Spatial policy, planning and infrastructure investment: Lessons from urban simulations in three South African cities

Maria Coetzee(†), Louis Waldeck, Alize le Roux, Cathy Meiklejohn, Willemien van Niekerk & Tsepang Leuta

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Abstract

This article is based on the assumption that more spatially efficient investment choices in both economic and basic infrastructure spending can make a significant impact on the equity, efficiency and sustainability of human settlements. Emerging from work conducted as part of a Department of Science and Technology (DST)-funded Integrated Planning and Development Modelling (IPDM) project, the article argues that decisions about infrastructure investment in South African metropolitan areas ought to be grounded in robust and rigorous analysis and scenario evaluation. More evidence, and better evidence, an understanding of spatial trends and the underlying forces that shape them, are needed to support planning and infrastructure investment. Urban simulation platforms offer valuable tools in this regard. Findings of simulation work in three metropolitan areas (eThekwini, Nelson Mandela Bay and Johannesburg) are presented to demonstrate this, and some implications for spatial policy, planning and infrastructure investment are highlighted.

RUIMTELIKE BELEID, BEPLANNING EN BELEGGING IN INFRASTRUKTUUR: LESSE UIT STEDELIKE SIMULASIES IN DRIE SUID-AFRIKAANSE STEDE

Die artikel is gebaseer op die aanname dat ruimtelik-effektiewe beleggingkeuses in beide ekonomiese en basiese infrastruktuurbesteding ’n beduidende impak op die gelykheid, effektiwiteit en volhoubaarheid van menslike nedersettings kan hê. Werk wat gedoen is as deel van die Integrated Planning and Development Modelling (IPDM)-projek, en befonds is deur die Departement Wetenskap en Tegnologie, argumenteer dat besluite omtrent infrastruktuurinvestering in Suid-Afrikaanse metropolitaanse gebiede gegrond moet word in robuuste en grondige analise en scenario evaluering. Meer bewyse, asook beter bewyse, sowel as ’n begrip van ruimtelike tendense en hul onderliggende kragte is noodsaaklik om beplanning- en infrastruktuurinvestering voldoende te ondersteun. Stedelike simulasie platforms bied waardevolle instrumente in hierdie verband, en bevindinge omtrent simulasie werk wat gedoen is in drie metropolitaanse gebiede (eThekwini, Nelson Mandela Baai en Johannesburg) word voorgelê om dit te demonstreer. Sommige implikasies vir ruimtelike beplanning, beleid en belegging in infrastruktuur word ook uitgelig.

MAANO A DIBAKA, MERERO LE CHELATE YA DITHULUSI TSA HO NTLAFATSA TEROPO: DITHUTO TSE TSOANG

Serapa sena se tobana le monahano oa hore ho etsa diqeto tsa ho kenya chelete moruong le dithulusing tsa ntlafatso ya teropo, ho ntso beuoe dibaka menahanong, ho ka thusa haholo ka ho thusa haholo ka ho lekana ha batho, tshebetso e phethahetseng kda ho tlala, le tswediso pele ya bolulo ba batho. Ho tsoa mesebetsing ya Lefapha la Saensi le Thekenoloji (DST) e bile e tsheheditsoe ka chelete ya projeke ya Integrated Planning and Modelling (IPDM), serapa sena se thuisa taba ya hore diqeto tse etsoeng ka dichelete tsa dithulusi tsa ntlafatso ya teropo Afrika Borwa di hloka ho shebisisoa ka botebo boo matla. Kekektso ya bopaki, le bopaki bo betere, kutloisiso ya diphetho tsa dibaka tse kholo le tse ding tse ka di qheketsang, di hlokahala kaofela ho tshehetsa merero le dichelete tse eang dithulusing tsa ho ntlafatsa teropo. Methati e nkoang hore e tsebe ho ntlafatsa teropo ke eona e bohlokoa ho fan aka maeletsi tabeng tsena. Mehlala e tsoang teropong tse tharo tsa Afrika Borwa (e leng eThekwini, Nelson Mandela Bay le Johannesburg) ke eona e hlahisitsoeng ho bontsha taba ena le ditla morao tsa maano a dibaka tse kholo, chelete ya dithulusi tsa ntlafatso ya teropo le merero dia hlaha serapeng sena.

1. INTRODUCTION

South Africa is striving to overcome a deeply rooted legacy of spatial disparity, the manifestation of social and economic inequality. The 2011 National Development Plan contends that spatial challenges continue to marginalize the poor: “Since 1994 ..., little progress has been made in reversing apartheid geography, and in some cases the divides have been exacerbated” (NPC, 2011a: 238). Despite long-term efforts to address these challenges, social and economic cohesion remains a significant problem in the country, and high and escalating numbers of people live in poverty in densely settled and increasingly

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vulnerable areas on the periphery of cities (Turok & Parnell, 2009; Van Huyssteen, Meiklejohn, Coetzee, Goss & Oranje, 2010).

