the QoL dataset, thus taking their actual home location into account.

Travel times to opportunities were measured by two different modes, namely commuter rail and minibus-taxi. Travel times included the walk from the home to the nearest rail station or taxi route, the in-vehicle time, and the final walk component of the trip. This resulted in two access indices: ACCINDEX-RAIL and ACCINDEX-TAXI. The distinction between taxi and rail is important as these modes play different roles in shaping an individual's access to the space economy. Taxis provide a base network of accessibility, serving all township areas and therefore playing a large role in shaping the spatial distribution of access. Rail, by contrast, does not serve all townships, but is important as it provides for lower-cost accessibility to selected destinations. A combined index (ACCINDEX) reflecting *both* taxi and rail access was constructed by simply summing the two modal indices. Areas with *both* good taxi and rail accessibility would score well on this measure.

[2] The exponential factor and parameter (-0.01) are standard for this type of measure. To give an idea, jobs that are 30 minutes' travel time away are discounted (i.e. 'made less attractive') by 25%; jobs that are 60 minutes by 45%; and jobs that are 120 minutes away by 70%.

Since the various indices described so far use different scales and units, they were standardised against the average value for each index across all townships. The average is calculated from the weighted survey data so it accounts for differential sampling rates in different areas. The standardised index is then expressed as a percentage above or below the average, for instance:

- an index value of 0.00 is identical to the average for the Province;
- an index value of 0.50 is 50% higher than the average; and
- an index value of -1.00 is 100% lower than the average.

2.2.3 *Mobility expenditure:* The amount of individual and household resources actually spent on travel is an indication of the costliness of accessing opportunities. It is a consumption measure, and therefore reflects the outcome of both individual decision making and of the opportunities afforded by a particular location. This implies that any measure of travel expenditure should be interpreted with care. High travel costs, for example, might be indicative of either a highly mobile, active lifestyle, or of a disadvantaged location requiring long commutes to get to any job. There is no one-way correlation between mobility expenditure and quality of life (Venter & Behrens, 2005).

On the question of how to measure mobility expenditure, we take the view that both monetary and time expenditure should be taken into account. The reason is that time and money are often traded off; travellers might choose to use less expensive travel modes (such as rail services) in order to save money, but incur longer travel times (slower travel and/or longer walks to/from public transport). This was confirmed by the existence of a significant negative correlation ($p<0.05$) between the travel time for the most frequent trip and the percentage of household income spent on public transport use in the QoL dataset. Time, like money, is a scarce resource that households can choose to allocate to other activities, and therefore long travel times might indicate relative disadvantage.

A mobility expenditure index (EXPEND) is defined by calculating the proportion of individuals in the sample, in each priority township, who reported *either*:

