Unpublished Report

The value of using urban simulation for land use management and planning

A case study of the Nelson Mandela Bay Metro

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1 INTRODUCTION

Simulating the land use and demand implications of different growth scenarios are critical to support long term planning and development of Spatial Development Frameworks (SDF) as required by the Spatial Planning and Land Use Management Act of 2013 (SPLUMA). Given the large amounts of government investment within South Africa's metro's, the simulation of the land use requirements and implications of such investments under specific growth scenarios becomes increasingly important. In this regard, the innovative urban simulation modelling framework under development in a number of SA's metro's, is one of the most powerful tools to inform and support key land use planning instruments to facilitate:

a. maximum development impact of that investment for poor households;
b. financial feasibility of the investment; and
c. sustainability of urban form.

This report provides an overview of the way in which urban simulation can be utilised to enhance the quality of spatial plans and land use management schemes to guide and enable high impact infrastructure investment and decision making in metropolitan areas.

The specific case study conducted by the Department of Rural Development and Land Reform in collaboration with CSIR and Nelson Mandela Bay Metro (NMB), clearly illustrates the way in which urban simulation, for the first time, enables a metropolitan municipality to determine (for a specific future growth scenario):

a. the possible impact of a proposed public transport investment (as per the Comprehensive Integrated Public Transport Plan 2013/14) on households' most probable location choices and their ability to access jobs for a minimum amount spent on public transport; and
b. the specific land use (zoning) and density requirements, as well as phased land release that will be required, to enable the higher density corridor development around this public transport investment and thus ensure its feasibility. It is also clearly evident how without the required zoning, phased land release and thus land use management support, the financial viability and sustainability of government's public transport investment can be questioned.

The case study illustrates the importance of integrated land-use and transportation planning, but more crucial, the importance of considering spatial implications of expected population and economic growth and spatial implications and outcomes of large scale government investment in cities. This is not only critical in supporting intergovernmental collaboration within Land Use Management Systems and SDF's but even more so in the required Capital Investment Frameworks and Built Environment Performance Plans in metropolitan areas.

1.1 CHALLENGES FOR EFFECTIVE PLANNING AND GOVERNANCE

The Spatial Planning and Land Use Management Act, gazetted on 5 August 2013, provides for one piece of legislation to guide and enable the formulation of policies, plans and strategies for land use and land development. The enactment of SPLUMA has brought a number of fundamental changes in spatial planning and land use management. The most critical of these is the reiteration of planning as the

primary mandate of municipalities, placing municipalities at the centre of planning. The Act also allows for the development of a single and inclusive land use scheme for the entire municipality, the development of spatial development frameworks (SDF's) by all three spheres as well as alignment of planning processes. This is aimed at strengthening intergovernmental support and implementation of spatial planning and development.

The Act requires municipalities to prepare spatial development frameworks that, among other things, "identify the long term risks of particular spatial patterns of growth and development and the policies and strategies necessary to mitigate those risks". The current planning instruments available to municipalities do not allow them to explore long term implications and spatial outcomes of certain land use patterns and growth trends. Under section 21 of the Act, requirements are listed regarding the content of municipal SDF's. Many of the requirements are future oriented and require municipalities to do projections, growth estimates, and identify future areas where investment will be prioritised, quantify and identify where in the city future infrastructure needs will be.

Municipalities are faced with the requirement to do forward planning while facing the challenges of addressing backlogs in service delivery, fiscal constraints, capacity constraints and a lack of information.

Given the current planning environment, the planning instruments available, capacity constraints in local government and the requirements set out to municipalities by SPLUMA, it seems that the capability to effectively engage future development trajectories and thus inform forward planning is a huge challenge. For spatial policies and instruments to be used to bring effect to the spatial principles and the desired urban form as promoted in the spatial plans and frameworks of South African cities, a substantial focus on future needs and probable land development implications is critical. It is increasingly evident that ad hoc interventions will not bring about spatial transformation and that clear direction and spatial coordination is required. Whereas one of the biggest problems confronting municipalities remains the absence of accurate data, another is the capability to systematically engage probable land development and land release requirements and strategies within specific areas, and the ability to utilise the planning instruments provided through SPLUMA in an effective way for that purpose. Together with the ability to monitor growth and dynamic change, cities need to be able to timeously guide investment, react to change and mitigate risks.