Infrastructure investment plays a key role in addressing these challenges. According to the 2013 National Treasury 'Estimates of National Expenditure' (2013: xix), spending on key infrastructure for the 2013/2014 period alone was to be R103 963.4 million. This figure excludes direct infrastructure investment by local government from their own revenue or by means of direct borrowing. In addition, there are the Human Settlements Development Grants (R17 billion in 2013/2014), the Urban Settlements Development Grant (R30.1 billion over the MTEF period), and the Neighbourhood Development Partnership Infrastructure Grants (R2 billion over the MTEF period). In the 2013 Medium-Term Expenditure Framework, R16.6 billion was allocated to key infrastructure projects. Key transport infrastructure is prioritised and one third of these resources are allocated to local government, housing and community amenities to be invested in water supply and regional bulk infrastructure, and municipal infrastructure. An integrated city development grant is being introduced to provide incentives for cities to strengthen planning and delivery capacity, and target infrastructure spending to transform the inefficient spatial form of South African cities so that they are more inclusive, productive and sustainable (National Treasury, 2013: iii, 169).

When a society spends as much (as South Africa is) on expanding the physical platform for growth, it must, at the end of that process, have more than ports and railway lines and dams (Patel, 2012). It is vital, therefore, that there is an explicit spatial rationale guiding policy and planning decisions relating to infrastructure investment.

The Presidential Infrastructure Co-ordinating Commission acknowledges that infrastructure is critical to both the functioning of human settlements and the unlocking of economic opportunities. In its National Infrastructure Plan (PICC, 2012: 9), it points to the critical role of infrastructure in "promoting balanced economic development, unlocking economic opportunities, addressing socio-economic needs, and helping integrate human settlements and economic development". This can only be achieved by aligning infrastructure investments in space and time and in the context of clear and unambiguous plans that find expression within municipal jurisdictions. However, the capacity of municipalities to plan effectively is a major concern raised by the National Planning Commission in its Diagnostic Report on Material Conditions (NPC, 2011b: 25). It points to challenges regarding institutional and human capacity, including "the existence of multiple players (with integrated planning and delivery still to be achieved), and limited capacity among many of these players to ensure appropriate expenditure".

This article reflects on the findings of the urban simulation component of the Department of Science and Technology-funded Integrated Planning and Development Modelling (IPDM) project in three South African metropolitan areas. Although the article does not allow for a full exposition of the detail of the project, it serves to highlight, with illustrative examples from the findings, the importance of evidence-based systems in challenging conventional policy, planning and infrastructure investment approaches. It is structured to provide a brief background on the IPDM project and the context within which it emerged; outline the nature of the evidence-based spatial simulation platform, and the processes and methodologies employed in the project; present key findings from the simulations conducted in three metropolitan areas, and draw out the implications of the findings of these urban simulation processes for existing spatial policy and the conventional planning and infrastructure investment approaches in South African cities. It concludes with a plea for evidence-based, modelling and simulation capability to be used to develop innovative policy, planning and infrastructure investment approaches which will overcome entrenched neo-apartheid spatial inequalities in South African metropolitan areas.

2. IPDM PROJECT – SIMULATION IN THREE METROPOLITAN AREAS

2.1 Background and context

In 2010, the Department of Science and Technology (DST) launched the 'Human and Social Dynamics in Development' Grand Challenge (HSDD GC) Science Plan (DST, 2010) through which it aimed to increase and deepen research in a range of fields related to human and social behaviour and societal change, while contributing to the development of evidence-based public policy that strives to overcome a deeply rooted legacy of poverty, inequality, and skewed economic development. DST's 'Global Change' Grand Challenge Research Plan (2010) identified 'Planning for sustainable development' as a key theme and advocated the development of evidence-based platforms to interrogate the relationship between urban form, infrastructure investment and city resilience and to inform spatial policy, planning and decision-making (Coetzee, 2011).

As part of its drive to support the notion of a developmental state, in which spheres and sectors cooperate and coordinate to realise its development path, the Department of Science and Technology (DST) identified the need to harness Information and Communication Technologies (ICTs) to make available rigorous spatial and temporal evidence of past, current and possible future development patterns and trends. It commissioned the Council for Scientific and Industrial Research (CSIR) and the Human Sciences Research Council (HSRC) to develop an information and modelling platform to support integrated planning, development and service delivery for South Africa. The IPDM project focused on a few key elements to support integrated planning at different scales, including developing spatial profiles to support planning at a regional scale, and housing and travel profiles to inform local integrated development planning processes. The focus, in this instance, is on the third element of the project, namely conducting urban simulations to inform planning processes at a metropolitan scale.