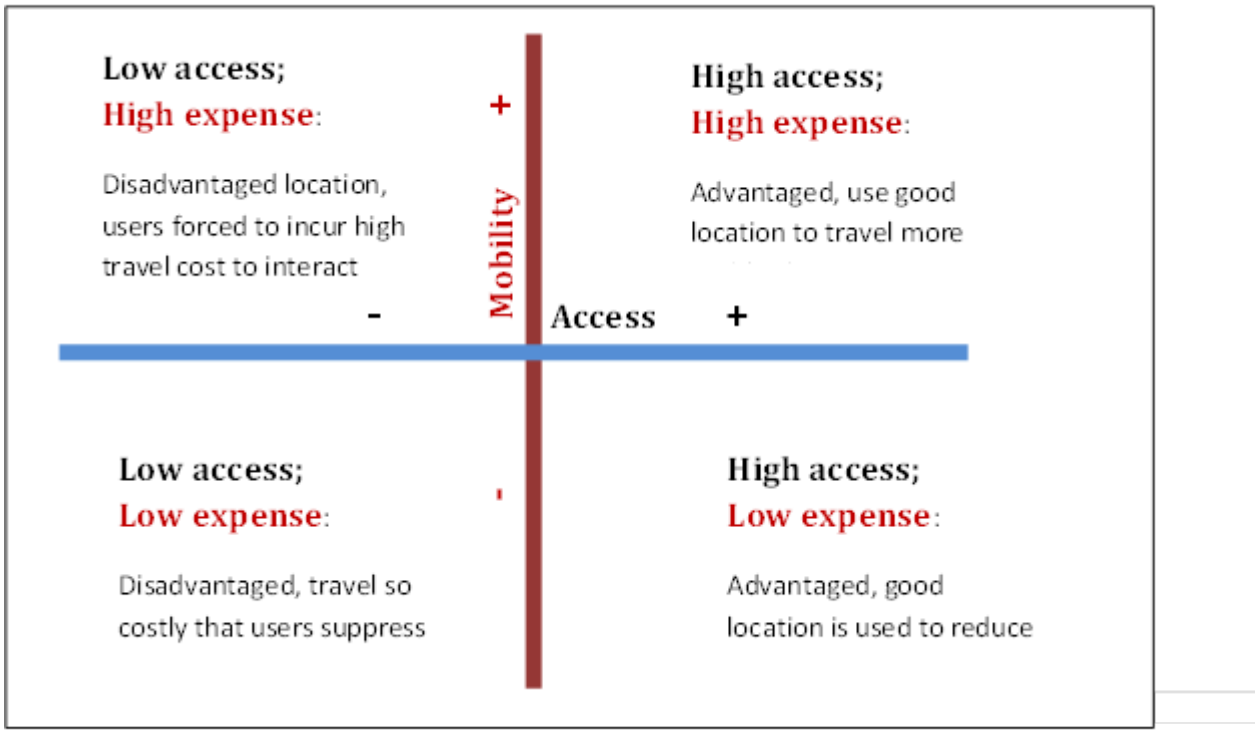
- Excessive travel times for their most frequent trip, *or*
- Excessively high travel costs, estimated as the percentage of household income spent on public transport by the entire household.

By expressing travel costs as a percentage of household income, the differing financial means of various households are taken into account. The index is standardised as described before. *Excessive* in each case is taken as the 75th percentile value, namely a travel time of 52 minutes (one-way), and a percentage spent on public transport of more than 50%. The travel time criterion corresponds approximately to the national benchmark of 60 minutes maximum travel time (DOT, 1996). The 50% cost criterion far exceeds the typical benchmark of about 10% of income, but this benchmark has been questioned as being inappropriate (Venter & Behrens, 2005). Without better information the 75th percentile should serve to discriminate between low and high cost situations.

2.3 Understanding mobility and accessibility together: the four-quadrant view

To help us understand the interaction between mobility and access, we plot them on two perpendicular axes (Figure 1), defining four quadrants with distinct access-mobility combinations. It is hypothesised that areas with both high access levels and high mobility expenditures (the upper-right quadrant) are relatively advantaged: residents are able to access opportunities close by, but some (or many) choose to travel further to access even better opportunities. In this case high travel times and/or costs might be interpreted as a choice outcome, and associated with higher quality of life and/or incomes. A high-access/low-expense combination (lower right) also signifies a situation of relative advantage, indicating that most individuals choose to use their good location to reduce their travel burden, for instance by walking to opportunities close by. Low access levels, on the left-hand side of the graph, can also combine with either high or low mobility expenditures. If high, it means residents still travel, thus participating in the economy, but are forced to bear high travel burdens in doing so. Worst-off would be residents in low-access/low-expense areas: isolation might force them to stay at home, and simply not participate in the space economy at all.

Figure 1: The four quadrants defined by accessibility and mobility levels



2. RESULTS

3.1 Within-settlement transport conditions

Table 1 shows the within-settlement component indicators and final standardised index for each priority township. Two areas stand out as having poor local access to facilities, namely Refilwe and Hammanskraal. Most other townships have relatively good access to schools and primary healthcare, reflecting the efforts of government in the recent past to improve social services in formalised townships. Taxi access is reasonably good in all areas, with most areas on average between 11 and 14 minutes away from the nearest taxi. This corresponds with the results of previous surveys around the popularity and good penetration of minibus taxi operators in urban areas.

