Financial and Fiscal Commission

The Economic and Fiscal Costs of Inefficient Land Use Patterns in South Africa

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Executive summary

Introduction

South African cities are characterised by low densities, highly inequitable land distribution patterns and relatively high carbon emissions in comparison with other similar international cities. By various definitions, South African cities are therefore considered inefficient. The existing urban spatial pattern is a result of apartheid spatial policies, modernist planning, inappropriate regulation, confusing and conflicting policy priorities and an unequal land market. The spatial patterns of Apartheid have been extended beyond 1994, particularly through the housing subsidy and service delivery programmes, despite national policy imperatives for compact, sustainable human settlements. The reasons for this seeming contradiction include the lack of incentives for developers to promote densification, and insufficient subsidies to provide low cost housing at higher densities on better-located land. The perpetuation of an inefficient spatial pattern results in high transport costs to households, particularly poor households, with transport operating subsidies having had a limited impact on the poorest households. The lack of integration between employment opportunities and residential location also increases inequality. The need to improve the efficiency gains a sense of urgency with the imperative to lower carbon footprints.

There have been a number of government programmes to address the effects of the Apartheid spatial plan, the most significant of which has been the Development Facilitation Act of 1995, which specifically encourages a more compact and sustainable urban form. However, these policy intentions have failed because the arguments in favour of more efficient cities have not been articulated in terms of real costs. Instead, the urban form has been driven by market forces and land developers, combined with a government under pressure to deliver services and housing. It is argued in this paper that spatial patterns can only change through demonstrable financial logic. There is thus a need to develop a methodology to measure the economic and fiscal costs of current patterns. This methodology has two important uses. Firstly, it enables policy-makers to see these costs, as well as the opportunity costs of not developing more efficient cities. Secondly, it provides an instrument to test new policy proposals to ascertain the impacts of these proposals on urban efficiency. With this methodology, the risk exists that cities continue to develop inefficiently, imposing greater costs on the economy while simultaneously weakening the economy's capacity to generate more jobs and wealth. A further risk is that the State embarks on new initiatives to address the costs of inefficient patterns of development without fully understanding the drivers of these costs, which are likely to fail and may also generate a new set of unanticipated costs.

This study therefore aims to develop the required methodology to cost city efficiency, identify the specific drivers of current spatial patterns, and identify who incurs the costs of these patterns over time.

Methodology

The methodological approach taken in this study is to develop a financial model to calculate the current and projected costs of city efficiency. This City Efficiency Costing Model (CECM) was developed to calculate the capital and recurrent costs of a given city, with a given spatial form, over a period of 10 years. In addition to calculating these costs, the model allocates these costs to four financial 'actors' within the city: households, businesses, the City and the State, through an analysis of subsidy and tariff structures. An additional 'actor' is defined as the environment and the costs to the environment in terms of carbon emissions from transport, resource use (water and electricity) and waste generation. The costs that are quantified are limited to those that are directly related to space: land, housing, infrastructure (engineering infrastructure for municipal services) and transport.

To avoid data constraints and to widen the applicability of the model, the CECM was tested on a 'hypothetical city', with characteristics similar to the three largest South African Cities. The hypothetical city was split up into 37 indicative zones with homogenous housing typology and a mix of residential and commercial land use. 11 vacant zones around the city were also defined. The zones were allocated attributes in terms of housing, land, transport, density, resource use and demographics, which was based on real data from the three metros. Unit costs were applied to calculate the recurrent costs of operating the city in the base year (2010) and cross checked against city budgets and state subsidy flows.

The growth of the city was then modelled over 10 years using a number of growth parameters including household growth rates, economic growth rate and housing delivery programme. Two growth scenarios were modelled: an 'urban sprawl scenario' using existing development principles; and an alternative 'compact city' development model. Parameters such as densification factors in existing zones, new housing typology mix, transport mode switching, and use of vacant land were used to differentiate the two growth patterns. The space requirements for residential and non-residential growth, combined with the intensity of land use determined whether the city would develop new zones beyond the existing footprint, or be able to be contained within the urban edge. However, increasing density was assumed to have secondary effects, such as decreases in travel speeds and increases in land prices. Once the growth of the city had been modelled, the recurrent costs for year 10 (2020) could be calculated, based on the new spatial arrangement. The difference in recurrent cost between the current cost and the recurrent cost use in 10 year's time can be interpreted as the annual cost of inefficient land. The capital investment required to facilitate this growth, as well as to rehabilitate existing assets, was calculated for each scenario in order to determine what the capital cost of effecting an alternative spatial arrangement may be.

Results

The results generated by the CECM are for a hypothetical city, and are thus only indicative of the trends that are likely in a real South African City.

For the current year the recurrent costs for the hypothetical city were calculated to be R53 billion per annum, split into housing (including municipal property rates) (53%), transport (29%) and infrastructure (18%). The split between the financial 'actors' is: households (90%), business (9%), City (-1% - indicating a small surplus), and State (2%), and this split remains constant in the future scenarios, reflecting the static subsidy regime that was assumed in the model. The recurrent costs increase in the 'urban sprawl' scenario to R99 billion per annum (real 2010 Rands) and to R92 billion per annum (real 2010 Rands) in the compact city scenario. This represents a 7% operating cost difference in the two growth scenarios, or an amount of R6.4 billion per annum after 10 years.

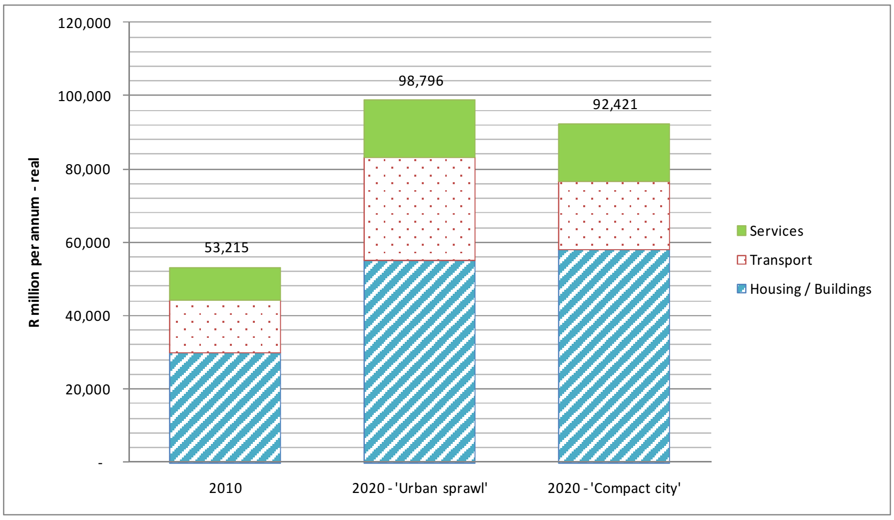

Figure i: Recurrent cost by sector (R million per annum real)

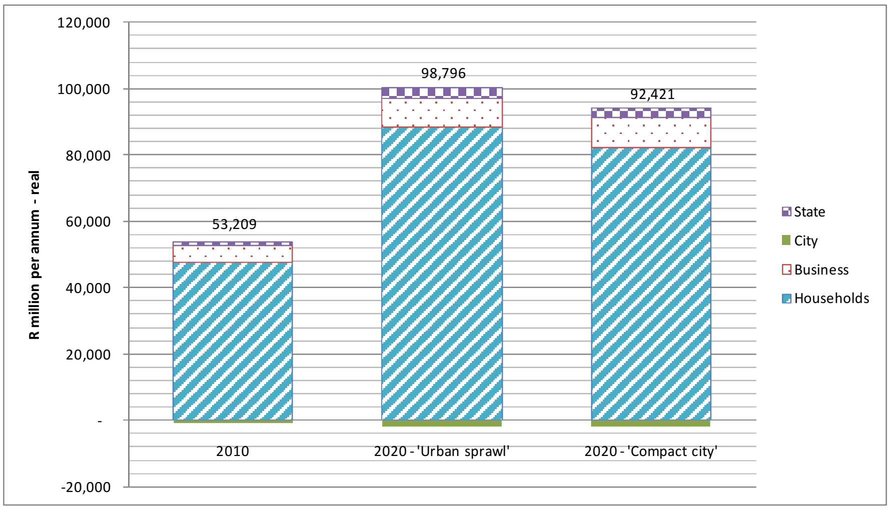

Figure ii: Recurrent cost by financial actor (R million per annum real)

In analysing the recurrent expenditure by income group, some interesting patterns emerge. Low-income households spend 14% more in the urban sprawl scenario, but 10% *less* per household per month on these services in the compact city scenario than in the base year. Middle income households spend 8% less in the urban sprawl scenario and 13% less in the compact city scenario. Higher income households incur a higher level of monthly expenditure in the urban sprawl scenario (12% increase), while for the compact city scenario the increase in monthly expenditure is less (10% increase). Low-income spending is dominated by transport costs, while high-income spending is dominated by housing expenditure.

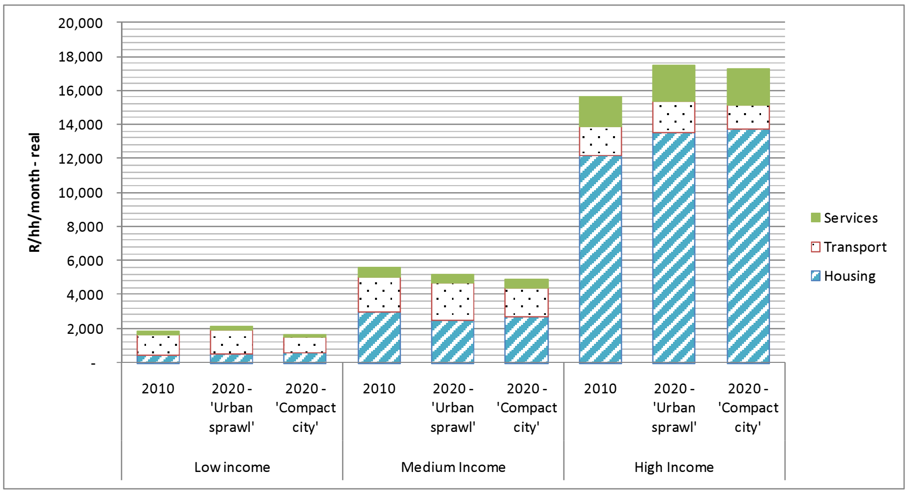

Figure iii: Average recurrent household expenditure (R/hh/month real)

The calculation of total capital investment over 10 years for growth of the hypothetical city under each of the two development scenarios produces the surprising result that the capital costs are very similar – the urban sprawl scenario is only 2.1% more expensive than the compact city scenario. Overall housing costs for the compact city scenario are lower because of smaller units, but land costs are higher because of the increase in land price assumed under this scenario.