2.2 Purpose of the urban simulation component

The main aim of the urban simulation component of the IPDM project was to develop an integrated open source spatial simulation capability (UrbanSim) to enable cities to simulate spatial change in settlement patterns in the context of a range of population and employment growth scenarios over a 30-year period. The urban simulation platform is not a single model, but an urban simulation system comprising of UrbanSim, MATSim and ArcGIS (UrbanSim is a prominent second-generation urban growth simulation platform; MATSim is used for transportation simulation resulting from a commuter population pursuing their daily activity schedules, and ArcGIS is a geographic information system). Current planning applications of the urban simulation platform within the United States of America includes the cities of Detroit, Durham, Eugene, Houston, Phoenix, Salt Lake City, San Antonio, San Francisco and Seattle (Synthicity, 2014). It is designed and continues to "evolve to address integrated planning, while being sensitive to the institutional and political challenges of integrated planning" (Waddell, 2011: 216).

By combining three components of traditional decision-support systems, namely information, models and visualisation (Waddell, 2002), this spatial simulation capability renders a time series of annualised spatial images (or maps) depicting future spatial development patterns that will result from the implementation of spatial policies, plans and infrastructure investments. These sets of time-change maps are underpinned by data and statistics on a range of household and enterprise attributes. They provide decision and planning support to metropolitan planners and policymakers on a range of development issues. For example:

- Future patterns of demand for infrastructure, facilities and services such as water, electricity, sanitation, schools, clinics and hospitals.
- The economic infrastructure investments that will be required to sustain the economy, including in public and private transport infrastructure.
- How future urban form may impact on the sustainability of cities, using indicators such as travel time and travel cost, access to social and economic opportunities, as well as energy and carbon efficiency.

UrbanSim includes the key choices about location and development of the main actors in the urban markets, such as households, businesses, developers and government. It can, therefore, help the public and private sectors make more informed decisions regarding major investments (such as transportation systems), and urban growth management strategies that will have huge social, economic and environmental impacts (Waddell, 2002: 306; Borning, Waddell & Forster, 2008: 439, 447).

3. METHODOLOGIES

3.1 Living laboratories

'Living-laboratory' processes were integral to the urban simulation work in the cities of eThekwini, Nelson Mandela Bay and Johannesburg. To improve the uptake of evidence, it is essential to boost the development and application of planning support systems in close alignment with the planning process and context (Geertman & Stillwell, 2004). These living-lab processes, which require the collaboration of all stakeholders, took the form of a series of interactive work sessions with end-users to ensure the participation and collaboration of the end-users in the process of developing, testing and evaluating the simulation platform and interpreting and applying the results thereof. The respective living-laboratory processes were aimed at finding context-specific solutions to their particular spatial planning challenges, and have subsequently highlighted the need for reviewing existing long-term planning approaches and investment decision-making processes in these metropolitan areas.

3.2 Interrogation of plans

The strategic spatial and other relevant sector plans of the three metropolitan areas were interrogated to identify key long-term planning issues, and the relevant data to provide the content for the urban simulation was collected. In addition, demographic and economic projections for the metropolitan areas were developed by IHS Global Insight (one of the world's largest repositories of global economic, financial and industry data) after participating in some of the living-laboratory events. These served as 'control totals' needed as an input for UrbanSim.

3.3 Data collection

In parallel with the data technical preparation, initial living-lab discussions about scenarios and indicators proceeded. Proposals regarding specific scenarios and indicators relevant to each metropolitan area were then presented. This process included engagement with key metropolitan role players over two or three work sessions, which resulted in the projection scenarios being adopted. Through participation in the living-laboratory process, the metropolitan stakeholders had insight into the methodology being applied and were able to influence the assumptions underlying the simulations.

3.4 Technical simulation work

Key long-term planning issues (outlined briefly in 3.5) for each metropolitan area were distilled from their strategic spatial plans. A synthesis of these provided a context for engaging with the metropolitan role players in the living-laboratory process about the specific content of simulations, and served, together with the demographic and economic projections, as input to the urban simulations. In most instances, the metropolitan role players proposed conventional planning instruments and measures, such as high-priority transport corridors, increased densities, mixed land uses, urban edges, and development lines, assuming unquestioningly that they would have the desired outcomes in their cities.

