

Land use and transportation integration within the greater area of the North West University (Potchefstroom Campus), South Africa: problems, prospects and solutions

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Abstract

The main problem that this paper will address is the traffic congestion within the geographical area adjoining the NWU (Potchefstroom Campus). Therefore, the existing traffic patterns and land development tendencies are quantified, related and integrated through a 100% land use and traffic survey of the study area. The data is analyzed through the application of EMME4 modeling and simulation techniques.

The results of the modeling will be used to formulate conclusions and strategy and recommendations as to address inter as well as intra traffic congestion, traffic movement, parking provision based on specific land use development and integration scenarios. The research will also assess the status quo geographical road design capacities, traffic movement enhancement, parking development and preferred land use development policies in terms of sustainable precinct development planning as the main goal and objective.

The paper will serve as an important methodology and assessment tool and technique for urban areas experiencing similar spatial growth and spatial development problems due to a lack of land use and transportation development integration.

Keywords: land use and transportation integration, traffic congestion, land development, urban densification, traffic movement and accessibility.



1 Introduction

From Dimitriou [1] it follows that the urban transport problem in Third World (i.e. developing nations) cities is due to the rise in the number of automobiles, poorly enforced land-use control regulations, inadequacy of resources to provide for the maintenance and management of transport services and infrastructure, insufficient public transport services and the absence of adequately trained staff.

Sustainability is defined by O'Flaherty [2] and Brundtland [3] as a practice of development that meets the needs of the present without losing the ability of future generations to meet their own needs.

In the area adjoining the North-West University (NWU) the traffic volumes, road capacity and lack of parking provision is a problem especially during peak-hours. Therefore, this paper aims to address some of the transportation problems by optimizing current parking supply and demand, to minimize traffic volumes and thus encourage alternative transport modal use in order to ensure a sustainable environment for the future generations.

It is deduced from research [4–7] that the traffic problems being experienced within the geographical area adjoining the NWU (Potchefstroom Campus) are due to the following:

- The physical layout of the area consists of a traditional grid road pattern with numerous intersections that restricts traffic flow and traffic movement patterns.
- An increase in private motor vehicle ownership amongst the predominantly student population residing in and around the university campus led to serious parking problems on campus.
- The ad hoc approval by the local municipality of land use rezoning due to the market needs for higher density housing, business development and supporting facilities serves as the catalyst in the resulting traffic congestion.
- The lack of modal choice public transport serving the university.

2 Study area

Potchefstroom (see Figure 1) is an academic, industrial, service and agricultural city with a population of 149,230 situated 120 km South West of Johannesburg in the North-West Province of South Africa. The study area includes the NWU (see the star in Figure 1) and the adjacent residential area of the NWU.

From 2009–2013 the average annual growth rate for full time students were 4.57% (undergraduate 4.75% and post graduate 3.59%) and the average annual growth rate for the total number of campus staff (academic and supporting) were 5.08%. In these five years the percentage of full time students that resides on the NWU Campus fluctuated between 53.5% and 56.5%. In 2013 the number of total staff equal 3331 and the number of full time students were 15,885. The theoretical number of parking spaces on the main campus is 8088 or 24.26 ha. The shortfall is calculated to be 12 ha of land.



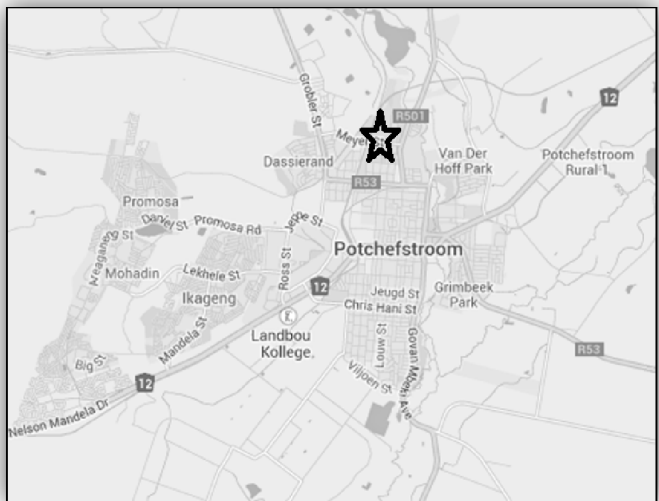


Figure 1: Regional perspective of the study area. Source: Google Maps.