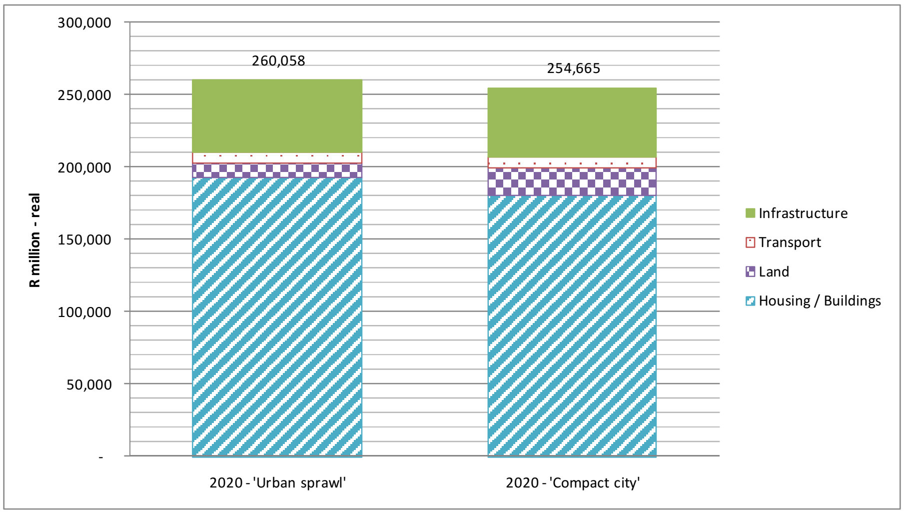

Figure iv: Total capital investment over 10 years by sector (R million real)

When the capital costs are broken down by service and financial actor, the results show that households and businesses will pay relatively more for infrastructure and transport in the compact city scenario, but less for housing/buildings. Investment by the City is equivalent, and focussed on infrastructure (and rehabilitation thereof), while investment by the State is less in the compact city scenario, largely due to lower investment in connector infrastructure for low-income households.

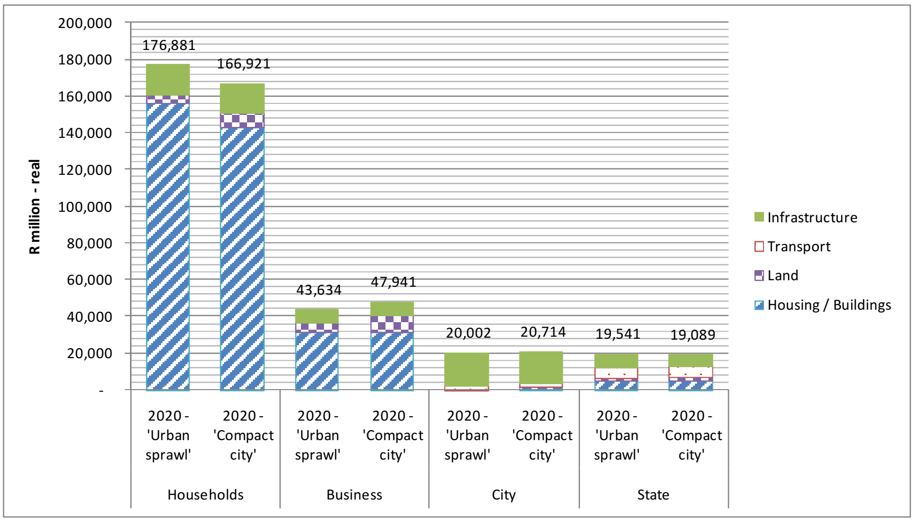

Figure v: Total capital investment over 10 years by sector and financial actor (R million real)

The environmental cost analysis shows that the resource use and waste generation rates between the two growth scenarios are unchanged. The most significant result is a 22% difference in the tons of carbon emitted by all transport modes, as shown in the figure below.

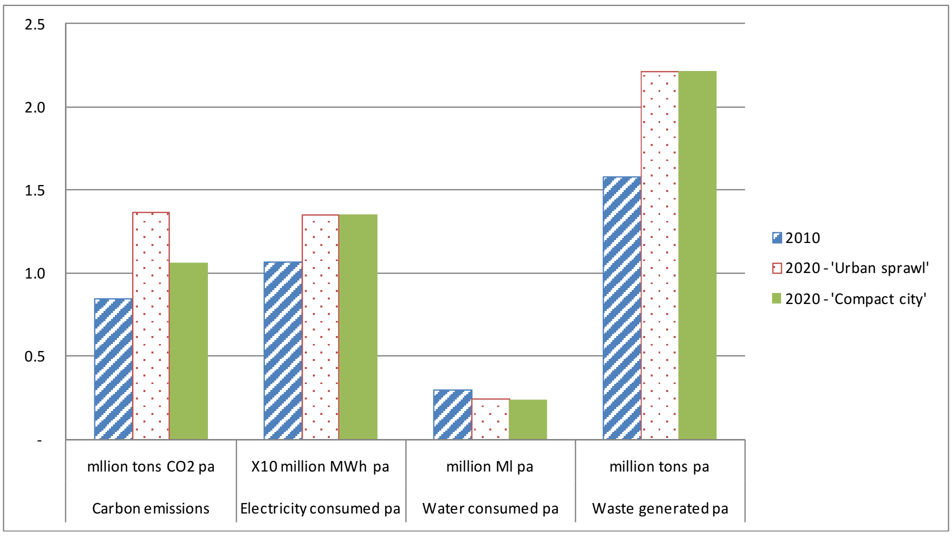

Figure vi: Environmental impacts of the two growth scenarios

Conclusions

By international standards, South African cities are inefficient, as measured by low density development, high travel times and distances, and high carbon footprints. The hypothetical city has illustrated a methodology by which the economic and fiscal costs of this efficiency can be quantified. By applying this methodology to a 'hypothetical' South African city, this research has calculated that the present recurrent cost of housing, transport and infrastructure in South African cities is in the order of R53 billion per annum, with a large burden for these cost falling directly on households. The growth model has shown that the implications of a sprawling growth pattern are increased recurrent cost (7% - a difference of R6.4 billion per annum) and increased total capital investment (2% - a difference of R5.4 billion over 10 years). If this is extrapolated to all 6 metros, the difference between the urban sprawl scenario and the cheaper compact city scenario is approximately 1.4% of GDP by year 10. This cost differential is likely to continue to increase with time.

While all income groups are better off financially in the compact city scenario, it is low-income households are most adversely affected by the urban sprawl scenario, having to pay significantly more for transport.

The most significant difference, and an undeniable implication of the urban sprawl scenario is the increase in carbon emissions due to increased travel distance and private car use. A number of more qualitative environmental and social benefits of the compact city exist, but have not been quantified in this study, and will need to be the subject of further research.

In order to effect a more efficient urban form, the results produced by this research point to a number of fiscal and financial instruments that are required. These include significant capital investment in public transport in dense, low-income areas, which arguably produces the greatest economic benefit for the money spent. In addition, a substantial increase in capital spending on low-income housing is required in order to produce the requisite densities in well-located areas. This needs to be combined with incentives for private developers to undertake the type of development that generates a compact urban form.

The hypothetical city is only a test case for the methodology, but has shown a viable method for quantifying city efficiency that can ground debates around the impact of the financial framework on spatial form and vice versa. Future application of the methodology in real cities will provide more concrete results that can inform both spatial planning and public finance policy debates.

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1 Introduction

This study stems from a hypothesis that the current land use patterns in South Africa are inefficient. South African cities are characterised by low densities, highly inequitable land distribution patterns and relatively high carbon emissions in comparison with other similar international cities. The urban poor are typically located on the urban periphery, facing high transport costs, with little access to housing and services, and being marginalised from the formal city economy. This inefficient land utilisation is costly to society in terms of forgone GDP, wasted physical resources, marginalisation of vulnerable population groups and exacerbating inequalities. The proposition is that an alternative, optimum land use pattern exists that has the potential to improve the social, economic and environmental effectiveness of South African cities.

State interventions, post-1994, have intended to address the spatial inequalities of the Apartheid City, but have, at best, ameliorated its effects through subsidised housing and transport, but perpetuated the spatial layout through poor location of housing and services. One of the drivers of these spatial decisions have been short-term capital constraints, but at what long term cost? And who is bearing the cost of current land use patterns? How do financial frameworks aid or impair efficient land use? Is there a financial argument that can be put forward and justified, to alter financial frameworks to enable short term capital investment in spatial interventions for long term economic gain?

This study seeks to systematically and comprehensively establish the size and scale of fiscal and economic costs that the current land use patterns have on the South African economy and urban centres in particular. The specific objectives of the project are:

- To describe the current land use patterns in South Africa and highlight their associated weaknesses/strengths.
- To establish and quantify the financial and fiscal costs (or opportunity costs) of current land use patterns in South Africa.
- To establish the financial and fiscal costs of current land use patterns with respect to the transport, infrastructure, land and housing sectors.
- To make policy recommendations on fiscal policy alternatives required to restructure patterns of urban land use in the housing, transport, infrastructure and land sectors.

In order to confirm or refute the proposition that an alternative land use pattern is more 'efficient', two research methods will be used. The first is to undertake an international comparison to measure the South African spatial model against similar international cities using a number of efficiency criteria. This includes a literature review to understand the drivers behind the existing land use patterns in South Africa. Arising out of this comparison and analysis is a problem statement around the current state of South African cities.

The second is a more dynamic approach, using a financial model to develop a methodology by which city efficiency can be measured under a number of alternative spatial arrangements. The methodology was developed after consulting the literature and engaging with a wide range of professionals working in the field.

Following from the international comparison and modelling, the report draws together conclusions from the study and provides provisional policy recommendations, as well as identifying areas for further research.

2 Current state of South African cities

2.1 South African cities: exceptionally inefficient

Exactly how inefficient are South African cities? Table 1 compares South African cities with similar cities in developing countries in terms of population density, average trip times and their carbon footprint. What is apparent is the low density of South African cities, measured in terms of number of persons per hectare, compared to cities like Curitiba, Ahmedabad and Bangalore. Conversely, the rate of carbon-dioxide emissions in South African cities is much higher than in the other cities.

This indicates the need for concerted efforts around urban restructuring to improve the urban form in South African cities. Curitiba, a city hailed as one of the most sustainable cities in the world, has taken decisive action in this regard, especially as far as the innovative integration of land use and transport is concerned. Curitiba for example encourages higher density and mixed-use developments along its famous bus rapid transit (BRT) routes (Magalhaes, 2009). Acioly (2004) shows the active role played by the local state in Curitiba in facilitating sustainable development through promoting density and more intense land use though innovative land use planning and regulatory measures like the transfer of development rights which allows developers to swap buildings of historical or architectural significance for land parcels in other parts of the city, increasing the allowable floor area ratios (FAR) and relaxation of zoning restrictions. Similarly, the government of India is making considerable investments in transport infrastructure, through its "National Urban Transport Policy (2006) to "ensure safe, affordable, quick, comfortable, reliable and sustainable access" to urban residents to employment and other services (Center for Sustainable Transport India).

Table 1: Comparing efficiency of South African and international cities

	Joburg	***Cape Town***	***Ethekwini***	***Tshwane***	***Curitiba***	***Ahmedabad***	***Bangalore***	***Addis Ababa***
Population Density (persons/hectare)	20.9	12	14	9.5	57	134	207	560.8
Average Commuting Time (minutes/capita/ commuter trip)	52	50	45	60		20		62
Average Trip Length (km/person trip)		15.9 km			7.5 km	5.5 km	9 km	10 km
Productivity (GVA/capita)	R 51 000	R 41 000	R 30 000	R 42 000				700 euros
Carbon Footprint (tons CO_2/capita/annum)	7 tons	8 tons	6 tons	9 tons	4.2 tons per light vehicle	0.05 tons	0.12 tons	

2.2 Why so inefficient?

South African cities are characterised by low density sprawl and highly unequal land distribution patterns. This is largely a result of Apartheid policies, but inappropriate regulation, confusing and often conflicting policy priorities and an unequal land market have contributed to and entrenched Apartheid spatial patterns post-1994. Apartheid spatial planning had a profound impact on the urban landscape. The 2004 State of the Cities report (SACN, 2004) argues that the "Apartheid City was a political economy of space" which was based on two policies, i.e. racially-based spatial planning and development for some at the expense of others". Through legislation such as the Group Areas Act 1966 for example, Apartheid urban planning reserved specific spaces for the specific races and classes and residential location ultimately determined the level of access to resources, infrastructure, other services and economic opportunity. Dewar argues that the interaction between Apartheid spatial planning and the "modernism" urban planning ideology with it's emphasis on suburban development, separation of urban activities of work and leisure as well as the prioritisation of technical efficiency over social and environmental imperatives have profoundly impacted on the spatial urban form so that South African cities are characterised by spatial characteristics of low density, fragmentation and separation (2006, 211).