Table 1: Indicators and combined index (SETINDEX) for within-settlement transport
(Colours indicate performance relative to other townships; green=best, red=worst)

Priority Township	% >5km primhealth Mean	% >3km public school Mean	Walk time to taxi Mean	Dissatisfied with roads %unsatisfied	SETINDEX
Atteridgeville/Saulsville	1.57	8.10	14.77	36%	-0.48
Boipatong	0.05	0.00	12.73	31%	0.59
Bophelong	3.55	1.46	14.88	57%	-0.12
Daveyton	0.74	0.99	12.77	34%	0.41
Garankuwa	0.00	0.00	14.45	35%	0.54
Hammanskraal	22.52	8.43	11.53	87%	-2.81
Kagiso	0.00	0.00	13.43	19%	0.58
Katlehong	0.00	0.00	12.74	27%	0.6
Khutsong	2.52	1.40	16.07	64%	-0.01
Kwatsaduza	0.41	0.21	13.13	38%	0.5
Mabopane	0.00	2.75	13.47	48%	0.27
Mamelodi	2.97	0.95	14.37	35%	0.17
Mohlakeng	0.05	0.05	12.14	40%	0.61
Munsieville	0.31	2.62	15.58	13%	0.2
Orlando	0.00	0.00	13.21	15%	0.59
Ratanda	9.95	7.31	13.88	34%	-1.23
Rathibiseng	2.66	2.41	14.08	30%	-0.03
Refilwe	26.43	16.85	14.25	47%	-4.34
Sebokeng	0.00	0.00	14.05	48%	0.55
Sharpeville	0.00	0.00	11.99	55%	0.62
Soshanguve	0.53	0.99	13.71	39%	0.38
Soweto (East)	0.00	0.27	12.40	25%	0.58
Soweto (West)	0.00	2.35	13.75	39%	0.32
Tembisa	1.15	0.64	14.37	30%	0.35
Wattville	0.40	0.00	11.00	21%	0.61
Winterveldt	1.65	2.99	14.82	62%	-0.03
Zola	0.00	0.00	13.48	16%	0.58

Dissatisfaction with local road conditions varies more markedly across townships. Worst performing are Hammanskraal, Winterveldt, Khutsong, Bhopelong, and Sharpeville, all of whom have more than half of respondents reporting dissatisfaction. There appears to be no strong correlation between local access to services, access to taxi, and dissatisfaction with road conditions, suggesting that no single township has been entirely neglected in terms of local transport conditions.

3.2 Area-wide accessibility levels

Figure 2 plots the standardised taxi and rail access indices for the priority townships, reflecting both the availability of public transport and the relative proximity of each township to jobs. Figure 3 shows the combined accessibility score on a map.