3.5 Existing spatial planning approaches

3.5.1 eThekwini

The eThekwini Metropolitan Municipality's planning approach is informed by the need to promote spatial concentration to make the best use of existing resources and infrastructure and to increase residential and employment opportunities in close proximity to each other. It also aims to improve productivity and use infrastructure delivery to impact positively on household and community quality of life. Metropolitan policymakers and planners argue that these will be realised by promoting more compact development which encourages higher densities and reduces the need to travel by increasing accessibility. The following strategies are used to attain this vision, as outlined in the eThekwini Spatial Development Framework: encouraging efficient use of infrastructure; reducing the separation between homes and places of work; promoting the regeneration of key economic nodes and corridors; promoting investment in key sectors; developing road and rail networks; investing in and maintaining tourism nodes; creating a diverse economy, and reducing the cost of doing business (eThekwini Metropolitan Municipality, 2012).

3.5.2 Nelson Mandela Bay

To achieve its objectives, the Nelson Mandela Bay Municipality (NMBM) aims to increase densities in close proximity to transport/activity corridors by creating opportunities for more people to live closer to one another and public services. Mechanisms to increase the densities include multi-unit residential developments, double and triple-storey buildings, and mixed-use buildings such as those holding residential, commercial and recreational opportunities (Nelson Mandela Bay Municipality, 2009). NMBM also envisions a transport corridor and transportation network to improve overall mobility in the city which will, in turn, make employment opportunities and services more accessible. In integrating the city and addressing accessibility and reduction of travel costs, the municipality aims to create self-sufficient neighbourhood units, called Sustainable Community Units, which contain services and employment opportunities within close proximity to one another (Nelson Mandela Bay Municipality, 2011).

3.5.3 City of Johannesburg

The City of Johannesburg's spatial plans are oriented towards an urban management approach with the view to maximising development in strategic areas of the city. The urban development growth boundary is used as a tool to limit expansion beyond the urban edge. Public transport management areas have also been identified, and the city is actively trying to 'densify' these corridors with mixed-use developments. The policy of the City of Johannesburg is geared towards multimodal transportation and land-use patterns that support public transport and pedestrian movement, and increased densification of strategic locations with coordinated investment in infrastructure to support such densification initiatives. The metropolitan municipality has also identified the need to implement corridor development so as to unlock under-utilised economic and social development potential, and strengthen key economic centres in order to balance and share growth within the city and with neighbouring municipalities. City planners emphasise the need to cluster various activities at accessible nodal locations to strengthen the functioning of the nodes with regard to public and private sector investment and facilitation of economic growth and development (City of Johannesburg, 2011).

4. FINDINGS OF THE URBAN SIMULATIONS

The project demonstrated the value of the UrbanSim platform by simulating a number of scenarios – specific to each metropolitan region – and comparing the performance of the metropolitan areas under these different scenarios. Comparisons were made in terms of indicators such as the supply and demand of land, housing and infrastructure, as well as travel times, modes and costs (Waldeck & Coetzee, 2012). The urban simulation process helped planners from the three metropolitan municipalities get a glimpse of what public transport and densification policies may, or may not, achieve in their respective metropolitan contexts. The urban simulation findings clearly demonstrated the need for more refined policy and planning approaches. They showed the metropolitan officials of all three municipalities, for example, that their density projections were far more than is likely to happen, given the current growth patterns and projected population growth of their cities. The findings for each metropolitan municipality are briefly presented to illustrate some of the important findings that have implications for broader spatial policy, planning and infrastructure investment in South African cities.

4.1 eThekwini

As highlighted earlier, the eThekwini Metropolitan Municipality places an emphasis on structuring growth through transport infrastructure. Spatial frameworks and urban policies are thus focused on creating appropriate densities to support public transport networks (Waldeck & Coetzee, 2012). It was agreed during a living-laboratory work session to test the 'Trend' scenario, which would incorporate the proposed Spatial Development Framework densities, and compare/contrast this to a 'Blue Skies' scenario. The 'Trend' scenario is based on the supposition that development continues on the existing trajectory, that is, that no specific interventions are taken by the state or private sector aside from development events or urban management interventions that are already in place. By contrast, the 'Blue Skies' scenario takes the position that the metropolitan municipality drives a strong densification scenario in support of public transport and that it combines a range of spatial planning instruments to give effect to this scenario.

In preparation for the simulations, the model was validated by simulating a period in the past and comparing the simulated growth with what actually happened during the same period. Since the work was completed before the release of Census 2011, the actual growth was obtained from the Growth Indicator dataset of GeoTerra Image (based on remote sensing). The deviation between actual and simulated growth by Transport Analysis Zone (see Figure 1 for an example) was less than 2 housing units per hectare for the majority of TAZs in all cities, with only a few being less than 5 housing units per hectare. The validation period varied from 6 to 9 years depending on the best data available from GeoTerra Image.