The delivery of housing and other services post-1994 has entrenched the Apartheid spatial form. Despite national policy imperatives arguing for sustainable human settlements with an emphasis on higher density developments on well-located land, better integration between land use, transportation and the provision of infrastructure and services, the delivery of subsidised housing has not been in line with these policy prescriptions. According to Biermann and van Ryneveld, the primary reasons for this are the "greater affordability and availability of land on the periphery of cities as opposed to expensive land in the more central areas, coupled with insufficient subsidy amounts to build at higher densities to offset higher land costs" (2006, 563). Low density developments on the urban periphery have serious implications for the delivery of transport infrastructure and mobility. This has resulted in a situation where transport subsidies in South Africa often match or exceed housing subsidies. Public transport subsidies for rail and bus transport in Cape Town, for example, increased from R415 million in 1998/1999 to R430 million in 2001/2002. During the same period, money spent on subsidised housing in Cape Town was R206 million in 2001/2002 and R231 million in 2002/2003. This means that the amount spent on the transport subsidy was more than double what was spent on the housing subsidy[1]. Location impacts on the economic efficiency of cities and a lack of interaction between employment and residential location result in unacceptably high commuting times and high carbon-dioxide emissions. According to the State of Energy in South Africa Report (2006) the average carbon dioxide emissions in South Africa's six big cities is 6.5 tons per person which exceeds the global average. These factors will be elaborated in further detail below. The mismatch between employment opportunities and location of housing contribute to income inequality between rich and poor. According to Bertaud (2009) poor households cannot afford to access economic opportunities whereas middle and higher income groups can rely on private motorcars to access these opportunities. Van Ryneveld[2] (2010), commenting on the relationship between agglomerations of economic opportunities afforded by cities and income distribution, also argues that "where a city has high levels of private motoring convenience and poor public transport, car owners are able to access the agglomeration opportunities but public transport users are not."

South Africa currently has an urban population of 57%. Between 2001 and 2006, the populations of the nine major cities in South Africa increased by an average annual rate of 1.92% (State of the Cities Report; 2006: pg. 6-3). Data from Statistics South

[1] Western Cape Strategy for the Development of Sustainable Human Settlements, June 2006

[2] Van Ryneveld, P (2010) Public transport: Cape Town, and the national context. Paper presented to the African Centre for Cities, 13 October 2010

Africa shows that between 2001 and 2006, 3 million South Africans migrated from one district or municipality to another, with most migration being into the more economically prosperous provinces of Gauteng and the Western Cape (State of the Cities report, 2006). There has also been a growing out-migration from the economically declining provinces of the Northern Cape and the Eastern Cape to the Western Cape (Tomlinson et al, 2003 in Todes et al, 2010). Significantly, most of the growth in urban areas has occurred on the periphery of cities (Pillay et al, 2006). Another important trend is the growth in the number of households, as this has important implications for backlogs and the provision of housing and other services. The average number of households in the nine major cities in South Africa grew by 27.5% (2.13 million households) between 1996 and 2001, which is more than double the population growth rate (Pillay et al, 2006). This has largely been attributed to declining household sizes; average household size in South Africa has decreased from 4.47 persons in 1996 to 4 in 2001 (ibid). This has important implications for backlogs and the provision of housing and other services.

Economic activity, poverty and inequality are highly concentrated in South African cities. According to the 2006 State of Cities report, the nine major cities in South Africa account for 62.5% of gross value added and annual economic growth rates in all nine cities were higher than 2.8%. Economic growth rates in the nine cities included in the State of the Cities report, increased from 3.2% over the 1996-2001 period to 3.8% over the 2001-2004 period and economic growth has outstripped population growth in most cities (State of the Cities Report; 2006: pg. 3-8). This demonstrates the economic pull of people to the cities where they correctly assess that their prospects of employment are higher than in smaller towns or the countryside.

Approximately 80% of South Africa's economic growth is generated in the Gauteng province and the cities of Cape Town, Durban-Pietermaritzburg and Port Elizabeth (Nel and Rogerson, 2009). In 2001, the five[3] biggest city economies provided 44.1% of the national number of jobs (4223 449/9583770). At the same time, 77.31% of people living under the minimum living level[4] are located within 60 km of areas that generate at least R1 billion of geographic value added[5] (GVA)[6]. Whereas there has been a slight decrease in the levels of inequality in the nine SACN cities between 2001 and 2005 as indicated by their gini coefficients[7] , inequality in South African cities remains high. With regards to urban inequality, although there has been a slight decrease in interracial inequality, overall inequality has increased since 1994 (Crankshaw and Parnell, 2004 cited in Boraine et al, 2006). South African cities have inequality measures similar to some of the world's most unequal societies (State of the Cities report, 2006).

As has been argued before, the form of South African cities has huge implications for mobility patterns and the provision of sustainable transport infrastructure. It is argued that "the state of public transport in a city, in terms of its accessibility,

[3] Johannesburg, Cape Town, Tshwane, eThekwini and Ekurhuleni

[4] The minimum living level is a poverty line used by the Bureau for Economic Research at UNISA and refers to "the minimum necessary for an average family if its members are "to maintain their health and have acceptable standards of hygiene and sufficient clothing for their needs' (Dasnois; 2005) The level is currently set at R1950 a month

[5] *National Spatial Development Perspective* due for release in late 2006

[6] Geographic value added is a measure of economic performance and reflects the level of output in the economy and excludes taxes and subsidies.

[7] Measure of inequality in income

affordability, acceptability and availability, is a good indicator of the commitment of the city towards sustainable development (SACN, 2009). Two-thirds of South Africans rely on public transport (DBSA, 2008). The Sustainable Public Transport Overview Report (2009) argues that public transport still imposes huge social and economic costs on poor households as commuting times are unacceptably high. Moreover, transport expenditure as a percentage of households expenditure, for the 20% of households with the lowest income band, increased from 4% in 1995 to 10.6% in 2005/2006 (SACN, 2009; 6). Public transport trips in South Africa are higher than global averages; whereas in Tokyo, public transport commuter trip lengths are 8km, in the City of Tshwane for example it is more than 25km (ibid).

The South African government is attempting to correct this unsustainable situation through massive investments in transport infrastructure. An amount of R44.5 billion over a five-year period has been budgeted for improvement of the national road system, although the bulk of this expenditure is destined for national roads linking cities rather than for roads within cities. In addition R61 billion has been set aside over a 5 year period for investment in rail infrastructure (DBSA, 2008). Table two below provides an overview of the massive amounts of capital that have been and are going to be invested by the South African government in the maintenance and improvement of South Africa's public transport system.

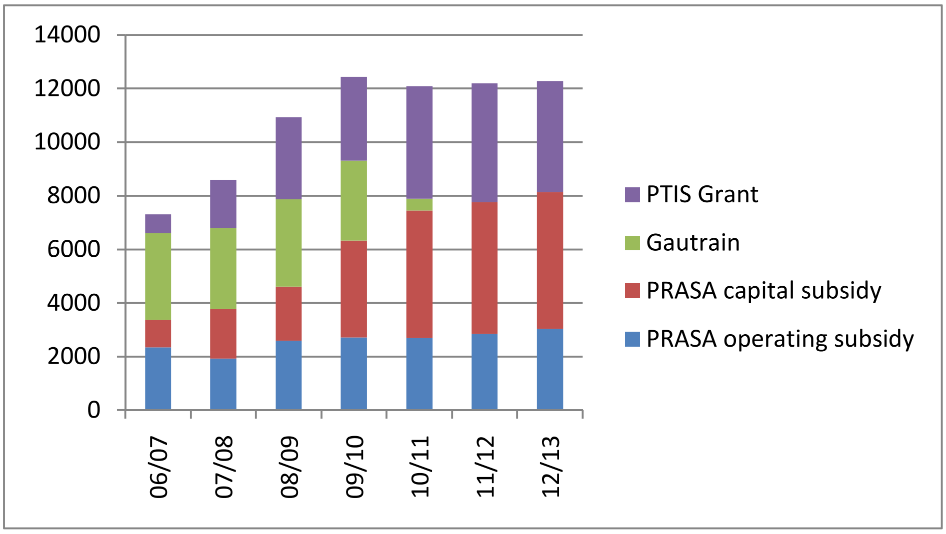

Figure 1: Historical, current and future transport expenditure (R millions)

Source: Philip van Ryneveld, 2010 - modified to assume that 85% of PRASA subsidy goes to commuter rail

The South African government has recently embarked on a major infrastructure drive. This is driven largely by economic growth imperatives as well as broader social concerns. The South African government has set a target to halve poverty and unemployment by 2014. South Africa therefore faces a triple infrastructure challenge:

- to provide infrastructure which would stimulate economic growth,
- to maintain existing infrastructure and
- to provide infrastructure and services to the poor in order to eradicate poverty (State of City Finances Report, 2007;40).

A number of factors account for South Africa's infrastructure challenges. One of these is South Africa's historically low investment in infrastructure. Between 1976 and 2002 infrastructure investment declined from 8.1% to 2.6% of GDP and per capita investment declined from R 1 268 to R356. This is significantly lower than the international benchmark which ranges between 3 and 6% (Fedderke et al, 2006, p.1041). According to the DBSA investment in transport infrastructure has fallen by 1% per year since 1975. In the late 1990's this low level of infrastructure investment was to a great extent due to South Africa's macro-economic policy, the Growth Employment and Reconstruction Programme (GEAR), which stressed fiscal discipline and constrained public expenditure (Kirsten and Davies,2008; 8&9). The Development Bank of Southern Africa (DBSA) sums up South Africa's infrastructure challenges as follows; "government must ensure sufficient services to the core economy whilst extending them to historically marginalised groups" (2008;19). The current emphasis on infrastructure investment is a conscious effort by the State to break out of the pattern of underinvestment in infrastructure.