2.1 Inter-traffic survey points

Figure 2 shows the inter-traffic survey points which were used as traffic counting points (stations) to calculate the traffic movements on major access roads serving the study area.

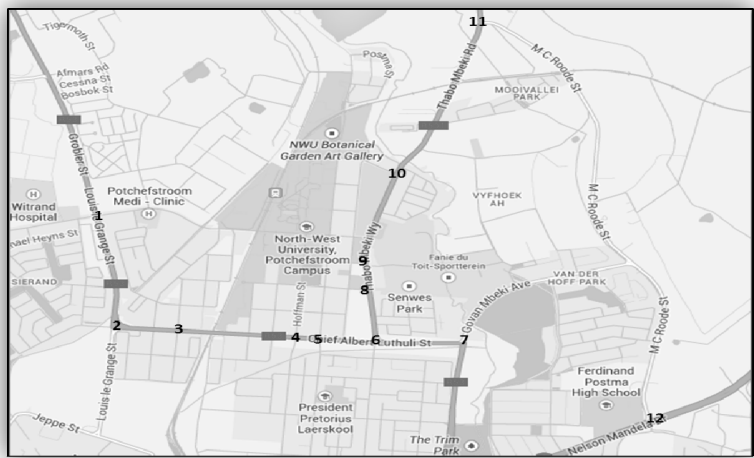


Figure 2: The inter survey points and road links for the study area. Source: Google Maps.



2.2 Intra-traffic survey points

Figure 3 shows the intra-traffic flows within the study area and on Campus.

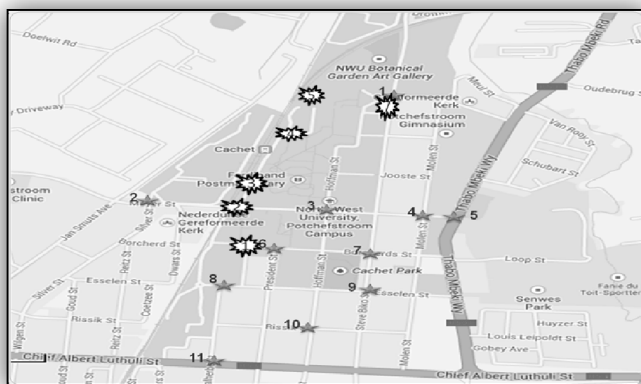


Figure 3: The intra survey points within the study area and on the campus.
Source: Google Maps.

3 Traffic survey patterns, land use and development pressures

In 2013 a detailed land use and traffic survey for the area adjoining the NWU was undertaken due to the current traffic congestion in the area. These surveys includes all land use (zoning) data, the actual dominant uses of land within the area adjoining the NWU and all inter- and intra-traffic modal split data. Figure 4 shows the land zoning and traffic parcels (i.e. centroids) used in the taking up of the traffic survey data in 2013.

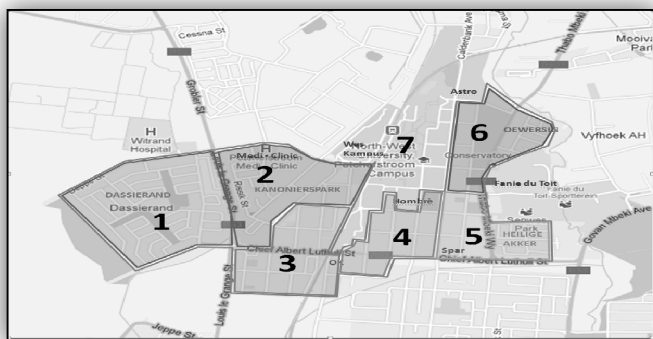


Figure 4: Centroids for data collection. Source: Google Maps.

4 Modelling approach

The aim of the modelling process is to assess the accessibility within the area adjoining the NWU. The modelling methodology follows from conclusions which will be deduced from the traffic flow patterns (existing and projected), land-use patterns (existing, zoning data and projected), need for parking provision and development strategies within the area adjoining the NWU.

4.1 Design capacity of the roads

The road network within the study area consists of Class 5 (local roads) and Class 4 (local distributors) roads. The Class 5 roads (intra traffic) capacity is 600 passenger car units per hour and can serve some 200 housing units. The Class 4 roads (inter traffic) capacity is 600 to 1200 passenger car units per hour and is serving between 400 and 1 500 housing units on average [8]. For both road classes the free flow speed is 40 to 60 km/h in the study area.