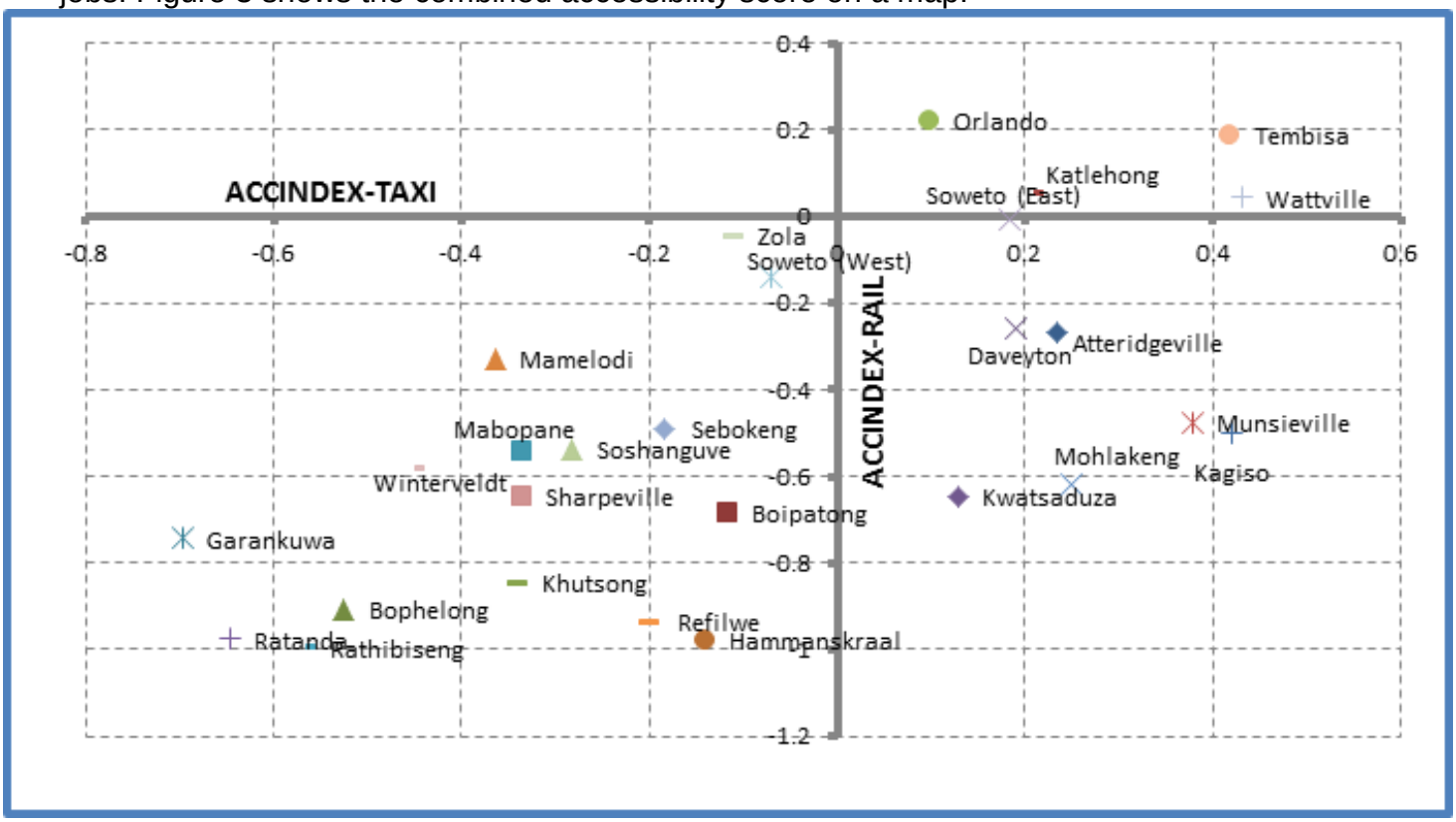


Figure 1: Standardised Taxi and Rail Access Indices

Only a few townships enjoy superior rail access (the top half of Figure 2): The Eastern parts of Soweto and Orlando, Wattville, Tembisa, and Katlehong. These areas are very advantaged, relatively speaking, by the combination of having a good location close to the core of employment in the Province, and good access to train services. On top of that, they also enjoy good taxi accessibility.

The Western part of Soweto performs somewhat worse owing to its slightly lower proximity to the Johannesburg CBD. Some areas have poor rail access but good taxi service, notably Atteridgeville, Daveyton, Munsieville, and Kagiso. Some townships, such as Mamelodi and Atterdigeville, have rail access and reasonable proximity to job opportunities, but receive lower scores on the ACCINDEX-RAIL indicators than expected. The reason for this might lie in the poor location of the rail line on the boundary of the township, requiring potential rail commuters to undertake long walks or internal taxi feeder trips to get to the station, both of which reduce rail accessibility.

Townships in the lower left of the graph are worst off in terms of relative access. This is clearly driven by a combination of poor location relative to jobs and their lack of access to rail. Worst off are areas like Garankuwa, Rethabiseng, Bophelong and Ratanda, all on the urban periphery.

3.3 Mobility expenditure

Figure 4 shows the values of the mobility expenditure index, plotted against the combined accessibility index (rail and taxi). It appears that only a few townships are in the relatively advantaged position of being in the high-access/low-expense quadrant, namely Soweto East, Orlando, and Wattville. Residents of these areas use their good location to reduce their travel times or costs. These areas are well served by rail, which, it can be seen here, results in real savings in transport expenditure to households.