1.2 NELSON MANDELA BAY METRO CONTEXT AND DEVELOPMENT CHALLENGES

Nelson Mandela Bay Metro, the only metropolitan municipality in the Eastern Cape and covers an area of 1 950km$_2$. The metro was established in 2000 by joining the local authorities of Port Elizabeth, Uitenhage, Despatch and several adjacent local authorities. Nelson Mandela Bay has a population of just over 1.1 million. In 2011 36.6% of the population was employed and 69% of the population was between the ages of 15 and 65 years (StatsSA Census 2011). In 2011 there were approximately 254 000 formal households, 22 400 informal households and 49 000 qualifying households in backyard accommodation. In 2011 (StatsSA Census) 74% of households had access to piped water and 90% of households had access to electricity.

Nelson Mandela Bay plays a fundamental role in the economy of the Eastern Cape Province by contributing approximately 44% to the GGP. However, unemployment has increased over the last five years. Over the same period, the number of people living below the Minimum Living Level increased from 31% to 38%. Nelson Mandela Bay is a well-capacitated municipality with a clearly defined structure where strategic planning is co-ordinated at the office of the Chief Operating Officer.

The NMB has a unique development challenge to South African metropolitan areas, in that they are concerned that they may be over-catering for growth within their metro area. The trend that the NMB demographic study reveals, is one of a degree of intra-metropolitan movement of people (which sometimes creates an impression of growth, for example, in the appearance of new informal settlements on the urban periphery) but not of substantial growth or influx of people into the metro. Officials are concerned that they are in fact, in their housing and other programmes, over-catering for growth in their metro area. They see one of their key development challenges as the need to generate economic growth and attract investors to the metro area as a stimulus for growth. The N2 Node project, which includes a super-regional shopping centre and light industrial area of Greenbushes, is seen as one possible way of generating such growth for NMB. Jachtvlakte, a proposed industrial development is seen as another key initiative in this regard. Whether COEGA IDZ fulfils its development potential is another key challenge in the minds of metro officials who recognise the potential contribution of this to the future development of NMB. They argue that if the COEGA harbour is fully operational then the related industrial development and employment generation will bring the growth that NMB needs. The city is also facing a challenge of a shortage of government-owned land in the inner-city and in serviced areas. In addition to this, the city is also having difficulties in achieving their spatial restructuring goals which together with the absence of a long-term capital investment plan has hindered economic growth and socio-economic development (Nelson Mandela Bay Municipality 2014). The city has also seen a rapid decline in building investment between 2010 and 2013.

Metro officials have set for themselves the challenge of developing sustainable community units in which citizens can ideally access facilities and employment within walking distance or with easy access to public transport networks. They see this as a key methodology in attaining more integrated and equitable urban development. They also look to their restructuring zones and the funding attached to these social housing initiatives, as providing a catalyst for restructuring urban space and achieving a more integrated mix of incomes and activities within these residential developments. They see these zones as providing ideal opportunities to create Live-Work-Play areas. They have undertaken the requisite planning for these zones in the LSDFs, but recognise that a lot of the success of such areas depends on effective management.

2 THE CAPABILITIES OF URBAN SIMULATION AND HOW THE USE THEREOF CAN ENHANCE THE QUALITY OF PLANNING INSTRUMENTS

Any planning dialogue unavoidably concerns time since all planning experiences are with the past, but all decisions are about the future (Mandelbaum 1985). The past, present and the future are all significant in and for planning. For land use planning and the development of a land use scheme or a SDF, it is important to explore the future and to plan in anticipation of certain issues, which is also highlighted in SPLUMA.

It was recognised that plans made in NMB will have to not only be informed by the present and the past, but by engaging probable future outcomes. The Integrated Urban Simulation Platform (developed by the CSIR in collaboration with the Department of Science and Technology (DST) and various metro's including NMB and based on adapted versions of UrbanSim and OpenTripPlanner) is a numerical modelling and simulation platform that provides the experimental space within which likely patterns of urban growth can be studied 30 years into the future. Within the NMB case study this was utilised to evaluate the long-term impact and viability of spatial policies, interventions and investment decisions that are made in the present.

The urban simulation platform is city specific and requires detailed data for each land parcel in the city as an input as well as other specific urban management policies and the means to implement such policies (see Figure 2 below). The second input that is required is indicators that will be used to evaluate the results of the simulation, for example; is it more or less efficient in terms of;

- infrastructure cost,
- levels of congestion,
- transport costs for households, and
- municipal income.

The third input required is population and employment projections for each year up until the 30th year.