Figure 1 shows the results of simulating the Blue Skies scenario between 2002 and 2030. At the time, all simulations were run from a base year of 2001, because the synthetic population used by UrbanSim is constructed from a 10% sample of census enumeration forms. Therefore, the year 2002 represents the first simulated year after the base year. The circles superimposed on Figure 1 represent buffer zones around designated growth nodes and existing railway stations.

The upper limit of the densification that could occur was estimated with the assistance of UrbanSim. If it is assumed that all future development (a growth of 221 859 households from 2012 to 2030) occurs inside the designated corridors, the average density will only increase by 3.5 households/ha (i.e. 221 859 households/63 192 hectares of residential land within the corridors). The significance of the year 2012 in this comparison is that, at the time of the study in 2011, it represented the start of the 'future' that could be influenced by implementing a policy scenario. These density increases are significantly lower than what would be required to make the kind of public transportation envisaged for the city sustainable. The findings of the urban simulations conducted in eThekwini thus provide another perspective on the intended infrastructure investment spending and point to the fact that other, more refined and locally specific, spatial planning policy and instruments may be required to achieve the vision of the eThekwini Spatial Development Framework.

4.2 Nelson Mandela Bay

In Nelson Mandela Bay, it was decided not to model two diametrically opposed scenarios, but to rather model two related or 'split' scenarios, namely the 'Trend' scenario and the 'SDF or Contained Growth' scenario. The 'Trend' scenario assumes that the current development trajectory will remain in

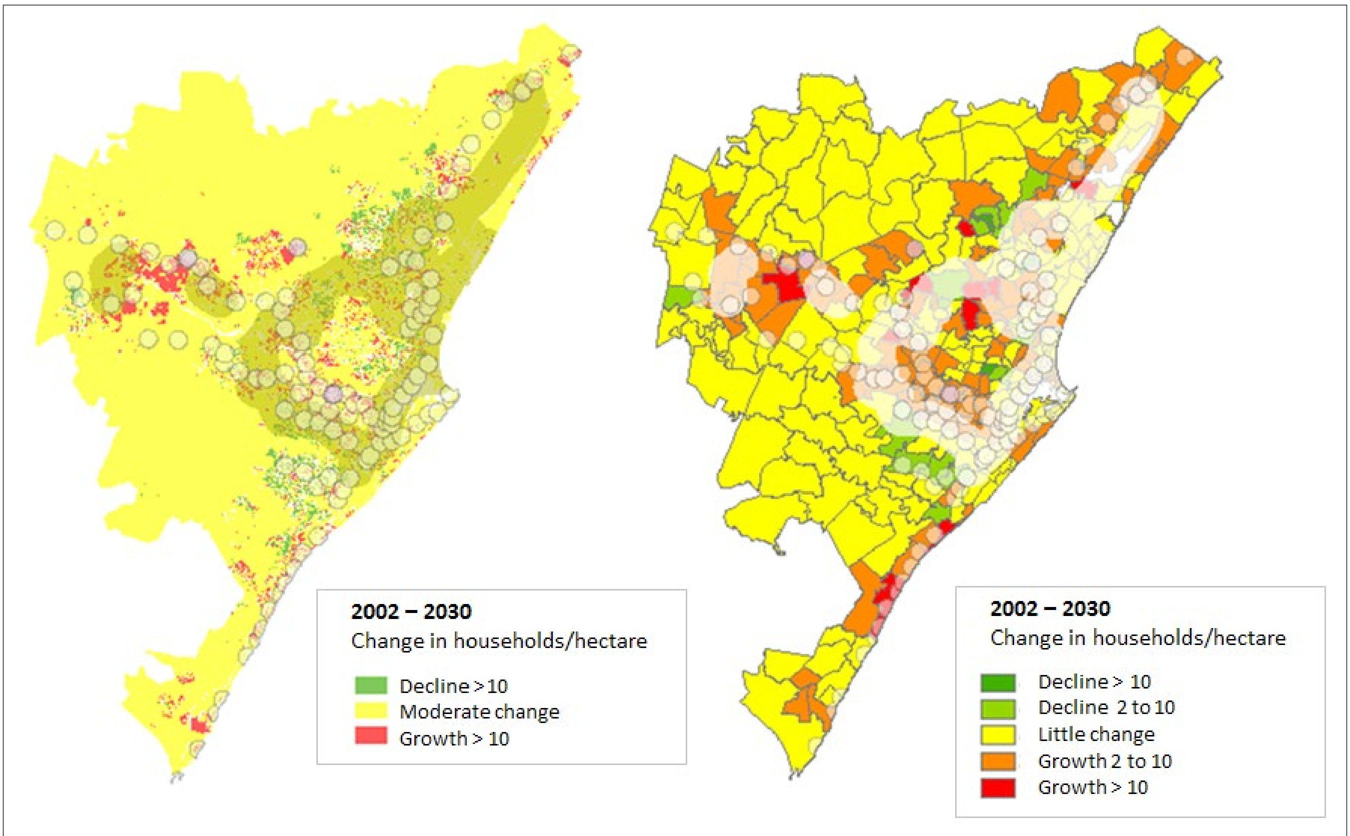

Figure 1: Projected change in population density in eThekwini between 2002 and 2030 at resolution of cadastral parcels (left) and Transport Analysis Zones (right)