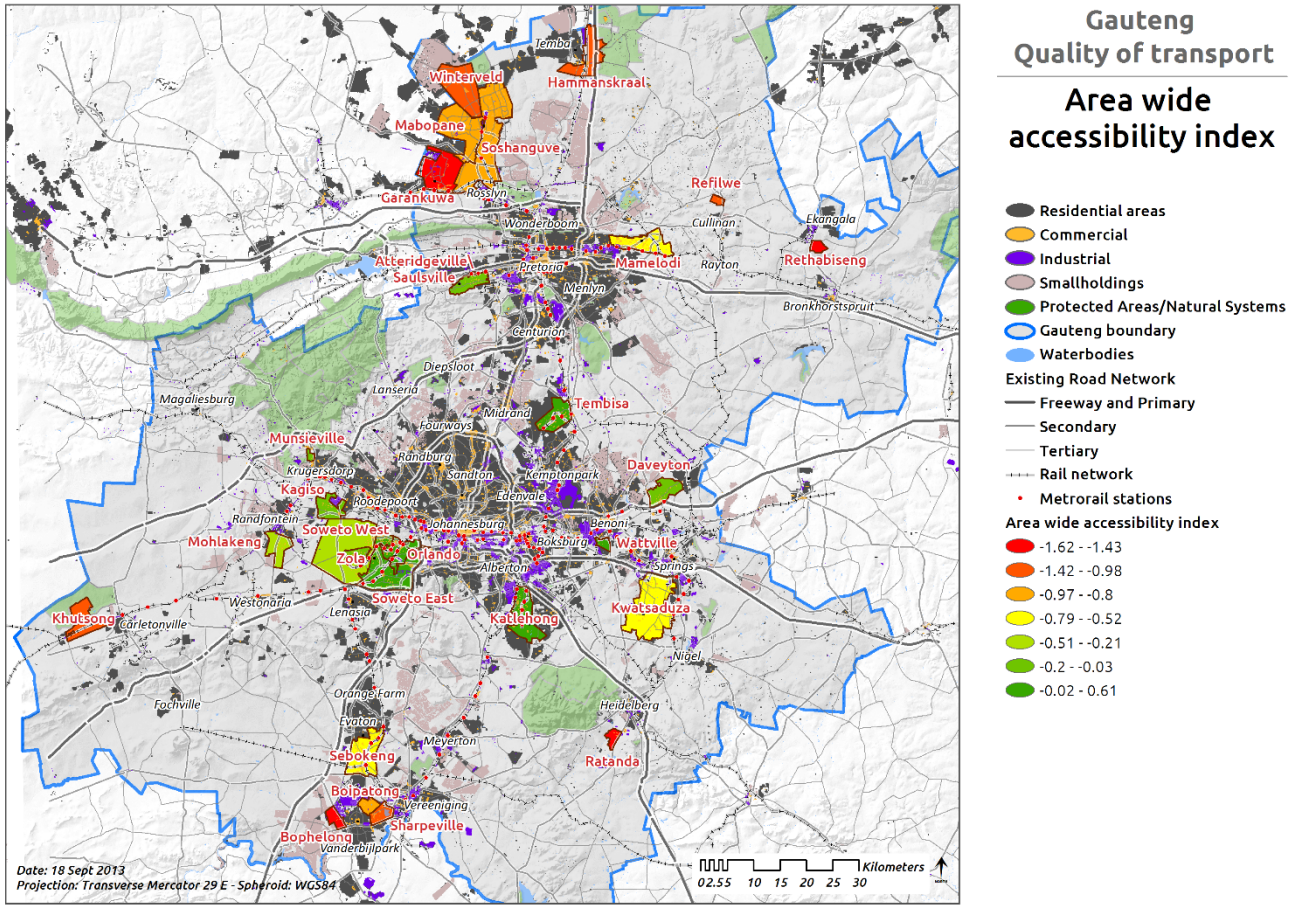


Figure 3: Combined Accessibility Index (ACCINDEX) of priority townships

This point is confirmed when looking at the average incomes commanded by households in each quadrant, across different commute distance bands (Figure 5). Workers in the high-access/low-expense locations (termed here INNER ACCESSIBLE, for short), are able to access high-paying jobs within 10km of the home, obviating the need for longer commutes. (This is notwithstanding the fact that some commuters choose to travel long distances of over 40 kms in order to secure even higher incomes.)

Two areas have good access but high expenditure, namely Tembisa and Katlehong. Termed INNER MOBILE locations, these areas are not immediately adjacent to large concentrations of jobs, but their good rail service and central locations give them access to very large pools of jobs within the 30-40km commute range, as far away as Pretoria (in the case of Tembisa) and Vereeniging (for Katlehong). Thus commuters travel much longer distances in order to secure the incomes they are looking for (see Figure 5).