The South African government has set very specific targets for the eradication of municipal service backlogs. These include the following (DBSA; 2008, 125):

Table 2: Service backlogs and deadlines for eradication

Backlog	***Deadline***
Eradication of sanitation bucket	2007
Access to potable water	2011
Access to sanitation	2011
Infrastructure for FIFA World Cup	2010
Universal access to electricity	2013
Solid waste	2014
Other municipal services	2014
Housing	2014

Source: Development Bank of Southern Africa, Infrastructure Barometer, 2008

Considerable infrastructure investment will be required to eradicate service backlogs. According to DBSA, the capital required to eradicate service backlogs ranges from R36 billion in 2007, increasing to R50 billion in 2011 and declines to approximately R35 billion in 2015, assuming that infrastructure targets would have been met by 2014. The State of City Finances report for 2007 indicates that municipal expenditure on infrastructure has increased substantially. Infrastructure expenditure constitutes more than half of capital expenditure which has increased from 13% in 2004 to 17% in 2006 (State of City Finances, 2007; 33)

3 Efforts to address efficiency: 1994 - 2010

In 1994, "South African cities were characterised by dire housing and service backlogs, inequalities in municipal expenditure, the spatial anomalies associated with the 'apartheid city', profound struggles against local government structures, high unemployment and many poverty-stricken households" (Pillay et al, 2006; 2). The new government made a concerted effort to address the effects of Apartheid spatial planning through a myriad of new policies and strategies post-1994. These include for example the Reconstruction and Development Programme (1994), the Urban Development Strategy which was subsequently published as the Urban Development Framework of in 1997, the Rural Development Framework, The Green Paper on Development and Planning (1999) which was the first official recognition of urbanisation trends, the Development Facilitation Act (1995) and the Integrated Development Plans at local level, Breaking New Ground (2004) housing policy to name but a few. The most prominent example of the State's efforts to introduce a more efficient urban development pattern was found in the General Principles for Land Development contained in Chapter One of the Development Facilitation Act, 1995:

"Policy, administrative practice and laws should promote efficient and integrated land development in that they-

i. promote the integration of the social, economic, institutional and physical aspects of land development;
ii. promote integrated land development in rural and urban areas in support of each other;
iii. promote the availability of residential and employment opportunities in close proximity to or integrated with each other;
iv. optimise the use of existing resources including such resources relating to agriculture, land, minerals, bulk infrastructure, roads, transportation and social facilities;
v. promote a diverse combination of land uses, also at the level of individual erven or subdivisions of land;
vi. discourage the phenomenon of 'urban sprawl' in urban areas and contribute to the development of more compact towns and cities;
vii. contribute to the correction of the historically distorted spatial patterns of settlement in the Republic and to the optimum use of existing infrastructure in excess of current needs; and
viii. encourage environmentally sustainable land development practices and processes."[8]

Atkinson and Marais (2006) in their analysis of the evolution of urban spatial policy in post-Apartheid South Africa argue that "a lack of clear urbanisation and spatial direction" from the South African government has had the following unintended consequences:

[8] Section 3(1)(c) of the DFA.

- Contradictory and confusing messages about the relationship between rural and urban development
- Narrow sectoral thinking has resulted in a failure to recognise the dynamic interaction between rural and urban areas and have resulted in uncoordinated spending patterns so that resources have been allocated without an appreciation and understanding of settlement patterns.
- Conflicting spatial settlement policies

Similarly, Turok and Parnell (2009) argue that the South African government's ambiguous stance on rural-urban migration and the lack of a clear national urban development policy to guide and complement local urban development initiatives have constrained efforts at efficient, sustainable and integrated urban development. Urban scholars and commentators are more optimistic though of recent trends in urban development policy, specifically the National Spatial Development Perspective (NSDP) of 2006, which it is argued reflects a growing realisation in government of the impact of urbanisation and the importance of the spatial dimension of economic growth and development.

With the benefit of hindsight one can reflect on the futility of earlier efforts to create not only more efficient but also more equitable and sustainable cities. The arguments in favour of more efficient cities have not been articulated in terms of real costs. While on the one hand it was glibly and widely accepted that a more efficient pattern of development was needed on the other there was no cogent argument – spelled out in economic and fiscal terms – that was capable of steering cities onto a more affordable path. The combined effect of the logics of property developers and of state bureaucracies was such that meaningful change in practice was highly unlikely to materialise. We are now wiser. We appreciate that undoing something as complex as the South African urban spatial pattern can only succeed where it is supported by a demonstrable financial logic. The frustration often expressed at the lack of change in urban spatial patterns is naive. Good intentions, however well supported by the policy thrusts of international agencies and academic experts, are simply unable to gain traction when confronted by the forces of the land market as well as the imperatives of a State engaged in addressing service delivery and housing backlogs in the shortest possible time. Even when translated into legislation, as was the case with the General Principles for Land Development in Chapter One of the Development Facilitation Act, 1995, very limited discernible change followed.

4 The problem now

The failure of policy and legislative measures to change the inefficient (and inequitable, unsustainable) patterns of urban development in South Africa is widely accepted. There is urgency to the issue that owes a great deal to the global concern with lowering the carbon footprint of cities. There have also been a number of recent attempts to quantify the cost implications of current patterns [9]. Within urban policy circles there is a growing confidence that a more cogent argument can be marshalled in favour of more efficient cities. This argument has to be premised on a methodology that measures economic and fiscal costs of current patterns. This methodology has two important uses. Firstly, it enables policy-makers to see these costs, as well as the opportunity costs of not developing more efficient cities. Secondly, it provides an instrument to test new policy proposals to ascertain the impacts of these proposals on urban efficiency.

Without a credible methodology for measuring the costs of urban spatial patterns some significant risks arise. The most obvious of these is that cities continue to develop inefficiently, imposing greater costs on the economy while simultaneously weakening the economy's capacity to generate more jobs and wealth. The second is that the State embarks on new initiatives to address the widely acknowledged, but still unproven, costs of inefficient patterns of development and because of an inadequate understanding of the causes and drivers of these costs these new initiatives not only fail on their own terms but also generate a new set of unanticipated costs.

The problem thus is that we know that inefficient cities are bad, but we do not have a shared understanding of what constitutes inefficiency. From the international literature we generally agree that urban efficiency includes a number of inter-dependant dimensions, including economic, social and environmental aspects. The debate about urban efficiency is centred on the sustainable use of particular, finite resources, with land and energy being the most important. Urban efficiency, according to Buxton (2006) is defined in terms of travel patterns, infrastructure and energy use, social and environmental costs, congestion costs and the cost of sprawl. We know that inefficiencies emerge from the ways in which the land market operates and the way in which the State invests in infrastructure and subsidised housing and transport, but we do not have a basis upon which to identify the specific drivers of spatial patterns. We know that high costs are incurred as a result of our patterns of urban growth, but we do not know who bears those costs, especially over time. These are problems that the methodology outlined here will help to resolve. A methodology such as this is necessarily constrained by time and budget and it cannot be expected to resolve all the problems conclusively. It is however an essential first step towards that goal.

[9] Biermann, S and van Ryneveld, M (2007); Venter, C; Bierman, S and van Ryneveld, M (2006).and Social Housing Foundation (2009)

5 Methodology

5.1 Methodological approach

The purpose of this study is to develop a methodology that quantifies the greater costs of inefficient land use (and related aspects such as public transport) in a transparent, robust and comprehensive way. This includes identifying what these costs are and who incurs these costs. For this purpose, four financial 'actors' are defined, namely households, businesses, the City and the State[10]. The methodology should be applicable in particular cities to produce consistent and defensible results. The numbers that will be generated through the study must be able to be used in the future to test scenarios that will inform macro-economic debates around urban development options and government policy interventions.

Sectors identified as those that are affected financially by location are housing, land, transport and infrastructure[11] (engineering infrastructure for water supply, sanitation, electricity, solid waste disposal and roads). Other sectors that have efficiency implications through location include education and health facilities and other regional scale public services. However, it is argued that the efficiency implications of the location of these services are reflected through existing travel patterns[12]. For example, if an area does not have adequate access to schools, the cost implication is that people will have to travel further to access schools and this cost is captured by the daily travel patterns and reflected in the consequent household expenditure on transport for that zone[13].

Location affects the costs of the four identified sectors in two ways. Firstly, there are increased recurrent costs that are incurred through low-density dispersed settlements, such as increased transport costs due to greater distances, increased maintenance costs on longer pipe networks, etc. Secondly, the capital cost of new infrastructure, and rehabilitation of existing infrastructure is impacted by the spatial arrangement of a city. This may be a positive or negative relationship to increasing density. While low densities mean that rail lines, roads and pipe networks may be longer, higher density buildings are more costly than low density dwellings, and unit land costs in dense settlements will be higher.

Thus, the first task is to assess the current operating costs within a typical South African city, and how these may be different under an alternative spatial arrangement. Secondly, the capital cost differential needs to be assessed. It may be possible to cost a South African city from 'scratch' in alternative spatial arrangements, but this would be a highly theoretical exercise, with little practical application, given that the urban fabric is already established. Instead, in order to calculate the capital cost of alternative land use patterns, it is more useful to cost alternative growth trajectories: one that takes the existing layout of South African cities and extends it, firstly through existing development principles – an 'urban

[10] Provincial government is excluded in this analysis as it functions largely as a conduit through which national funds flow to the City or to households.

[11] Physical engineering infrastructure associated with municipal services…

[12] The future location of these services will impact on city efficiency, but is beyond the scope of this study.

[13] Conversely, if the state invested in more schools, the benefit would be reflected in the reduction in travel time and cost to the household, but the capital cost to the state would be outside the scope of this methodology.

sprawl scenario'; and secondly, another that costs an alternative 'compact city' development model.

5.2 The hypothetical city and the City Efficiency Costing Model

From the project hypothesis it is assumed that South African cities share common characteristics (e.g. low cost housing on the periphery, informal settlements on small parcels around the city, racially segregated communities) and that spatial growth is informed by similar drivers (e.g. apartheid planning policies, housing subsidy structure). In addition, our three largest cities have similar populations, areas, and socio-economic profiles. It is therefore possible (and prudent) to develop a 'hypothetical' South African city with these common characteristics. The risk of using a 'hypothetical' city, instead of a real case study of a particular city, is that the costs cannot be definitive, and the results cannot be directly applied for making planning decisions at a city level. However, the benefits of a hypothetical city, include the development of a generic structure that can be applied to any real city in future, and more generalisable findings. Despite being hypothetical, the city model will be developed using real data from all of the three largest metropolitan municipalities (metros), Johannesburg, Cape Town and eThekwini. Using a hypothetical model also avoids the need to achieve high degrees of accuracy to justify conclusions drawn about one particular city.

The tool that has been developed for this project is the MS Excel-based City Efficiency Costing Model (CECM). For the purposes of this costing exercise, a hypothetical city was created with 37[14] indicative zones of homogenous housing typologies (Figure 2). In addition, 11 vacant zones were added to simulate vacant parcels of land within the urban edge of the city. Each zone (indicative and vacant) has a number of attributes that define the zone in terms of land use, intensity of use, housing typology, commercial and industrial activity, location, transport characteristics and infrastructure requirements.

[14] The number of zones is fairly arbitrary, but was selected to match the transport data used in the model.