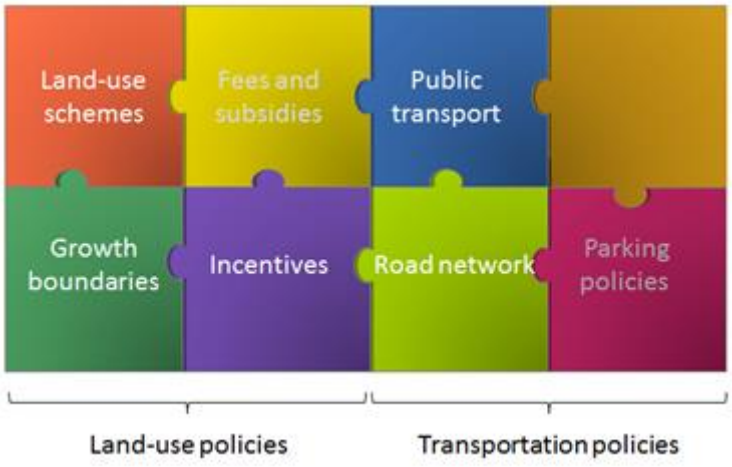


Figure 2: Urban management policies

Once the platform is developed for a specific city, it can be utilised to simulate probable future spatial development and land use demands and resultant spatial patterns under certain population and economic growth scenarios. These sets of simulation images are extremely useful in illustrating and testing the spatial implications for implementing spatial plans, policies, land use schemes, and development control mechanisms. To develop these sets of images households and enterprises as actors in the urban market, are associated with statistics on a range of variables. Variables that best describe aspects such as location choices and observed behaviour under certain conditions are selected.

2.1 APPLYING THE URBAN SIMULATION PLATFORM IN NELSON MANDELA BAY

The urban simulation platform's capability to generate useful information on probable future land uses to substantially support forward planning as part of SPLUMA implementation was tested in Nelson Mandela Bay, with inputs and support of city officials

The NMB wished to investigate what the requirements are in terms of densities and land use along the proposed corridors to support and ensure efficiency and viability of the integrated public transport systems, under certain growth conditions.

For NMB various scenarios were developed through a separate process aimed at ensuring the long term financial sustainability of the metro. Only the preferred outcome scenario aptly named 'Walking together' and a variation of that scenario based on an optimistic growth target for the automobile manufacturing industry based in Uitenhage is considered here. With public transportation being an important factor to consider in the financial sustainability debate, the metro had an interest in land use and densities along the proposed corridors to minimise subsidisation of integrated public transport services.

The NMB urban simulation model viability study can be summarised as:

1. Using the existing urban simulation model for Nelson Mandela Bay, and thus on the one hand the magnitude of spatially explicit data categories related to land use, land use demands for different segments of the city's population, land rights, land value, transportation networks, etc., and on the other hand the verification, validation and simulation capability created in the NMB urban simulation model as part of the StepSA (CSIR, DST, NMB) initiative as basis. Validation of the NMB urban simulation model was already proved during that initiative, with NMB the model predicted areas of decline correlating with spatial patterns evident from the 2001 to 2011 growth in the census;
2. Adapting the model to reflect the selected high growth socio-economic development scenario and associated land development pressures; as well as the specific integrated public transport intervention;
3. Using the NMB urban simulation model to iteratively:
    a. Simulate the collective impact (in space and over time) of choices made by individual households; businesses as consumers of property and services; developers as suppliers

of property; and government as a supplier of infrastructure and services given the above conditions and interventions; and

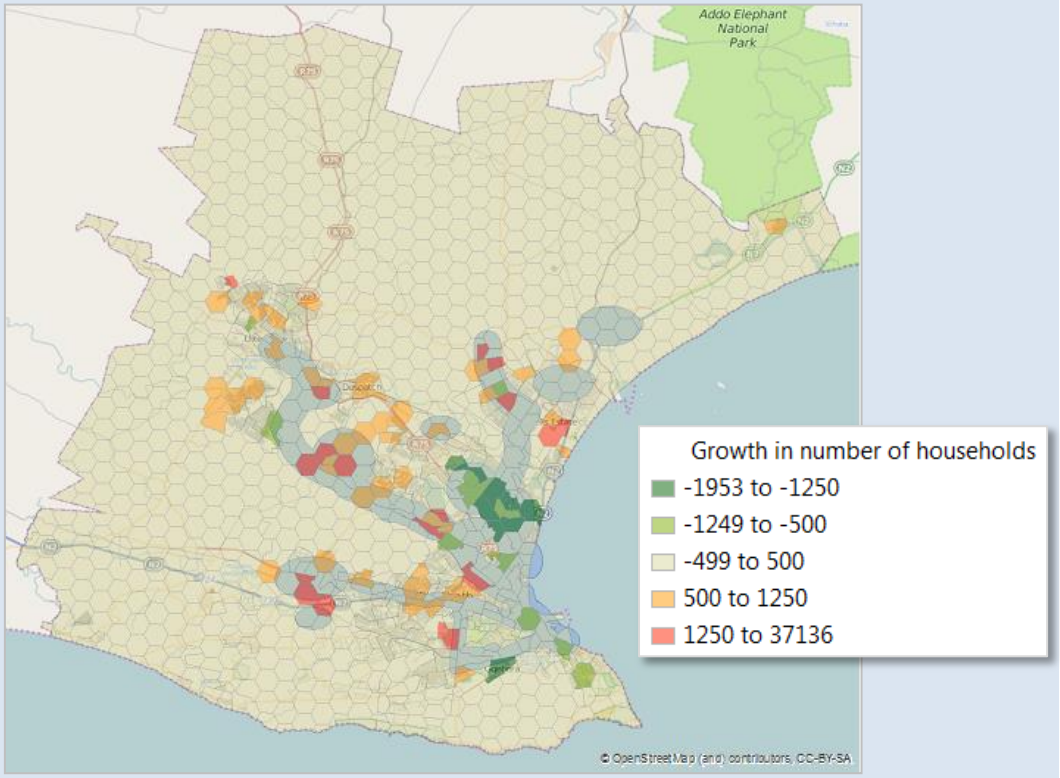
b. Adapt the land development requirements (type of land, land rights, size of land and densities) to adhere to the density requirements for a financially viable public transport investment, as well as ensure sufficient and appropriate land is available for development;