Source: CSIR simulated results 2011

place, with the only major intervention being the 7-year Housing Plan with all subsidised housing developments that are in the pipeline. The 'SDF or Contained Growth' scenario, on the other hand, includes all the elements of the 'Trend' scenario as well as:

- An urban growth boundary;
- All spatial 'mega-projects' (planned) 2011-2030, and
- Increased densities around high-priority corridors.

By modelling this split scenario and including the opportunities for development that would be created up to 2030, an estimate of the 'take-up' of formalised and serviced residential and industrial land between 2001 and 2030 was simulated (simulations must run from previous census year, due to synthetic population requirement). The results showed no visible signs of the Bus Rapid Transit (BRT) system and/or the proposed Khulani Corridor influencing the pace and direction of development. This observation, regarding the limited impact of such transport infrastructure investment both on the densification required to make it viable and on other positive city structuring outcomes, is common to all metropolitan areas and was confirmed by living-laboratory participants in NMBM.

The urban growth boundary had some measureable influence on urban densities in the simulations conducted; it achieved a net change of 13.7% of a total growth of 108 354 households between 2011 and 2030 (the second part of the split scenario after implementing the urban growth boundary and other elements of the 'Contained Growth' scenario described earlier). The influence was, however, not hugely significant, because there is no real pressure on developing outside the urban growth boundary in NMBM. The primary difference between the NMBM results and those of other metropolitan municipalities is that, in NMBM, there is an over-supply of land in all sectors/land-use types and that in-migration into NMBM is at a low scale with population growth being insignificant.

In the 'SDF/Contained Growth' scenario, only 36% of the household growth that occurred between 2011 and 2030 was located within the 'mega-project' areas. Although very little growth occurred between these years, the majority was spatially allocated outside the proposed 'mega-project' areas designated by the metropolitan planners for development. This places a question mark over the spatial rationale of the 'mega-project' areas if development is not tending to gravitate towards them. Another useful pointer from the simulations conducted, was the indication that service infrastructure backlogs for backyard housing areas will be a challenge that will need to be addressed by NMBM planners in the future.

An important finding from the NMBM simulations (which was similar to the other metropolitan areas) is that the densities required to sustain public transport systems of the kind currently being promoted and planned (integrated rapid public transport networks, as envisaged in the National Public Transport Strategy announced in 2007 by the National Minister and taken up in provincial and metropolitan policy) will not be achieved.

An additional policy implication demonstrated by the simulation results is that the metropolitan municipality's planning approach should target focused development in specific small nodes as opposed to an increase in average densities across large areas of the City. These conclusions confirm that the NMBM 'Sustainable Community Units' model is the most appropriate approach to pursue. NMBM planners arguing for Sustainable Community Units (SCUs) as a basis for intermediate level planning and as the building blocks for the city have obviously founded it on sound sustainability principles, but also on a very good implicit understanding of how the metropolitan area functions and of the densities that are attainable in NMBM.

4.3 City of Johannesburg

The scenario development phase of the Urban Simulation process proved to be valuable and knowledge intensive. The City of Johannesburg demonstrated their commitment to the project by adding local-level expertise and a thorough understanding of development trends within the metropolitan context. Through the dissemination of knowledge, outlining of policies and growth management strategies, the process of scenario development was comprehensive and rigorous. It was decided to focus on conceptualising two spatial policy scenarios, namely the 'Unmanaged Demand-Driven Growth' scenario and the 'Managed Growth' scenario.

The 'Unmanaged Demand-Driven Growth' scenario is based on the assumption that the City does not play an active enforcing role in guiding and/or managing development. This scenario paints a picture in which development continues along the existing trajectory, a 'business-as-usual' approach. It is also based on the assumption that no specific state or municipal intervention (plans, policies or regulations) take shape, other than existing development events and plans already approved or those in the pipeline.

The 'Managed Growth' scenario, on the other hand, sees a role for the City of Johannesburg as actively driving the implementation of its full suite of planning frameworks and planning tools. Planning incentives are encouraged and take the form of tax incentives, density bonuses and reducing developer contributions. Further infrastructure investments will be used as a means to structure growth and to create balanced and integrated settlements across the city. Investment mechanisms would include the use of an urban growth boundary, nodal development targeted at key economic areas, maximising densities and incorporating mixed land-use in strategic locations, and supporting social housing initiatives in well-located areas.