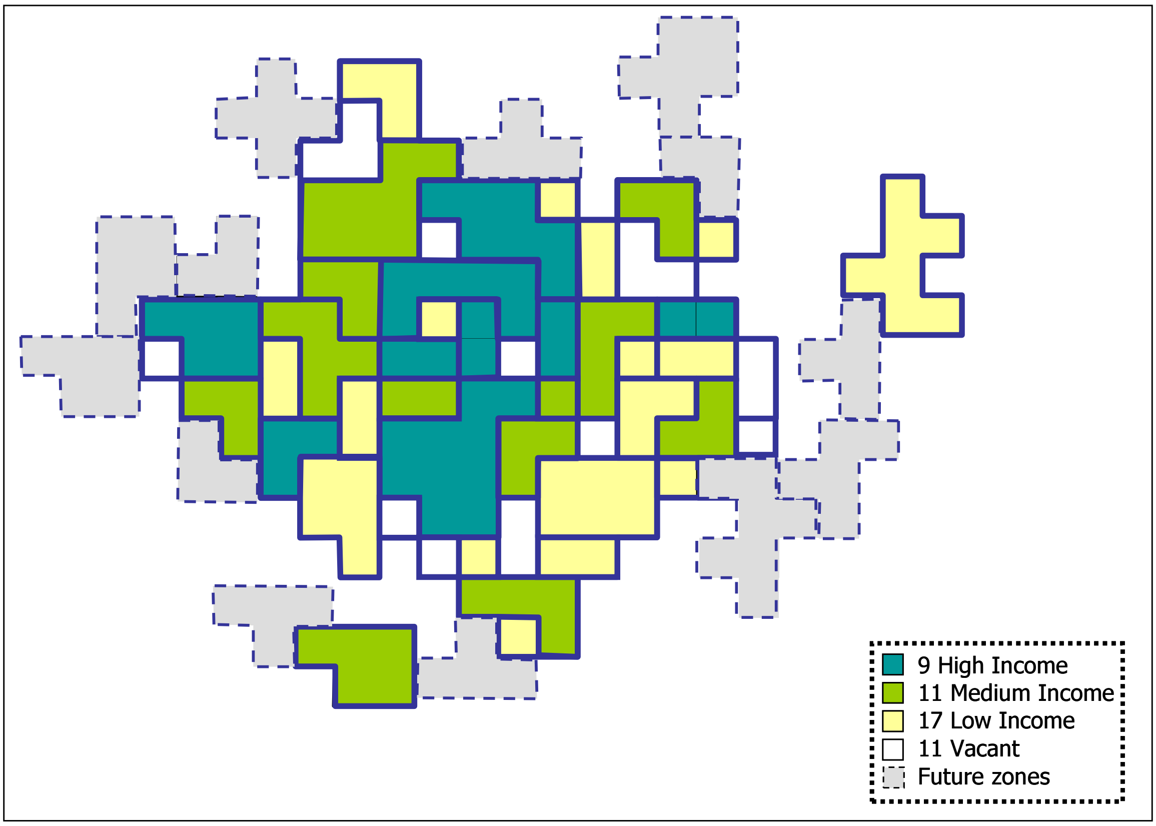

Figure 2: Example of a 'hypothetical city' with sample development zones

In theory, any number of zones can be defined and the attributes, or 'fields' can be unique for each zone. However, to simplify the way residential areas are modelled, and to reduce data requirements, thirteen standard housing types were defined. These housing types will have their own set of attributes including income profile, building typology, rental characteristics and levels of service. A full list of the housing typologies and attributes is given in Table 7. The sums of the values entered for each zone were checked against the real conditions in the South African Metros (e.g. population, transport usage, water consumption, etc). Variables within the model were adjusted to calibrate the assumptions until a 'realistic' scenario was achieved.

5.3 Calculating cost

5.3.1 Recurrent costs

The model calculates the monthly recurrent cost for housing, transport and infrastructure in each zone as a whole by applying unit costs to the amount and type of housing and non-residential potion, travel patterns and infrastructure service level. However, an important consideration is that costs[15] are incurred at three primary 'levels': consumer (households and businesses), City and State (the national fiscus, including flows from the fiscus via Provinces). It is important to understand these costs separately and also understand the relationship between the first three tiers of costs. This is achieved by superimposing the state subsidies and city rates and tariff

[15] While it could be argued that costs can be seen as being independent of the body which incurs them, this argument will not assist in providing an understanding of how to improve the spatial efficiency of cities through economic and fiscal measures as these measures are in the realm of public finance policy which is controlled largely by City and State.

policies on the total operating costs to determine who actually pays for the services, i.e. how the costs accrue to the different financial 'actors'. This process is shown in Figure 3.

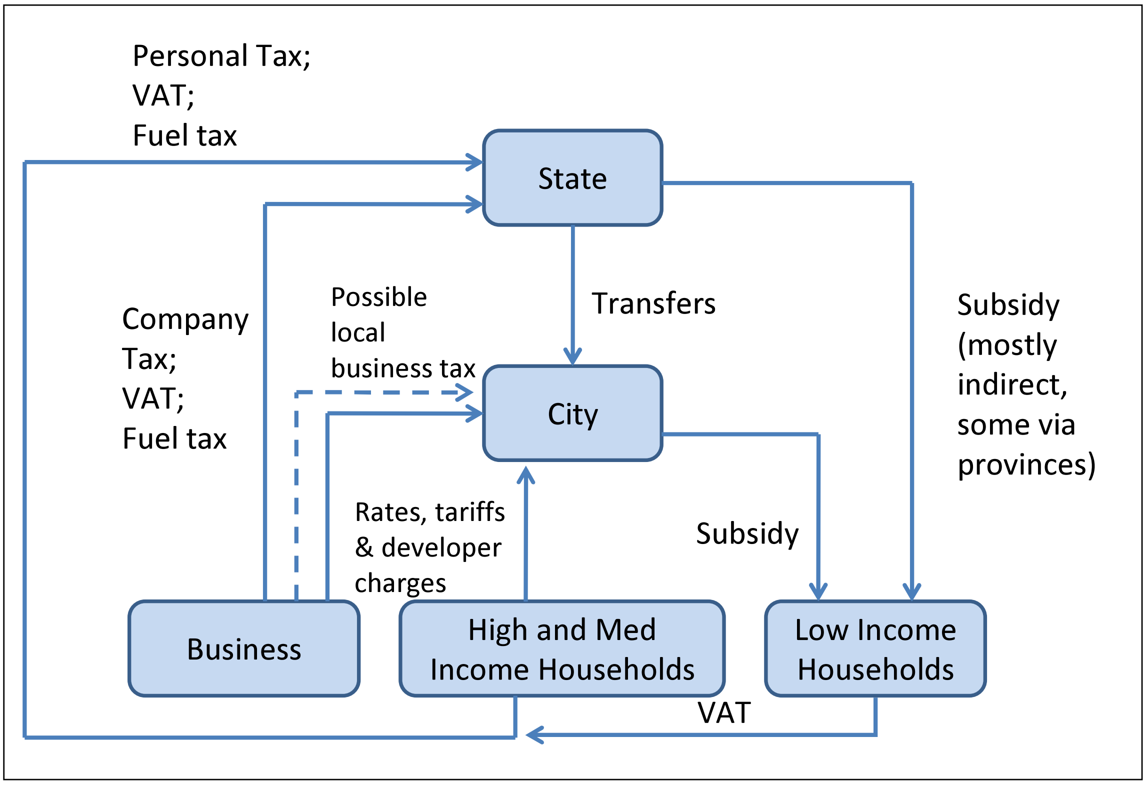

Figure 3: Framework for financial flows in South African cities

A further 'level' of costs is defined as costs to the environment, which have had to be measured through a combination of direct and indirect measures. Given the scope of this study, the costing of climate change impact is not possible. However, it is recognised that the energy balance of a city is an important economic parameter and, therefore, high level numbers on electricity and fuel use by households within the hypothetical city have been included in order to assess the 'first order' costs to the environment. Further, in considering costs associated with water, energy, waste and wastewater treatment and disposal, it is possible to increase the cost of these bulk services over time to allow for real cost trends in these sectors.

From the point of view of the methodology for this study, costing is most important at the household/business tier. In the case of households one must ask "How much does it cost to provide households with services, transport, land and housing, and how much do they pay for it?" The inclusion of only three household groups: high-income (typically earning above R12,800 a month), medium-income (typically earning R3,500 to R12,800 per month) and low-income (typically earning below R3, 500 a month) is an obvious simplification but allows some key concepts to be shown.

5.3.2 Capital costs and the city growth model

The first step in calculating the capital cost is to value the total existing assets in the city through the application of unit capital replacement costs to the amount and type of infrastructure to construct a high level 'asset register' for the city. These figures were calibrated against similar figures that were calculated using the Municipal Services Finance Model (MSFM)[16] in previous work done for the metros.

For city expansion, two key growth parameters were used: natural household growth through population increase and household fragmentation, and economic growth. Household growth was used to model the growth in housing and service demand, while the economic growth parameter was used to determine a) the movement of households between income brackets, and b) the rate of commercial and industrial expansion. The housing module within the model allocates households to primary and secondary dwellings (backyard shacks, formal rental rooms and granny flats), including downward-raiding of low-income housing stock by middle income households, with the remainder being accommodated in informal settlements. The result of these growth and housing demand projections are the numbers of new consumer units, and the associated land demand, in year 10.

Spatially, this residential growth was accommodated in the hypothetical city using the following logic:

- Existing areas were densified by using a densification factor – which was varied according to the scenario being modelled.
- Vacant stands within existing residential zones were populated with the same housing typology as was assumed for the zone as a whole, provided the demand for that housing typology exists.
- Vacant zones within the urban edge were populated with housing typologies according to a pre-determined priority ranking, and according to demand. Vacant areas were ranked by their 'location factor'[17] and the best located sites were allocated the highest priority land use. For the 'urban sprawl' scenario, high-income, high-density housing was prioritised, followed by high-income, low-density housing, and so on, with low-income, low-density development being the penultimate priority before low-income informal settlement. For the 'compact city' scenario, development was prioritised by density (high to low) and then income (low to high), with low-income informal settlement again the lowest priority land use.
- In addition, an assumption was made about how much of the total portion of vacant land within the city was actually available for development.
- Once all available vacant zones within the urban edge were occupied, the remaining residential and non-residential demand was accommodated in new zones outside the urban edge. These new zones were all assumed to have the same transport characteristics as each other and a 'location factor' worse than any existing zone within the urban edge.
- New non-residential development was accommodated according to the same logic as residential areas, with the same proportions of residential to non-residential land use by housing typology.
- Growth is assumed to be linear and thus the total city situation in year 10 was calculated and intermediate years were interpolated.

Once this process was complete, the result is a new zonal definition for the land use and characteristics of the 48 existing zones and 13 new zones. These zones were

[16] A model developed by PDG for the DBSA and CoGTA and National Treasury. For more information, see DBSA, 2010.

[17] See Section 5.4 below for a description of the 'location factor'

then allocated new transport characteristics depending on a number of assumptions regarding public transport mode shifts and travel time increases/decreases. The following process was followed:

- A decrease in the percentage of commuters using private cars over 10 years was assumed (10% for the 'urban sprawl' scenario and 20% for the 'compact city scenario).
- A percentage reduction in non-motorised was assumed (50% for both scenarios)
- Public transport commuters were ascribed to mass transit (rail and BRT) according to zone density (higher density = higher mass transit).
- The BRT:Rail split for mass transit was assumed to be 35%:65% for both scenarios
- The remainder of public transport users were split between taxi and bus in the same ratio as for year 1

It was assumed that for existing zones, travel patterns would remain the same and would not be influenced by new development nodes. While this is not a realistic scenario, such a hypothetical exercise is not capable of predicting how travel patterns would be altered. The more sophisticated transport models do project travel patterns, and this future pattern could be used as a model input for the final model year.

The unit operating costs in year 10 were also assumed to have varied in real terms and these assumptions were used to inflate the unit operating cost and a calculation of the total recurrent costs in year 10 were then made for both scenarios.

The capital costs for the city growth was calculated based on the number of new units constructed, the land utilised and the service levels provided. Transport expenditure was calculated on the capital investment required to generate the assumed change in ridership for the various public transport modes. The recent expenditure on BRT in Cape Town and Johannesburg and the Cape Town Rail Plan were used to guide these capital investment figures. In addition to the capital costs for new infrastructure, rehabilitation expenditure was assumed to be required on engineering services and transport infrastructure[18]. A value of 2% of the total current replacement cost of the assets was assumed (correlating to an average useful life of 50 years for these assets). A total capital sum was thus calculated for each of the two growth scenarios. As with the recurrent costs, these capital costs were ascribed to each of the financial 'actors' through an analysis of the current subsidy structure. For the modelled scenarios, the current subsidy regime was assumed to continue unchanged. However, for future application of the methodology, the subsidy policy can be altered and the impacts on city efficiency can be assessed.

5.4 Data sources

The key data that is required for the CECM is transport data, i.e. travel time and distance by mode. This data is available in city transport models, but has, up to now, had very specific application for modelling transport route capacities at peak periods. Transport model data typically also has demographic, socio-economic and density

[18] Rehabilitation expenditure on private housing or business property was incorporated into the capital appreciation values included in the recurrent cost calculation and thus was not considered in the capital cost calculation.

attributes. When linked to land use and financial data, this data becomes very useful in determining the efficiency of a city. How people travel, over what distances, and how long it takes them is a good measure of city efficiency. One can assume that those zones with short travel times and distances are 'well located'. The transport data also shows which zones have access to which type of public transport infrastructure.