4. Utilise the simulation results to develop a spatial representation of the resultant most probable land development implications (spatial manifestation) of the above decisions
    a. Output 1: Step one of the simulation has been done for the time period 2001-2011. The spatial patterns resulting from this simulation compares well with actual development trends in the city during that time;
    b. Output 2: The second step in the simulation was to extend the above simulation to cover a 30year time period, from 2001 to 2031. The results thereof is an additional 20year simulation of predicted demands, choices and subsequent land development implications (2011-2031); and
5. Using the results of above simulation to evaluate the impact of the proposed public transportation system on the cost for individuals to commute to work and access public services and amenities (Output 3).

In addition to the above outputs, it was evident in the process of adapting the land development requirements (See 3.b above) to reach optimum implementation of the public transport intervention, that the simulation process and results are extremely effective to highlight parcel level land development and land release requirements, and thus the possible blockages that can be created by land use management and spatial planning instruments that do not enable the required and timeous availability of appropriate land for the required development and density mixes to support the development of an effective corridor. As such the spatial results of the simulation could in addition to guiding investment, be highly effective in evaluating and adapting existing spatial planning instruments (See Output 4).

OUTPUT 1: Simulation results for 2001-2011

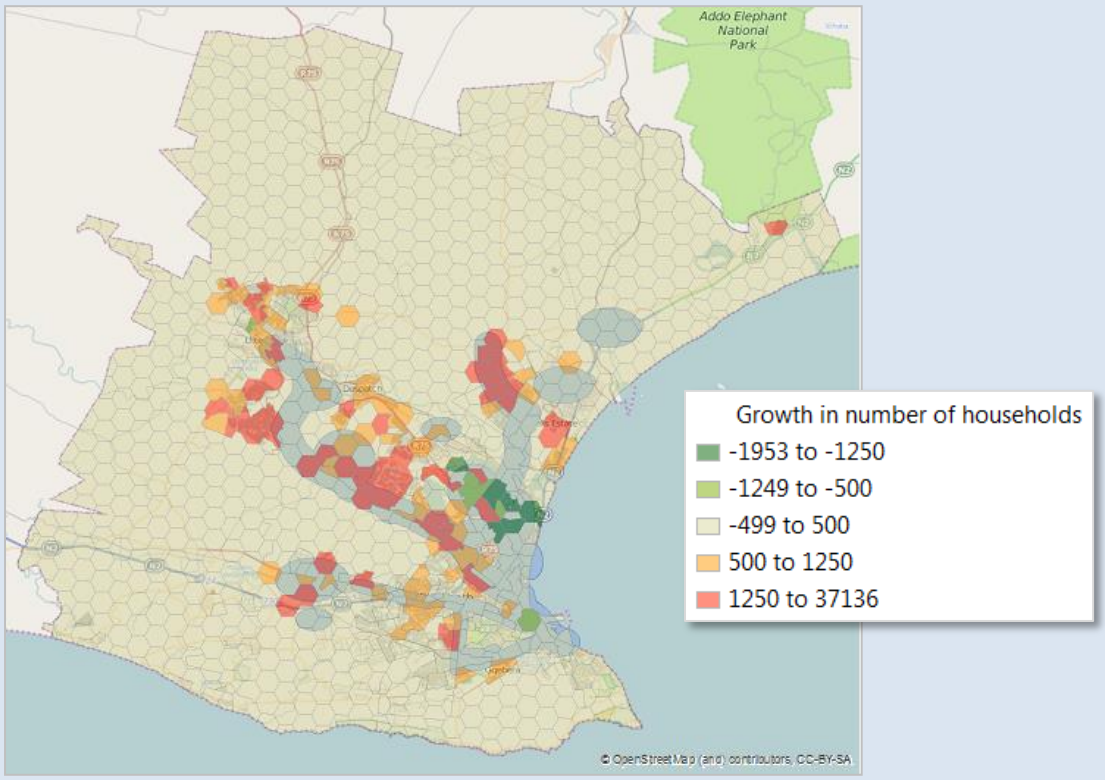
Walking together



Simulated growth in households over 30 years from 2001 with the implementation of the first phase of the integrated public transport system. These results correlate with actual spatial trends and areas of decline in the city during that time.

OUTPUT 2: Simulation results for 2001-2031

Walking together – Optimistic economic growth



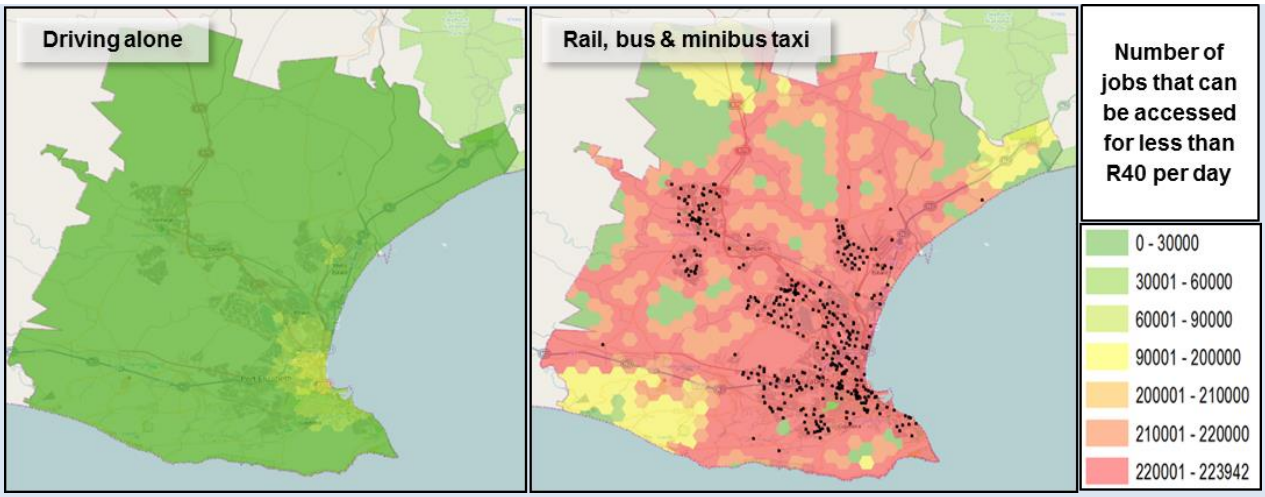
The map provides the spatial results of the simulated growth over 30 years from 2001 with all phases of future public transportation system.

Availability of appropriate land, with the required size but also land rights and types, as well as timeous release of land, enables a 23% increase in density within the identified corridors, compared to existing densities. It is evident from the simulation results that such an increased density will support financial viability of the investment as well as spatial outcomes as set by the city.

Note 1: At 15 du/ha the density is still relatively low. It is evident from the simulation that this could possibly be improved by better spatial targeting within the planning instruments influencing availability of appropriate land.

Note 2: Household growth resulting from economic injection in Uitenhage manifests all over the corridors. This is a possible unintended consequence of public transportation intervention which would not have been anticipated without simulation.

OUTPUT 3: Evaluate impact (spatial outcome) of the intervention



The maps illustrate how impact and specific spatial outcomes of public investments can be evaluated.