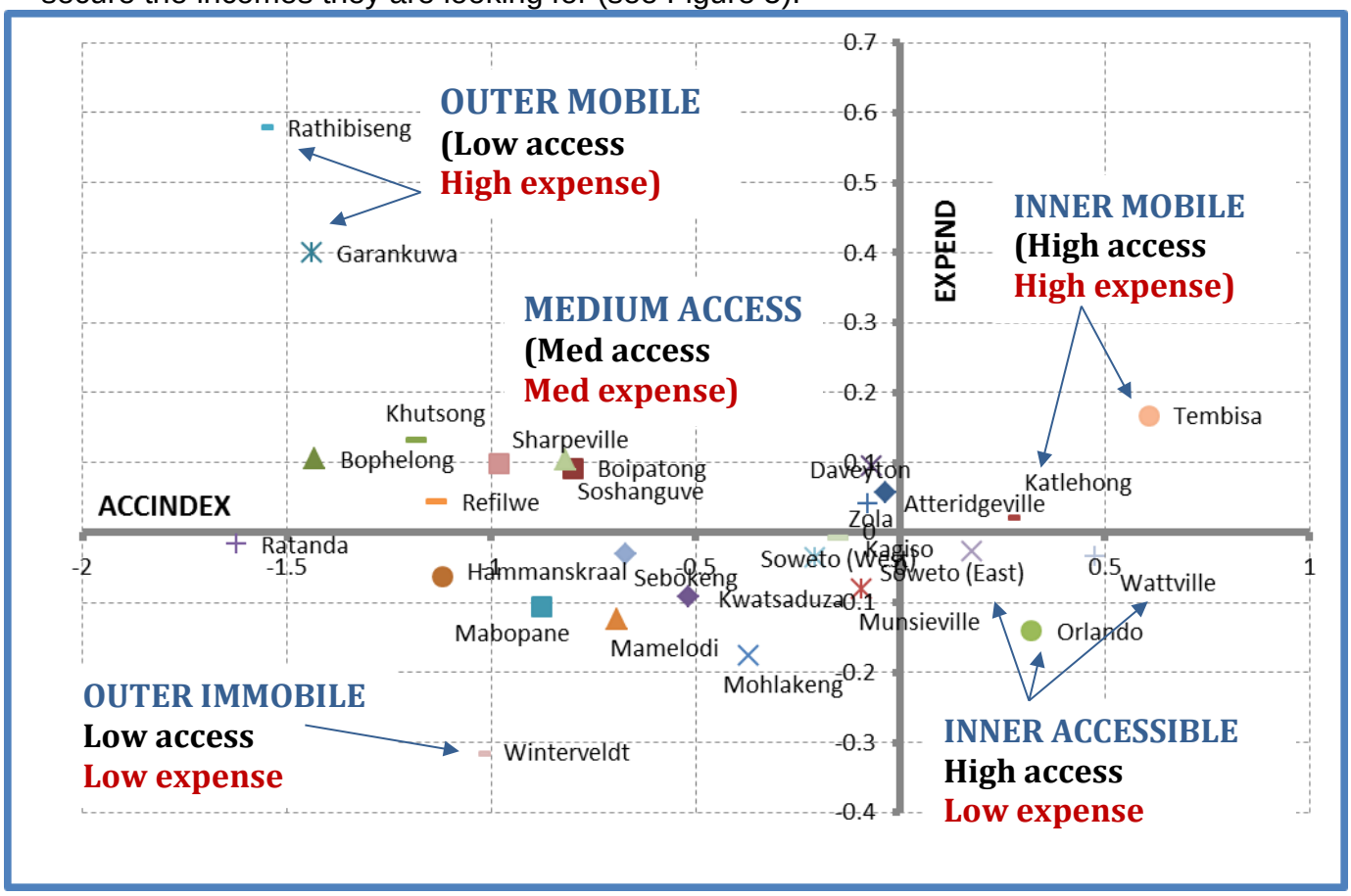


Figure 4: Four-quadrant plot of standardised Mobility Expenditure and Accessibility indices for 27 priority townships

Most townships occupy a position in the centre of the four-quadrant plot, with similar levels of mobility expenditure. These MEDIUM ACCESS areas have a positive wage gradient (Figure 5), meaning that while local economic opportunities are not great, households are located close enough to job concentrations that most workers can find worthwhile jobs within about 30km from the home. There is however little incentive to travel further than this, as the wage gradient turns negative for longer distances.