4.2 Existing traffic flow and land-use patterns and assumptions

Base year traffic volumes were calculated based on parking duration, parking spaces and the observed parking occupancy rates. Auto trips were assigned to parking spaces. It is assumed that there is a positive correlation between the allocated volumes for parking spaces and the trip generation of the zones.

4.3 Projected impact of traffic flow patterns and development strategies

This consists of the estimation of the traffic impact of the different land use scenarios; assessment of the traffic demand management strategies; evaluation of the potential use of the land and the estimation of the impact of traffic demand on the future road system in the study area and its catchment.

4.4 Projected future land use patterns in the area adjoining the NWU

Figure 5 illustrates the extent of land use rezoning application approved by the local municipality on land adjoining the study area.

In terms of residential density the number of dwelling units within the study area will increase by 35% within the next 18 months when fully developed. This implies that much higher intensities of traffic volumes will be experienced both on peak as well as off-peak hours and a related higher demand for parking.

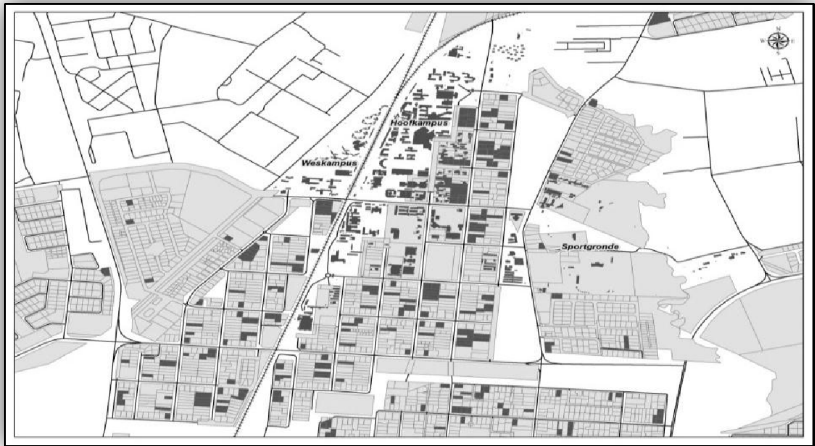


Figure 5: All the amendment schemed within the study area. Source: [6].

5 Modelling application

5.1 Traffic data survey

To determine the existing trip distribution and land uses in the area adjoining the traffic surveys were conducted in 2013 (see Table 1 and Table 2). Table 1 shows that the traffic flow rate on the main campus of the NWU is the highest at the Hoffman Gate and the lowest at the Esselen Gate. Furthermore, the usage of the subway to the new Engineering faculty is very low. Table 2 illustrates the traffic data for all survey points in terms of peak hour volume.

From Table 2 it can be deduced that the volume-to-capacity ratio for survey points 11 (inter traffic) and 9 (intra traffic) and the total for the NWU survey points are greater than 0.95. This is indicative of traffic congestion on the roads serving study area.

Table 1: Inflow and outflow of traffic on of the NWU Campus.

Location of gates	Percentage of this peak hour traffic handled by this gate/subway		
	7:00-8:00	13:00 -14:00	17:00 - 18:00
Gerrit Dekker gate:	19%	15%	12%
Hoffman gate:	21%	35%	40%
President gate:	20%	17%	15%
Esselen gate	18%	13%	13%
Subway to West campus	18%	19%	18%
Subway to the new Engineering faculty	4%	1%	2%

Source: Own construction

Table 2: Total traffic movements within the study area.

Traffic survey points (stations)	Peak hour (duration)	Peak traffic flow	ADT	Volume Capacity Ratio
Inter survey points 2013				
1	7:00–8:00	1262	4713	1.05
2	7:00–8:00	1713	6493	1.43
3	13:00–14:00	1254	5574	1.05
4	16:30–17:30	2212	6575	1.84
5	16:30–17:30	2124	8557	1.77
6	16:30–17:30	1533	6472	1.28
7	13:00–14:00	1705	6532	1.42
8	16:30–17:30	1589	6742	1.32
9	16:30–17:30	1656	5685	1.38
10	16:30–17:30	1462	5630	1.22
11	16:30–17:30	789	3073	0.66
12	16:30–17:30	1976	7972	1.65
Intra survey points 2013				
1	7:00–8:00	624	2806	1.04
2	16:30–17:30	1550	5973	2.58
3	13:00–14:00	1866	7777	3.11
4	13:00–14:00	765	2958	1.28
5	13:00–14:00	919	4120	0.77
6	13:00–14:00	423	1655	0.71
7	13:00–14:00	1093	4392	1.82
8	7:00–8:00	713	3259	1.19
9	13:00–14:00	1313	5442	2.19
10	13:00–14:00	689	2696	1.15
11	16:30–17:30	2126	8980	1.77
Intra NWU survey points 2013				
1	13:00–14:00	583	2153	1.94
2	7:00–8:00	379	1325	1.26
4	13:00–14:00	376	1397	1.25
6	13:00–14:00	700	2688	2.33
7	13:00–14:00	1270	5213	4.23