The simulation results from the City of Johannesburg point to the fact that the proposed decentralisation of activities and services from the urban core to neighbourhoods may not be sustainable, or financially viable

(Waldeck & Coetzee, 2012). The results presented in Figure 2[1] once again show no marked densification in designated nodes/corridors, with the exception of the wider Soweto area, probably because the areas covered by the nodes/corridors are already practically built-up. It was initially thought that there is a scarcity of land in Johannesburg, but the simulation findings showed that, even until 2030, there is adequate land (total residential and non-residential) available.

5. FINDINGS REGARDING THE USE OF THE LIVING-LAB APPROACH

The living-lab approach to conducting urban simulation processes was extremely valuable, although it did have some limitations. As highlighted in the accompanying paper 'A living laboratory approach in the design of user requirements of a spatial information platform', it is costly and time-consuming to involve municipal role players in such processes. The high technical demands of using UrbanSim and the pressing demands of city planners' jobs make it impractical to expect their involvement in, and input into the entire urban simulation process. The living-lab component of this project did not, therefore, result in an overtly user-driven technical innovation of the modelling platform. Rather, the living-lab component assisted in framing discussions to establish robust policy scenarios that were able to be accompanied by reliable data. Benefits of this approach included a shared learning and a shared reading of the current development contexts of the various metropolitan municipalities. It also had the advantage of encouraging city planners, urban strategists and policymakers, with the assistance of the urban simulation capability, to anticipate likely urban futures and to plan for them accordingly for the benefit of the City's inhabitants.

1 At the time (before the release of Census 2011), all simulations were run from a base year of 2001, because the synthetic population used by UrbanSim is constructed from a 10% sample of census enumeration forms. The year 2002, therefore, represents the first simulated year after the base year.

6. IMPLICATIONS FOR SPATIAL POLICY, PLANNING AND INFRASTRUCTURE INVESTMENT

The urban simulation processes in the three cities confirmed that a complex set of social, spatial and economic considerations affect the functioning and efficiency of urban areas. Pertinent implications of the urban simulation findings, as presented by Coetzee (2012), are that:

- Demographically diverse societies with high Gini-coefficients may need to tackle spatial restructuring in new and innovative ways.
- Many of the spatial policies and instruments punted by the planning profession will not bring about the desired urban form as espoused in the spatial plans and frameworks of South African cities.