Rethabiseng and Garankuwa stand out as low-access/high-expense cases – many households in these OUTER MOBILE locations bear extraordinarily high transport burdens in order to participate in the economy. Figure 5 shows the reason: almost no worthwhile jobs are available within the settlement itself (i.e. within a 10km distance band); some medium-paying jobs are available within the 10-20km range; but the majority of workers have to travel much farther to secure adequate incomes.

Winterveldt stands out as the worst in the low-access/low-expense quadrant. Spatial isolation and low local economic development mean that within 30km from the home only low-paying earning opportunities are available. Most residents cannot afford to travel the 30-40km needed to access better-paying jobs, leading to low mobility and relative exclusion from the urban economy.

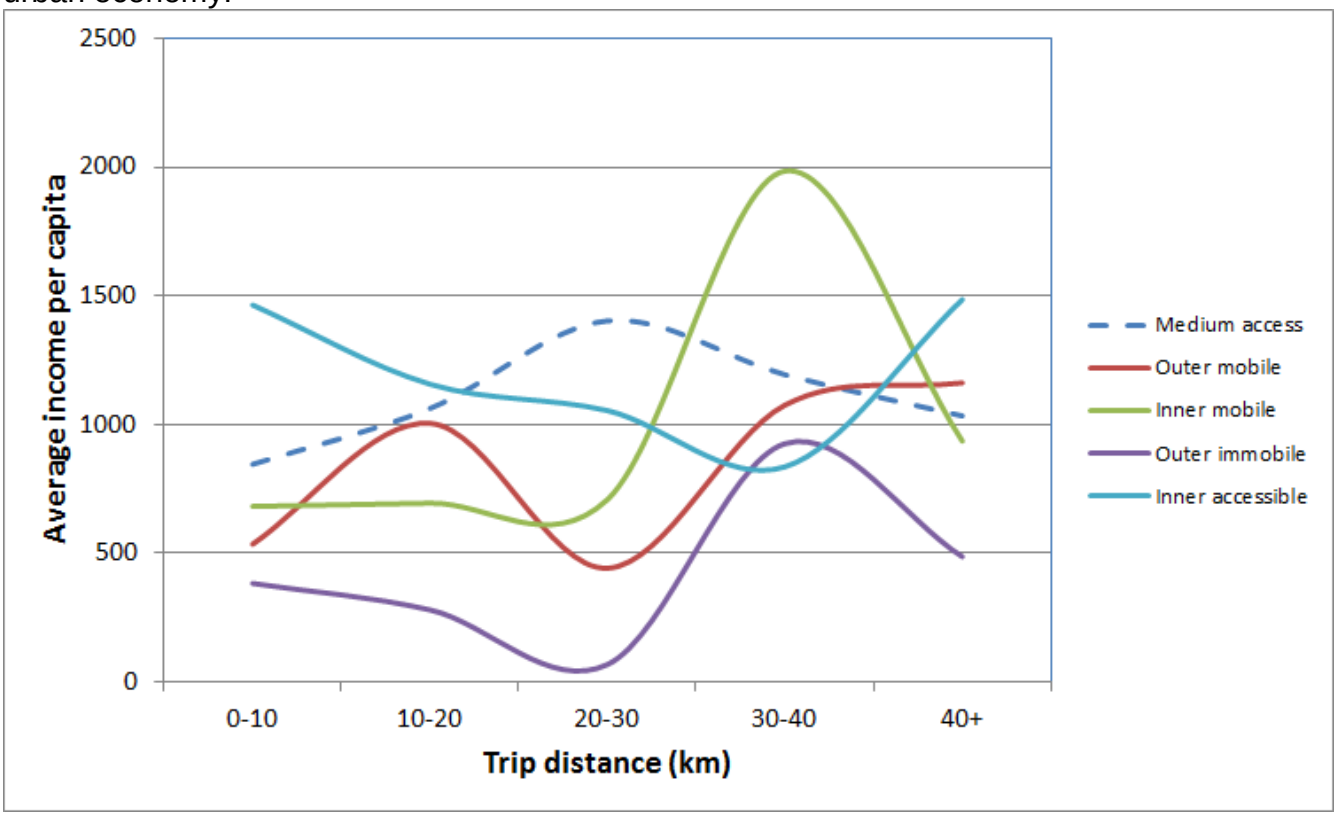


Figure 5: Wage gradients (average income versus trip distance) for households in each quadrant (refer to Figure 4 for definitions)