The use of real transport data enables one to model a polycentric city: this is how people *actually move* in a city (in as generalised a way as can be captured in a transport model), instead of having to make assumptions about who is moving to where. From this transport data, a 'location factor' is derived, which is a function of the time and the distance travelled. For this report, the location factor was calculated as the simple sum of travel time (in minutes) and travel distance (in kilometers), but each of these terms can be weighted if necessary. This location factor is used to prioritise zones for development and densification, but also to apply a cost premium to connector infrastructure. This 'connector infrastructure premium' is used on the assumption that 'poorly located' zones within the city are also more costly to service (longer pipe lengths, roads, etc)[19]. This enables the model to calculate the cost differential between servicing central versus peripheral locations. The connector infrastructure premium was calibrated to achieve a factor of 3 between the least and most costly zones[20].

Another key set of data that is required for the CECM is unit costs for housing, land infrastructure and transport. Land and housing unit costs were obtained from private sector property developers, as well as from previous studies (see references). It must be noted that land prices are highly variable and poorly researched and thus very broad assumptions have had to be made. For this reason, the sensitivity of the model results to land price has been tested. Infrastructure unit costs were obtained from case studies of metros using the Municipal Services Financial Model, in which the actual expenditure and revenue of cities for each of the services was calculated. Transport unit costs were obtained from previous studies undertaken by PDG to populate Public Transport Models for the country, and for the City of Cape Town. These costs were checked against current public transport projects.

Data regarding rates and tariffs were taken from the existing rates and tariffs of the three metros, and an average value was assumed.

5.5 Key assumptions

Two key drivers in the model are the economic growth rate and the household growth rate, and these have been set to the defaults in the MSFM, as shown in the table below:

Table 3: Economic growth rate used in CECM model

2011	2012	2013	2015	2020
1.0%	2.0%	3.0%	4.0%	6.0%

[19] Some complexity is introduced if one considers the premium paid for upgrading existing infrastructure in dense inner-city areas, but this has not been directly considered in the model structure

[20] A factor of 3 was taken as a 'reasonable' cost premium for servicing peripheral areas. More accurate estimates of this figure have been made by the eThekwini Metro in their Cost Surface Model, which calculates the premium paid for providing bulk and connector infrastructure in specific zones within the city.

Table 4: Household growth rates used in CECM model[21]

	2010	2015	2020
High-income	0.5%	0.5%	0.5%
Medium-income	1.0%	0.9%	0.8%
Low-income	3.5%	3.0%	2.5%

An additional key driver of growth and the form of cities is the subsidized housing delivery programme. It is necessary to project both the quantity and type of housing products delivered by the state over the model period. Given that housing delivery is strongly supply-driven at present, a figure was assumed for the quantities of full state subsidies used for low-income units and finance-linked subsidies (FLISP) for middle income units. This can be varied by setting the delivery rate at year 1 and year 10, but for these model runs the delivery rate was assumed to be constant. The split of units for rental and for ownership was also assumed. These assumptions are shown in the tables below:

Table 5: Subsidised housing delivery assumptions

	Delivery (DU pa)
Fully subsidised housing: Year 1	10,000
Fully subsidised housing: Year 10	10,000
FLISP subsidised housing: Year 1	2,000
FLISP subsidised housing: Year 10	2,000
	% owned
Fully subsidised housing:	80%
FLISP subsidised housing: Year 1	80%

The housing typology to be provided with these subsidies (e.g. high-density units, single formal units or incrementally upgraded sites, etc.) depends on which of the various housing programmes are prioritized by the national Department of Human Settlements and by the metros over the next ten years. Assumptions regarding the housing mix (including both subsidized and unsubsidized housing) were varied for each of the scenarios (see below).

Table 6: Assumed type of housing delivery for each scenario

Housing type	***Urban sprawl***	***Compact city***
LI flat	5%	20%
LI 3 storey	5%	30%
LI semi	10%	30%
LI single formal	80%	20%
MI flat	10%	20%
MI 3 storey	15%	20%
MI semi	15%	20%
MI single formal	60%	40%
HI flat	10%	20%
HI 3 storey	15%	20%
HI semi	15%	20%
HI single formal	60%	40%

[21] Note that households also shift between income brackets due to economic growth assumptions, so the high-income growth will be higher than natural growth, and low-income growth will be lower than natural growth.

The assumptions regarding the demographics and service levels for each of the 13 housing typologies are shown in the table below:

Table 7: Default characteristics of housing typologies

HOUSING TYPES	Dwelling units per consumer unit	Households per dwelling unit	People per household	Water	Sanitation	Electricity	Solid Waste	Road length (m/consumer unit)	Type of secondary dwelling	Net density (consumer units per hectare)	Average % rental of primary dwelling[22]
LI informal	1.00	1.00	3.49	Inadequate	Inadequate	None	Community contractor	0.2	None	150	40%
LI flat	1.00	1.10	3.49	In-house	W/borne	Serviced	Municipal Kerbside	2	None	200	80%
LI 3 storey	1.00	1.20	3.49	In-house	W/borne	Serviced	Municipal Kerbside	4	None	100	60%
LI semi	1.40	1.20	3.49	Yard tap	W/borne	Serviced	Municipal Kerbside	5	Backyard shack	80	20%
LI single formal	1.40	1.20	3.49	Yard tap	W/borne	Serviced	Municipal Kerbside	6	Backyard shack	67	20%
MI flat	1.00	1.05	3.49	In-house	W/borne	Serviced	Municipal Kerbside	2	None	100	80%
MI 3 storey	1.00	1.05	3.49	In-house	W/borne	Serviced	Municipal Kerbside	4	None	80	50%
MI semi	1.40	1.05	3.49	In-house	W/borne	Serviced	Municipal Kerbside	6	Backyard shack	50	30%
MI single formal	1.40	1.05	3.49	In-house	W/borne	Serviced	Municipal Kerbside	9	Formal room	40	30%
HI flat	1.00	1.00	3.49	In-house	W/borne	Serviced	Municipal Kerbside	4	None	100	60%
HI 3 storey	1.00	1.00	3.49	In-house	W/borne	Serviced	Municipal Kerbside	6	None	50	50%
HI semi	1.00	1.00	3.49	In-house	W/borne	Serviced	Municipal Kerbside	10	None	25	40%
HI single formal	1.00	1.00	3.49	In-house	W/borne	Serviced	Municipal Kerbside	15	Granny flat	20	40%
Vacant				Inadequate	Inadequate	None	None	0	None		
Commercial and Industrial				In-house	W/borne	Serviced	Municipal Kerbside	15		20	

For changes in the real cost of building materials, infrastructure construction costs, transport (fuel) costs and municipal property rates. The following assumptions were used:

Table 8: Real increase municipal property rates over 10 years

Residential	Commercial and industrial	Vacant land
10%	12%	10%

[22] It is assumed that all secondary dwellings are rented

Table 9: Real cost increases over 10 years

Real building cost increase	30%
Infrastructure capital cost increase	20%
Infrastructure operating cost increase	10%
Transport operating cost increase	50%

In addition to the above parameters, which were kept constant for both of the scenarios, there were a number of scenario-dependent variables. These relate to:

- Densification factors for existing zones;
- Percentage of total existing land assumed to be available for development;
- Maximum increase in land value due to scarcity
- Reduction in private car use;
- Increase in travel time; and
- Mass transit usage and split between BRT and rail.

A full list of the values assumed in each scenario for these variables is given in Appendix 1.

5.6 Links to the financial system at a city and state level

The division of costs between the four simplified financial 'actors' in the city (households, businesses, the City and the State) is defined by the level of subsidies and the qualification criteria for these subsidies. The model does not consider all of the fiscal flows illustrated in Figure 3, as it excludes VAT, social grants, payments by households to private entities (except for private transport companies) and financial flows to and from public entities such as Eskom. The main subsidy flows that are considered are:

Housing subsidies: described above. Assume that full subsidy amount of R77,868 is granted to low-income households to cover top structure costs first, then infrastructure costs, then land costs. Any shortfall between the subsidy and the actual cost is paid for by the city, up to a maximum of R40,000 per unit. A state electricity subsidy of R7,000 per low-income household is added to the housing subsidy for internal services. For the middle income FLISP subsidy, an amount of R5,136 (the subsidy amount for a household earning R7,000 per month) goes towards top structure and service costs, with the shortfall being paid by the household.

Infrastructure operating subsidies are handled as shown in Table 10.

Table 10: Basis for infrastructure operating subsidy assumptions

Service	***Income***	***State subsidy***	***City subsidy***	***Household charge***	***Subsidy mechanism***
Water, Sanitation Electricity and Solid Waste	Low	80%	20%	0%	Equitable share grant
	Middle	0%	Tariff minus cost	Tariff	City tariff policy
	High	0%	Tariff minus cost	Tariff	City tariff policy
Roads	Low	0%	100%	0%	City rates account

Service	Income	State subsidy	City subsidy	Household charge	Subsidy mechanism
	Middle	0%	100%	0%	
	High	0%	100%	0%	

Infrastructure capital subsidies are dealt with as shown in the table below:

Table 11: Basis for infrastructure capital subsidy assumptions

Service	Income	State	City	Household	Mechanism
New internal infrastructure	Low	76-95%	5-24%	Only informal households	Housing subsidy and city top up to make up difference, depending on the housing type and level of service
	Middle	0%	0%	100%	Developer costs passed on to household in purchase price
	High	0%	0%	100%	
New bulk and connector infrastructure	Low	80%	20%	0%	MIG grant and city top-up
	Middle	0%	80%	20%	Developer contributions, passed on to the household in purchase price
	High	0%	50%	50%	
Rehabilitation of existing infrastructure	Low	100%	0%	0%	MIG funding for rehab of state-funded assets
	Middle	0%	100%	0%	Capital reserves and borrowing
	High	0%	100%	0%	

Transport subsidies are not currently transparent and are difficult to determine accurately. However, the assumptions that have been made around capital and operating subsidies for public transport are shown in Table 12 and Table 13, below. The model can accommodate a shift in the focus of transport operating grant over time by entering different subsidy percentages for year 1 and year 10.

Table 12: Transport operating subsidy assumptions

Year	Funder	Car	Rail	Taxi	Bus	BRT
2010	State	0%	63%	0%	45%	20%
	City	0%	0%	0%	5%	5%
2020	State	0%	63%	0%	45%	20%
	City	0%	0%	0%	5%	5%

Table 13: Transport capital subsidy assumptions

Funder	Car	Rail	Taxi	Bus	BRT
State	0%	100%	0%	0%	80%
City	0%	0%	0%	0%	20%

6 Results

6.1 Recurrent costs

The total recurrent costs to run the housing, infrastructure and transport in the 'hypothetical city' in the base year were calculated to be R53 billion rand per annum. Over half of this cost is made up of housing costs. When these costs are escalated to 2020 in the two scenarios, the operating costs of the city escalate to R99 billion in the 'urban sprawl' scenario and R92 billion in the 'compact city' scenario (Figure 4) – a difference of 7% in year 10. As would be expected, the largest difference between the recurrent costs of the two scenarios is in the transport cost. The increases from year 1 to year 10 are due to city growth and the assumed real cost increases of the various services.