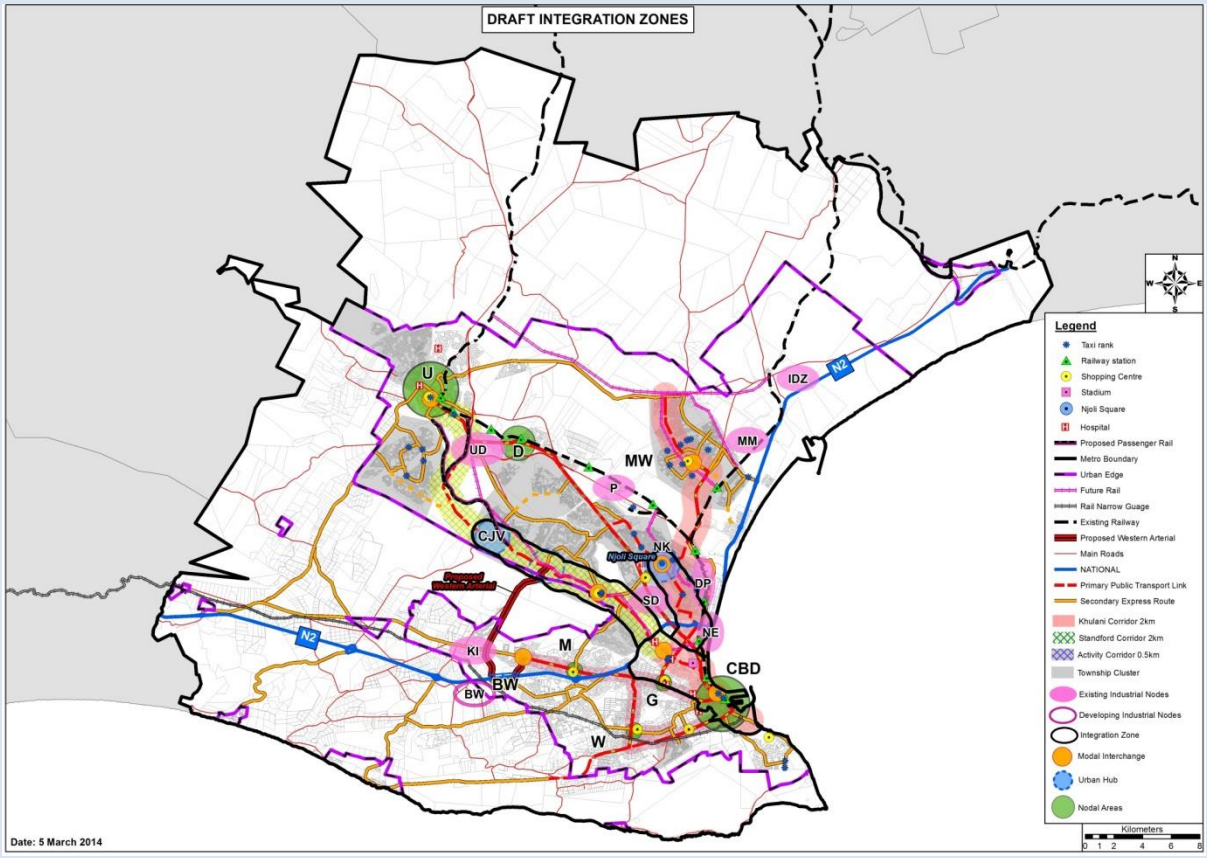
In this case it is done by using Output 2 of the NMB urban simulation model application, to compare access (distance and cost) to job opportunities for individual households that will be possible with the implementation of the integrated public transport intervention with a situation where there will no focus on public transport, and private car is the only effective mode of transport.

It is clearly evident that the availability of public transport through the specific intervention can have a major impact on household's ability to access jobs for limited cost, and thus provide households with more choice and opportunity.

OUTPUT 4: Evaluate and inform land use management and spatial planning instruments

As set out in the brief overview, the process of urban simulation (as it simulates household and developer choices) requires appropriate land (thus with required characteristics such as location, size, rights, density, cost, timeous availability) for utilisation in the interactive simulation of land development choices and growth over the simulated time period.