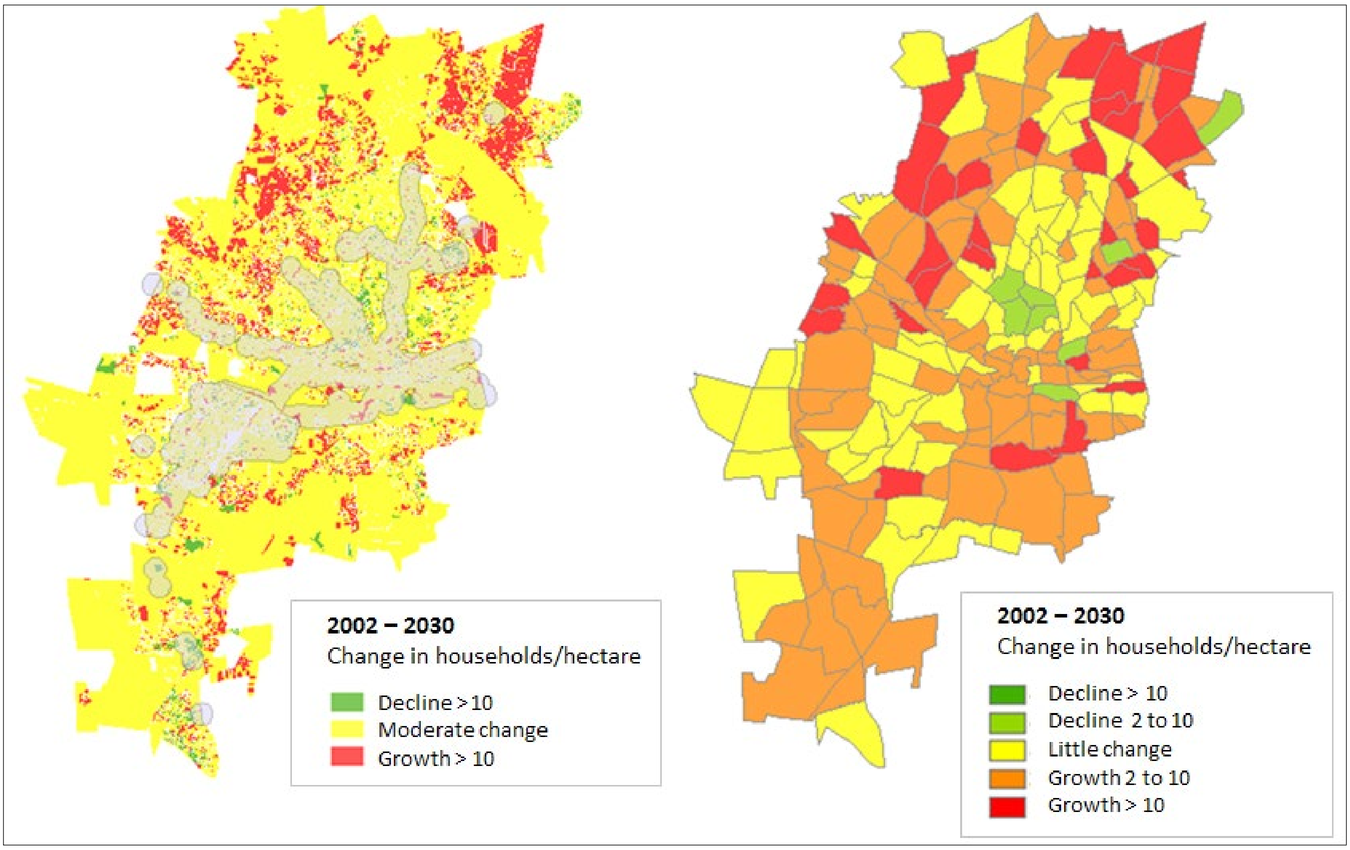

Figure 2: Projected change in population density in the City of Johannesburg between 2002 and 2030 at resolution of cadastral parcels (left) and Transport Analysis Zones (right)

Source: CSIR simulated results 2011

- The spatial and other contextual realities of South African cities and the forces that shape them require more differentiated approaches to spatial planning and growth management.
- Economically empowering households and enterprises will enable them to make better location choices, which will result in more sustainable and efficient cities.
- Rapid spatial change and newly emerging urban growth phenomena may require South African cities to radically rethink their Spatial Development Frameworks (SDFs), existing growth management strategies, and the use of spatial planning and financial instruments.
- The major infrastructure investment initiatives of the state and parastatals may radically change patterns of urban growth and start to reshape the South African space economy (sometimes in unforeseen ways).

Specifically, policymakers cannot ignore the policy implications of this urban simulation work for public transportation policy. International literature rightly suggests that greater population and economic activity density leads to greater efficiency in terms of transport in many world cities (Ruming, 2014; Gainza & Livert, 2013; Liddle, 2013; Dadhich & Hanaoka, 2012; Dempsey, Brown & Bramley, 2012). However, it should be recognised that transport demand of highly diverse economic household segments in South Africa is far more diverse and that state investment in public transport infrastructure (in the form of Bus Rapid Transit systems, for example) does not necessarily generate the required densities to make such public transportation infrastructure viable and sustainable in South African cities.

Proponents of a strong densification policy for cities base their arguments on studies which rightly maintain that “as dwelling density increases, transport energy use (Owens, 1986; Royal Commission, 1994), transport emissions (ECOTEC Research and Consulting Ltd, 1993), and travel distance (Rickaby, 1987, Guiliano & Narayan, 2003) falls” (cf. Buxton, 2006: 2). However, based on the urban simulation findings (particularly but not only in Nelson Mandela Bay), South African policymakers should also give cognisance to other studies in the international literature, such as Rickwood, Glazebrook & Searle (2008), which show evidence of greater efficiency through decentralisation to multi-centred cities, which combine the efficiency of concentration with lower levels of central congestion.

7. CONCLUSION

As planning activities and infrastructure investment decisions become more complex, due to the convergence of an increasing number of policy fields and the more robust participation of a multiplicity of end users and stakeholders (Geertman, 2006: 863), planners and decision-makers can no longer afford to ignore the power of evidence in developing a shared understanding of the complex social, economic and spatial dynamics that shape our cities and our futures.

In the wake of the National Development Plan (2012) and the modelling capability and evidence at our disposal, policymakers should use the window of opportunity to challenge conventional planning wisdom in light of the fact that we cannot simply continue along the trajectory of the past two decades. We do not need more restatements of the problem, nor empty appeals for greater integration, densification, sustainability and the like. Nor do we need massive investment in infrastructure that will not have the desired impact on city functioning. The time has arrived to harness hard evidence to develop fresh perspectives on planning and infrastructure investment that will help to extricate ourselves from the dilemma of neo-apartheid urban forms that perpetuate inequality and continue to marginalise the poor.

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