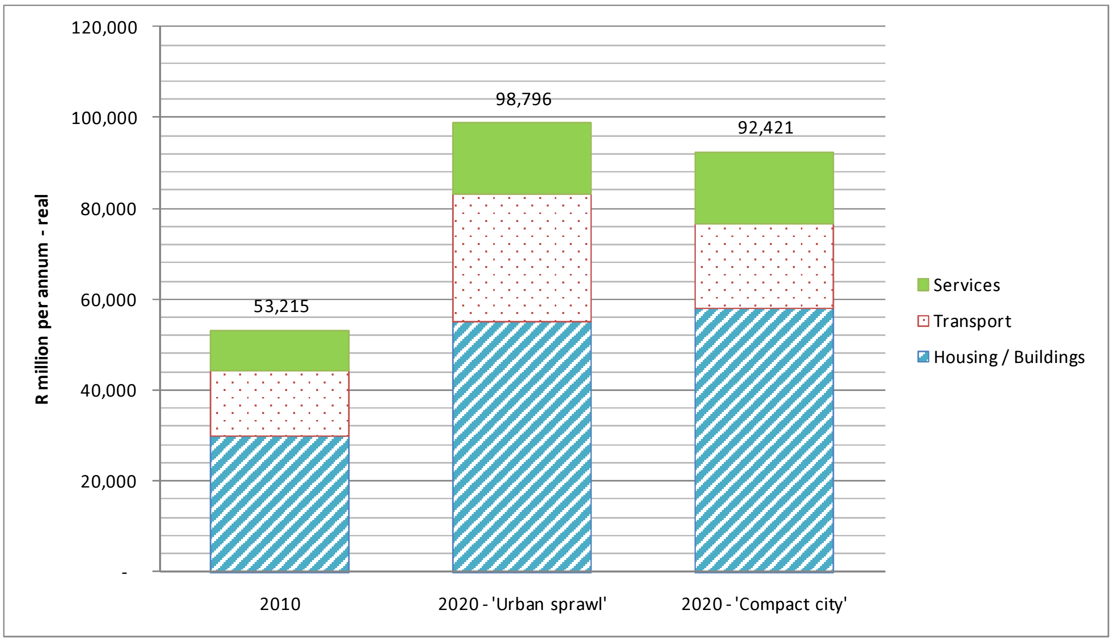

Figure 4: Total recurrent cost for the hypothetical city

When we examine who incurs these costs, it is clear that the financial burden is largely on households. In addition, Figure 5 shows that the cost *increases* from year 1 to year 10 are largely absorbed by households, particularly in the urban sprawl scenario. The recurrent costs incurred by business were limited in this analysis to rates and infrastructure costs. These are shown to increase by 85% and 72% in the urban sprawl and compact city scenarios respectively. The preliminary results show that the city makes a small surplus in the provision of these services. Water and electricity typically provide surpluses for municipalities to cross-subsidise other municipal functions. An assumption has been made that 10% of rates income is used to fund roads. Other non income-generating municipal functions have not been included in the analysis, and thus it is realistic that the services considered would show the City making a small surplus. Changing of rate tariff and subsidy levels can cause this figure to be slightly positive (i.e. City makes a net loss). The recurrent costs incurred by the state (through the Equitable Share subsidy for free basic services and public transport operating grants) increase by 179% over 10 years in the urban sprawl scenario (R3.3 bn per annum) and 140% in the compact city scenario (R2.8bn per annum).

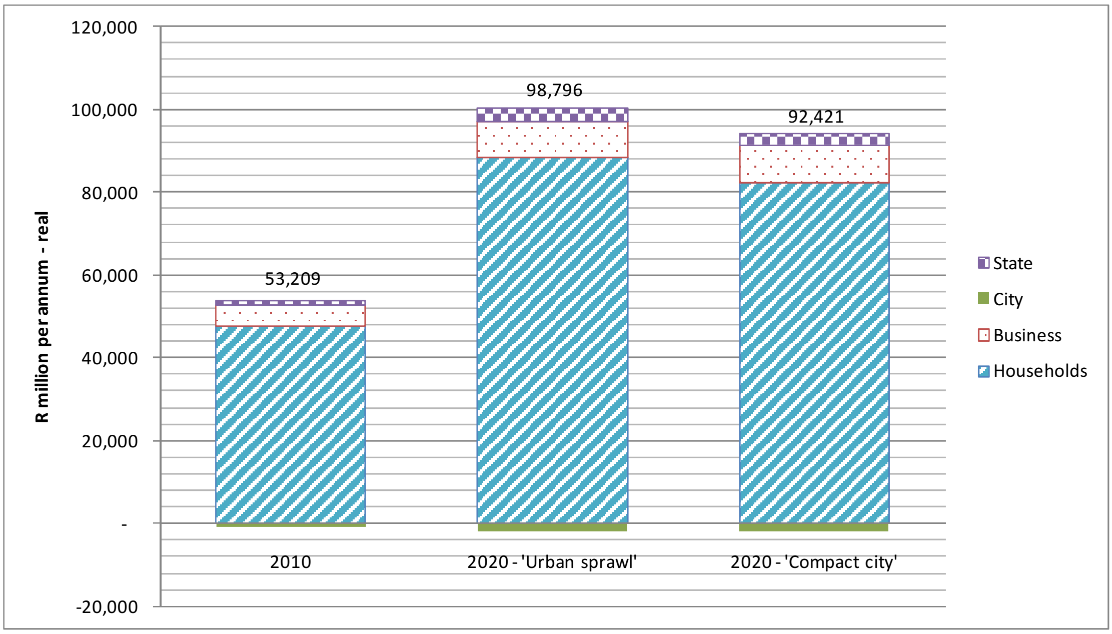

Figure 5: Recurrent costs broken down by financial 'actor'

In analysing the recurrent expenditure by income group, some interesting patterns emerge (Figure 6). Low-income households spend 14% more in the urban sprawl scenario, but 10% *less* per household per month on these services in the compact city scenario than in the base year. Middle-income households spend 8% less in the urban sprawl scenario and 13% less in the compact city scenario. Higher-income households incur a higher level of monthly expenditure in the urban sprawl scenario (12% increase), while for the compact city scenario the increase in monthly expenditure is less (10% increase). Thus, while all households benefit from the compact city scenario, middle- and low-income households benefit the most, while for urban sprawl, low-income households are affected most negatively.

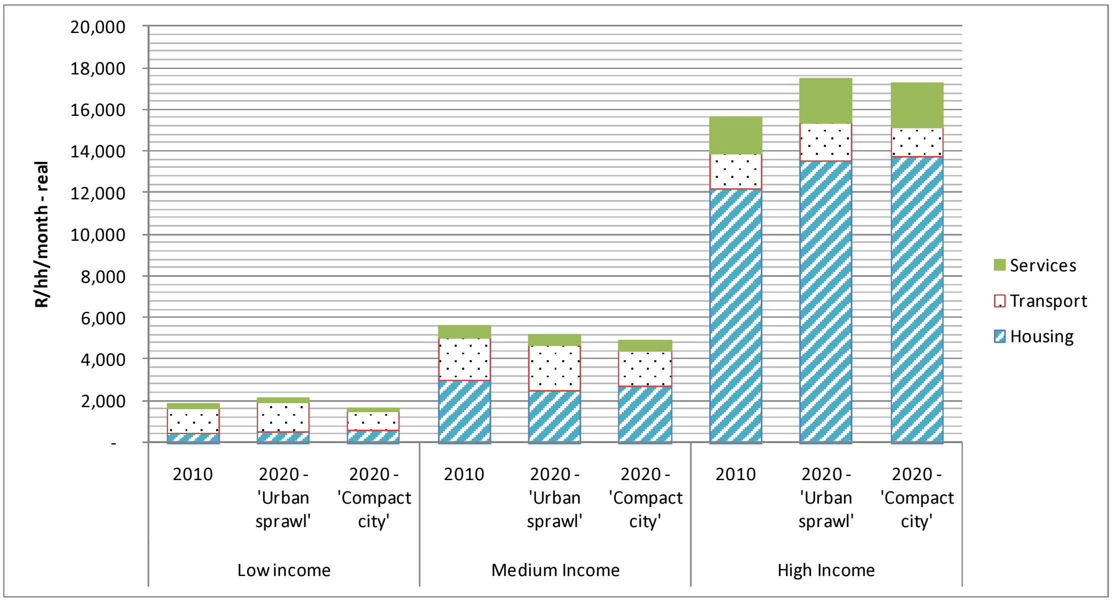

Figure 6: Average recurrent household expenditure by income category

Figure 7 shows household expenditure on housing, transport and infrastructure broken down by zone. The most 'well-located' zones are shown on the left, with the worst located zones on the right of the graph. Housing expenditure as a percentage of household income remains fairly constant across the income groups, while infrastructure spending remains constant across all zones. The greatest variation comes in the transport costs. In some cases, transport costs amount to 66% of household income. Transport expenditure is a function of modal split and distance travelled, and thus with the high level of data aggregation used in this model (e.g. assuming a whole zone to be low-income, but including private car usage of some high-income households) can cause inaccuracies.

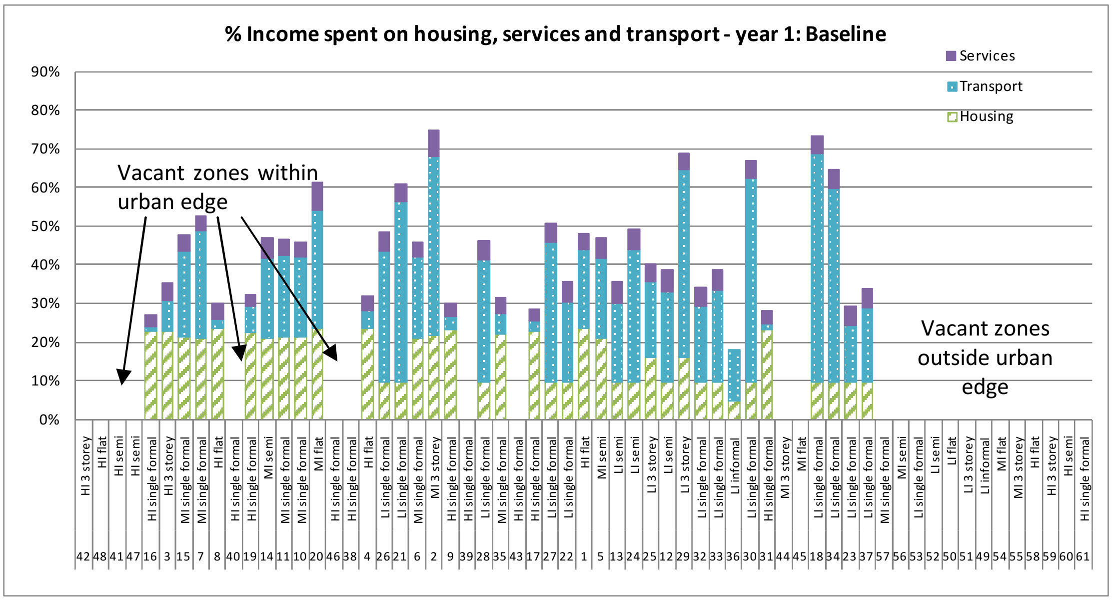

Figure 7: Household expenditure breakdown by zone – year 1

For the 'urban sprawl' scenario, the number of occupied zones increases from 37 to 54 because the vacant land that is assumed to be available for development is insufficient to fulfil the housing demand at the densities assumed. Therefore, development spills over the theoretical 'urban edge' into new zones established on the periphery. Figure 8 shows that transport costs have increased in general, and more rapidly for poorer located zones. New development on vacant zones within the city have low transport costs, while new zones outside the urban edge have relatively high transport costs, but interestingly, not as high as some of the existing zones. This anomaly is due to differences in public transport access, with those existing zones that have the highest transport costs, having the lowest access to mass transit (rail).