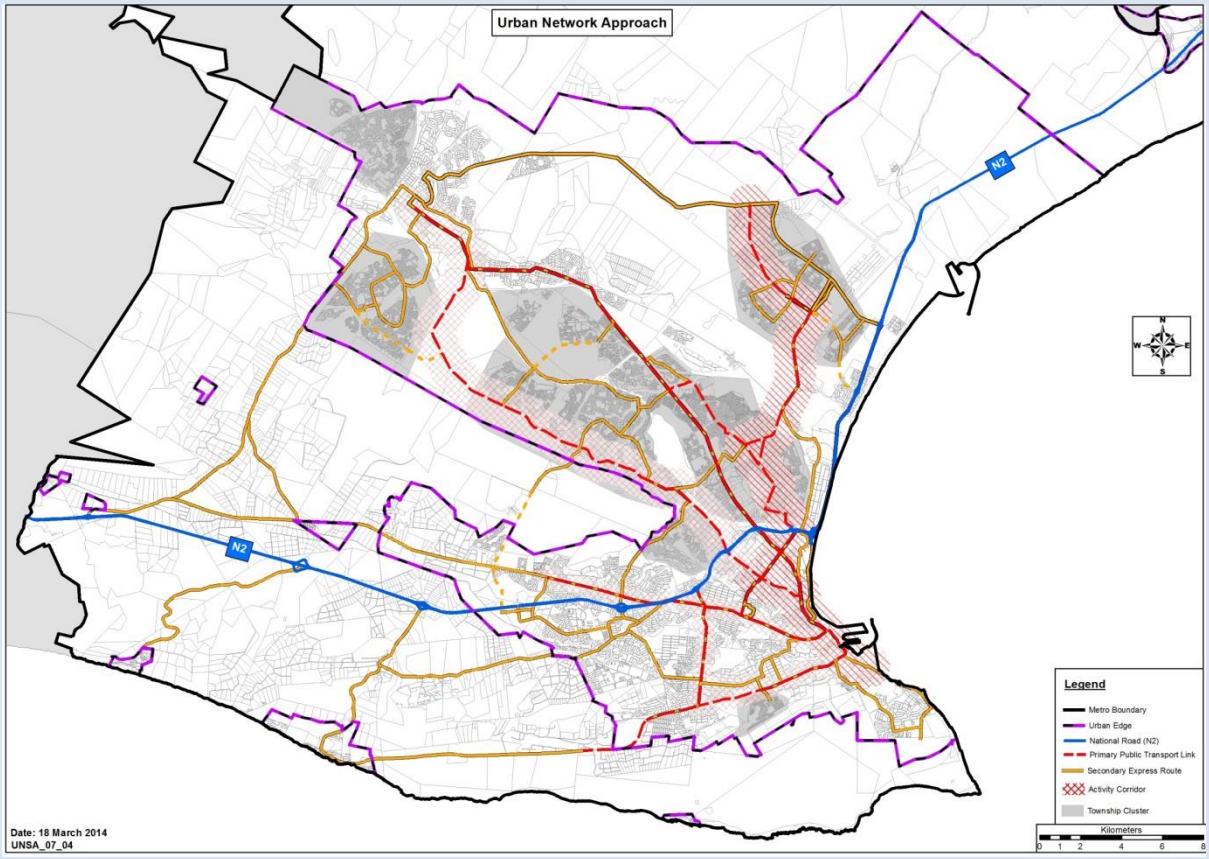
Interesting finding from the specific application was that whilst the "corridor" and associated land characteristics as designated in NMB's Integrated Transport Plan (which is conceptually in line with the Integration Zones the Urban Network approach) was used as input for the simulation, it was evident that a high level of detail regarding future land rights, densities, availability etc. is required to guide simulation of household and developer choices. During the simulation process it was found that the absence thereof, results in inappropriate and inadequate land availability for development and densification of the expected corridor development in the simulation exercise over the selected time period.



This clearly points to the major impact that land related restrictions and timeous availability of land has on development and thus on the implementation and feasibility of the proposed Integrated Public Transport Intervention.

Land rights within urban simulation model are affected by plans such as the SDF, the Comprehensive Integrated Transport Plan and the Urban Network Strategy. These plans make certain statements that affect land use and land rights, such as where densification and infill development will occur; where the urban edge is and where growth will be concentrated. But it is essential to determine if that land is actually timeously made available in the locations set out in the plan.

The simulation of development choices for the selected growth scenario, only resulted in the desired density and land use mix to support effective implementation of the Integrated Public Transport System once the "required mix" of land types, rights, size, availability, density etc. where provided as inputs to the NMB urban simulation model. Changing land types in effect means that land characteristics determined by current spatial planning instruments and the NMB land use scheme will not support or enable the intended spatial outcomes and impact.



Key implications of the above is that:

1. It has been starkly highlighted that spatial planning instruments and land development application processes (and resultant land rights and availability) play a major role in either facilitating or BLOCKING intended spatial outcomes and impact of investment interventions. THUS the importance of effective and well informed, future orientated spatial planning instruments;
2. The NMB urban simulation model and the specific simulation process enabled the identification of suitable types and amounts of land to be released into the market to ensure that there is enough land available at the required densities in the right areas in order to accommodate the expected growth in households and employment, as well as the influence of the planned integrated public transport system on the choices that are made by households and businesses. It is thus evident that plan evaluation, plan development and land use scheme adaptation can gain tremendous value by actively engaging future development and growth implications and requirements for developing an appropriate land use scheme for a city, and the specific value that can be added by utilising the urban simulation capability.

Using the urban simulation platform, the city will thus be able to determine if the correct types of land is available and if it will be able to accommodate the projected growth within the planned corridors. It is important that these spatial plans are closely aligned with land use management plans as to ensure that the sufficient amount of land is available at the preferred densities, and that this land is available in the right locations to support these plans. As such it is evident that city specific urban simulation models can also be used to inform certain urban and land use management policies that can, through land controls, ensure that the desired outcomes as set out in the plan are achieved, as well as test unintended implications of interventions on spatial outcomes.