Source: Own construction



5.2 Land use survey

To determine the existing land uses in the study area a 100% land use survey was conducted. The attributes include erf (stand) number, street name and address, floors (height) of building, zoning, actual use of land, activity, coverage (m² and %), number of parking spaces for residents and visitors, number of units and the quality of the level of accessibility. Table 3 shows the estimated potential equivalent passenger car units (e.pcu) generation for all land uses within the study area.

Table 3: Equivalent traffic generation based on land use patterns.

Land use (zonings)	Equivalent Traffic Generated (e.pcu)*
Residential 1	1239
Residential 2	841.5
Residential 3	869
Residential 4	136
Student housing	1325
Apartments	651
Mix of res and apartments	130
Townhouse (special zoning)	976.5
Total Traffic generated (equivalent traffic)*	6168
Total Parking(residents and visitors) excluding the NWU needs	11773
Total for study area	1444963

Source: own construction from survey undertaken.

*e.pcu: equivalent passenger car units.

From the estimation of future traffic needs the dilemma within the study area can clearly be deduced as future traffic demand for inter traffic (> 40%) and intra-traffic (> 63%) will increase without any additional capacity being provided in terms of the capacity of the road network serving the existing and future land uses and related development.

5.3 Parking

Figure 6 shows the different parking survey zones on the main campus of the NWU. The parking survey in 2013 consisted of 63 parking survey points. From the survey follows that the total number of parking spaces on the main campus of the NWU equal 4342. Thereof 932 were at hostels on the main campus; 923 were reserved and undercover staff parking and 2487 open parking for staff and students. The average parking occupied ratio during the day for the most remote hostels of the main campus were 92% for the onsite parking and 82% for the parking within the road reserve.



Figure 6: The parking survey zones. Source: Google Maps.

The parking survey also assisted to focus in on specific parking sites related to locational sensitivity such as parking sites 3, 4, 5, 6, 8, 10, 11, 12, 13, 14, 15, 20, 22, 30, 34 and 36. Figure 7 illustrates that whilst the last mentioned sites were occupied at full capacity staff parking were under occupied in cases of survey sites 7, 18, 23, 26, 27, 28, 29, 31, 32 and 37.

6 Conclusions and recommendations

From the research the following solutions can be drawn:

- The value of the application of the EMME 4 (see [9]) modelling in assessing traffic patterns and road network capacity from a transportation and land use planning perspective is well proven to support future infrastructural needs and upgrading. The problem is however with decision makers who view such instruments as 'paralysis through analyses'. This position is symbiotic of decision makers who are not in favour of aligning future planning and infrastructure development to practical needs and

focuses. The challenge is to change decision making from 'paralysis through crisis management' to implementation of sustainable planning and development interventions.



Figure 7: The different parking survey points in Block 2. Source: Google Maps.

- Notwithstanding the detailed application of the EMME4 modelling this paper clearly illustrates that capacity within the existing road network; existing and future land uses; estimated future equivalent passenger car units (demand) and the restrictions in road network capacity (supply) can be estimated in a simplistic and understandable technique that serves as an elementary 'tool' to predict future traffic supply and demand within closed spatial areas such as higher education (university and its immediate sphere of influence) environments. However, these conclusions need to be supported by scientific application of modelling tools such as EMME 4 for informed decision making and detailed analysis.
- Within the study area it is concluded that there is not sufficient space for any more large parking areas or new development on the NWU Campus. The existing parking spaces on campus are not sufficient in terms of student demand, therefore the provision of a public transport system (student shuttle services) with parking areas outside campus for students and workers should be considered (see Figure 8).

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