3.4 Variation within settlements

Notwithstanding the clear differences between townships that emerge from the above discussion, it is important to note that these differences reflect only *predominant* trends. They may hide the significant variation that exists within each location. To illustrate this, Table 2 summarises selected indicators for households living in formal and informal dwellings. Intra-township access patterns differ significantly depending on the type of dwelling: people living in informal housing (either backyard shacks or in informal settlements) have significantly worse access to rail services, to primary healthcare, and to schools than people in formal houses. Shack settlements tend to locate on the peripheries of established townships, where social services and infrastructure are (as yet) unavailable.

Table 2: Differences in access indicators between households in formal and informal dwellings in priority townships

	Distance to nearest taxi rank (km)	Distance to nearest train station (km)	Low access to primary healthcare*	Low access to public school*
Formal dwellings (89% of sample)	3.27	6.88**	1.27**	1.09**
Informal dwellings (including shacks in backyards and in informal areas within townships) (11% of sample)	3.36	8.62**	1.86**	3.49**

*Note: * Defined as above (see section 2.2.1) – higher value is worse*
*** Significant difference at 95% confidence level*

4 CONCLUSIONS

The paper suggested a way of analysing the accessibility and mobility dimensions of travel together, in order to obtain a richer understanding of the quality of economic and social engagement afforded by particular locations. We develop a four-quadrant plot of access and mobility indicators that, together with an analysis of the wage gradient obtainable from a location, provides a useful way of differentiating between areas with different locational benefits.

Applied to 27 priority township areas in Gauteng Province, the data confirm that location along the core-periphery axis is very important to livelihood access. Some townships, such as the Eastern part of Soweto and Wattville, benefit from a triple advantage of high proximity to core economic areas, good local access to amenities, and availability of a rail service. The fact that Soweto as a whole scores relatively high on all indicators suggests that government's efforts at economic and infrastructure improvement in this area have been paying off. On the other end of the scale, some townships (like Winterveldt in the far north of the province) are so isolated from jobs and local amenities that residents simply do not travel – a sign of disengagement from the urban economy that is worrying given concerns with marginalisation of disaffected groups.

In terms of implications for urban development and transport planning, the findings suggest a few strategies to improve access:

- Local economic development and, in particular, the availability of higher-quality jobs within a settlement, makes a large difference to accessibility and to reducing travel costs. Initiatives to promote this should be strengthened.
- While minibus-taxis play a very important mobility role, it is especially access to commuter rail services that seem to promote job access at a low cost. In the long run judicious rail expansion might be a very important strategy in the poverty reduction toolbox. However the location of rail lines within settlements affects their effectiveness and needs to carefully considered.
- Regarding the selection of locations for new development or upgrading, 'well-located' land should be defined not relative to a single city, but relative to the entire surface of opportunities available from a location. Thembisa is a good example: despite being peripheral to Johannesburg, its accessibility to both Pretoria and Ekurhuleni (via the rail network) offers many workers the opportunity to compete for higher-paying jobs

across a large part of the Province, even while incurring high mobility costs. Thus having access to more than one regional concentration of jobs seems to be useful.

- Most township dwellers in medium-accessibility locations find an optimal balance between income and commute costs at about 30km from their homes. Over this distance it is almost impossible to provide high-quality affordable public transport (like Bus Rapid Transit) without high subsidies, which might be unaffordable fiscally. Neither can unsubsidised services (like minibus-taxis) operate at high enough profit margins to provide adequate and safe services. There is thus a need to think about public transport improvement options in medium-distance, medium-density corridors that are affordable both to cities and acceptable to the commuter.

ACKNOWLEDGMENTS

This paper is partly based on a forthcoming report on mobility and transport in Gauteng, to be published by the GCRO. All analysis, results and conclusions are those of the author and do not necessarily reflect the views of GCRO or of the Gauteng Provincial Government. Maps were produced by Willem Badenhorst of MandalaGIS.

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