2.2 THE VALUE OF URBAN SIMULATION FOR PLANNING

Using the platform in NMB allowed the city to answer difficult questions regarding land use management and planning. The city was able to produce evidence for planning by making use of the simulation platform. Being able to make informed decisions and being in a position to test certain scenarios and to study the probable outcomes of these scenarios, enables a city to make better decisions for their city and their people. By having land uses support large capital expenditure projects ensures that these public investments have the desired and intended impact on the city and households. Not only is the city able to make informed decisions, but they have a support base for these decisions.

The platform can be used to project population growth, future demand for services and infrastructure, and identify areas that will experience environmental pressures. The platform can also be used to simulate different land use scheme scenarios in support of planned large scale public investment initiatives to investigate efficiency and viability of such initiatives, as in the NMB case study. These projections and simulations can also be used to support planning in enabling the identification of areas where incremental upgrading should take place and areas where development should be facilitated and fast-tracked. Land use change tracking and monitoring together with modelling can assist in identifying land uses, propose certain land use management schemes, control and regulation in areas previously not subject to a land use scheme, provide information on where affordable housing should be located, propose certain land use incentives in locations, and give effect to SDFs and other spatial and development plans. Also, the modelling of specific indicators that assist in measuring and analysing the extent to which development principles, norms and standards are realised; can support municipalities in meeting the requirements as set out in SPLUMA.

The platform simulates the choices made by households, businesses, developers and government, and for this reason it can be used to provide investment decision support for the public and private sector. Urban Simulation can be used to indicate where growth will likely manifest in space, it is able to consider the impact of development decisions outside of the metropolitan boundary, it can model for both the formal and the informal households and enterprises. Urban simulation allows municipalities and government to model spatial planning proposals and their market take up before committing to large capital expenditures.

Doing urban simulations encourages planners to make policies spatially explicit and to then see how households and businesses respond to these policies. The results may challenge conventional planning ideas and create the opportunity for planners to explore alternative and innovative approaches to planning. Urban Simulation exercises underline the importance of following an evidence-based approach to planning.

3 VIABILITY AND FINANCIAL SUSTAINABILITY

The urban simulation platform has the capabilities to provide support to municipalities in making informed planning decisions as to meet the requirements set out in SPLUMA and to ensure that their cities follow the principles of spatial justice, spatial sustainability, efficiency, spatial resilience and good administration.

The Comprehensive Integrated Transport Plan and the Nelson Mandela Bay Metropolitan Transport Area Three Year Capital Programme estimate that implementation costs will be R902 867 894 for the 2013/14 year, R1 277 743 394 for the 2014/15 year, and R1 640 848 394 for the 2015/16 year. This totals close to R4 billion over the three years and includes planning and design, maintenance, management and operation, and capital costs.

The cost of doing an urban simulation exercise is estimated at roughly R3.5 million for a new metro (0.08% of the total Comprehensive Integrated Public Transport Plan budget) and R750 000 for a periodic update of an existing model like those in NMB and the City of Tshwane. A new model can be completed in about one year. The bulk of the cost (60%-80%) goes into preparing a parcel dataset for the metro. The CSIR is currently exploring initiatives to reduce that cost.

When comparing the cost of running a simulation exercise such as the one described earlier with the implementation and operational costs of an integrated public transport system, as planned by the NMB, it fundamentally supports the argument that urban simulation exercises add value to such an immense public capital investment and the viability of it. When taking into consideration the savings in terms of transportation costs incurred by households and the cost to the public sector in terms of subsidies, the value is even greater.

In doing an urban simulation exercise that is able to indicate where and what sort of densities are needed in which corridors to ensure efficiency and effectiveness of the public transport system and to support public capital spending and increase the return on investment.

4 CONCLUSION

Previous urban simulation work demonstrated that density projections used by metropolitan municipalities when planning for large scale public investment projects, are far more than what is likely to happen given the current growth patterns and population projections of the cities and that the densities required to sustain a public transport system will not be achieved (Coetzee et al. Forthcoming).

It is important to realise that South African households are diverse in terms of their economic brackets and that as a result their transport demands are equally diverse. Therefore state investment in public infrastructure will not necessarily generate the required densities to make such a public transport system viable and sustainable (Coetzee et al. Forthcoming). Other interventions are needed in terms of land use schemes and land release schedules that will facilitate the uptake of land in the appropriate area and at the appropriate time by private developers, so that the desired densities and land uses can be achieved.

Making use of urban simulation to help determine the land use scheme and the land release schedule, together with being able to simulate the choices made by households, businesses and developers within the city, allows the city to control while facilitating development and to reach the desired spatial outcomes promoted in their spatial plans and frameworks and required in terms of SPLUMA and other spatial policies.

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