Figure 9 shows the transport cost benefit of the compact city model, with lower transport costs in general due to higher mass transit usage. Infill development has taken place, and because of higher densities, no new development is required outside of the urban edge.

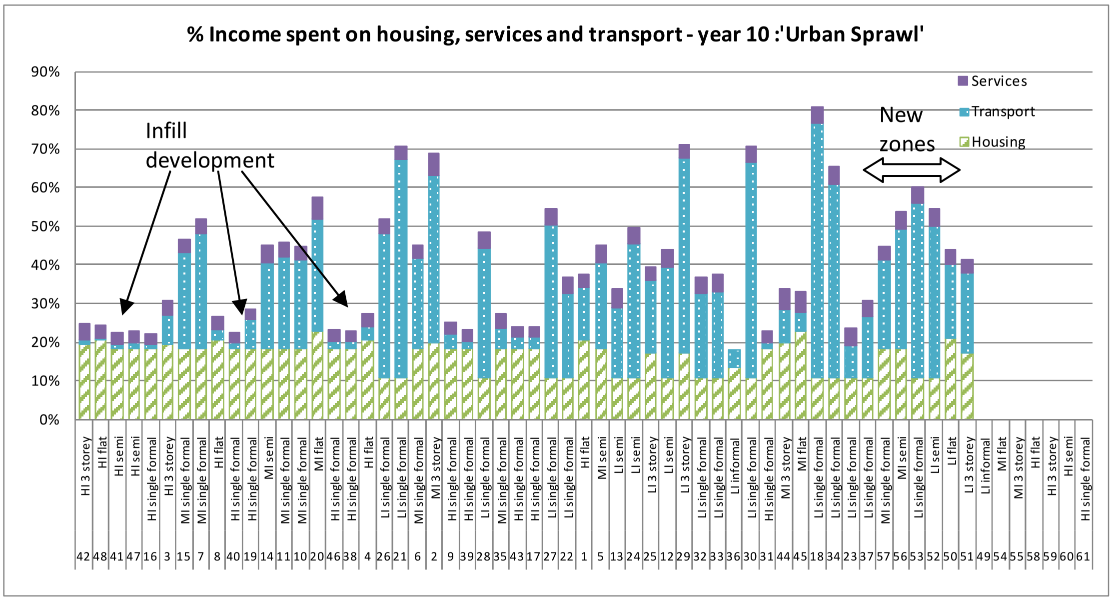

Figure 8: Household expenditure breakdown by zone – year 10 'urban sprawl' scenario

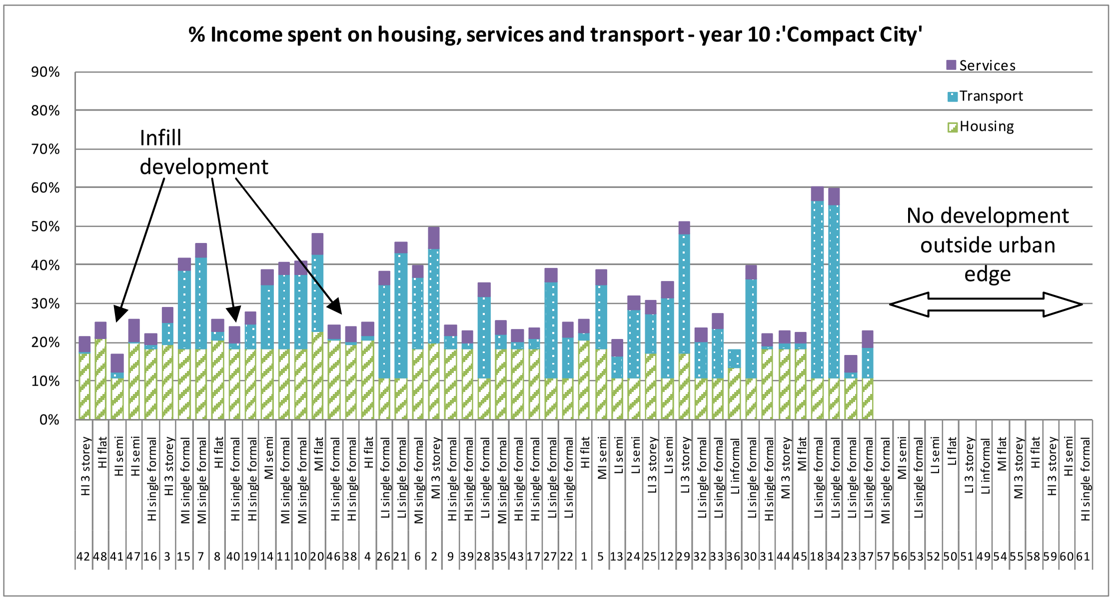

Figure 9: Household expenditure breakdown by zone – year 10 'compact city' scenario

6.2 Capital costs

The calculation of total capital investment over 10 years for growth of the hypothetical city under each of the two development scenarios show the capital costs for the urban sprawl model to be 2.1% higher at R261 billion (Figure 10).

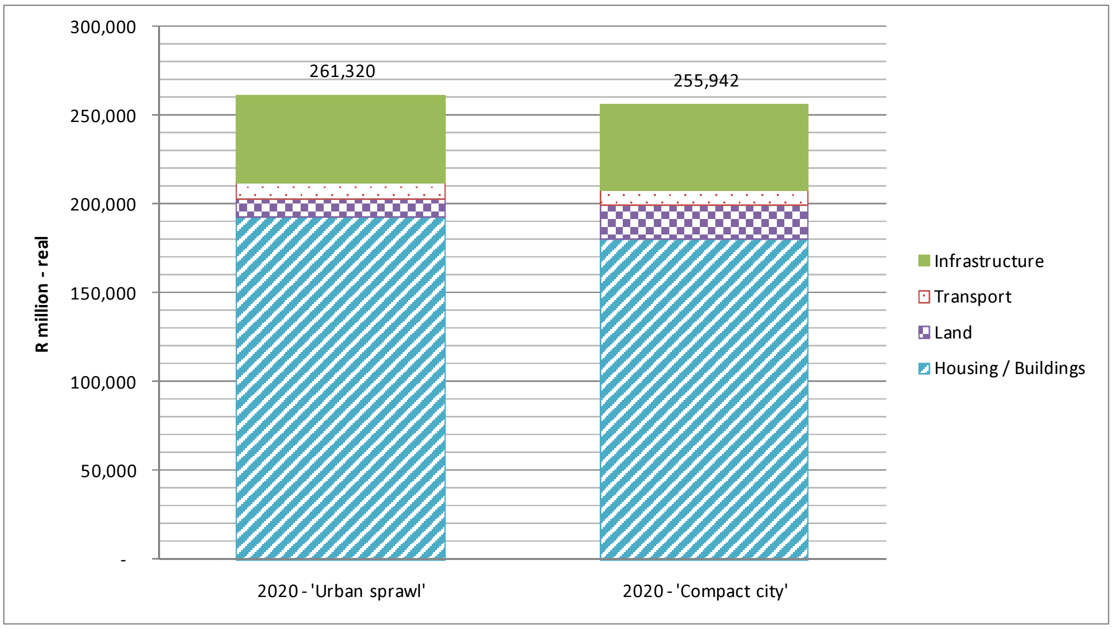

Figure 10: Total capital investment over 10 year for the two growth scenarios

Overall infrastructure and transport costs for the two scenarios are almost identical, as are. However, for transport, it is important to note that while the same capital is required, there is lower public transport usage in the urban sprawl scenario, i.e. more investment per passenger in the urban sprawl scenario. The main difference in the capital costs comes with land and housing costs. In the urban sprawl scenario, housing / buildings costs are greater because of the assumed values of high-income units. The average value of a high-income single residential property is less that an average high-income flat, for example. Thus, with increased density, the total capital required is less. With low-income households, the relationship is reversed, but because the value of low-income housing is so much less than high-income housing, it is the high-income trend that dominates. This is better explained graphically in Figure 11.

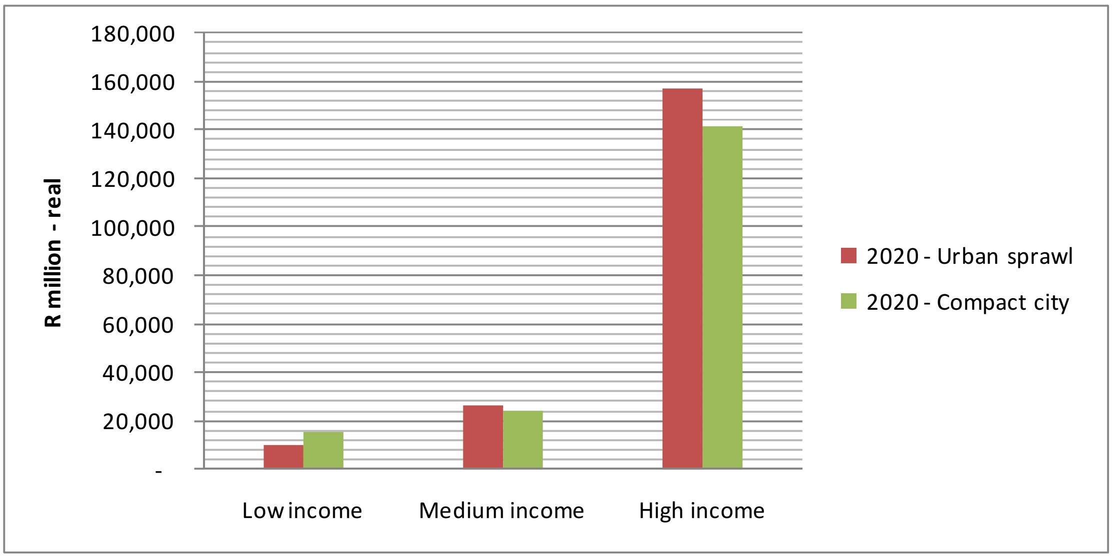

Figure 11: Total capital investment in housing/buildings over 10 years, by income group

To balance this trend, the land values in the compact city scenario are higher because of the assumed land price increases in the compact city scenario. For the urban sprawl scenario, the best located land was assumed to double in value over 10 years (100% real increase), while the worst located land would not increase in value. For the compact city scenario, the best located land was assumed to increase by a factor of 5. A sensitivity analysis on the land price increase is shown in Table 14 below. Thus if the premium on land in the two scenarios was equal (e.g. 300% increase in both), then the compact city scenario would be cheaper than the urban sprawl scenario. Alternatively if the land price increases were more divergent (e.g. 0% increase for urban sprawl and 500% for the compact city), then the compact city model would be approximately 5% more expensive.

Table 14: Sensitivity analysis on total capital cost versus land cost increase

Variable	Urban sprawl			Compact city		
%change in land price increase	Maximum land price increase	Total capital (Rbn)	% change in total capital	Maximum land price increase	Total capital (Rbn)	% change in total capital
0%	100%	202,821	0%	500%	210,246	0%
-200%	-100%	197,735	-1%	300%	205,829	-2%
-100%	0%	200,278	0%	400%	208,037	-1%
+100%	200%	205,364	1%	600%	212,455	1%
+200%	300%	207,907	3%	700%	214,663	2%
+300%	400%	210,450	4%	800%	216,872	3%

Figure 12 shows that there is little difference in who incurs this capital cost between the two scenarios, but that the bulk of the cost falls to households to fund themselves. Note that the capital costs incurred by businesses include investment in land, new buildings (rough approximation), internal infrastructure, and developer contributions for bulk and connector infrastructure.

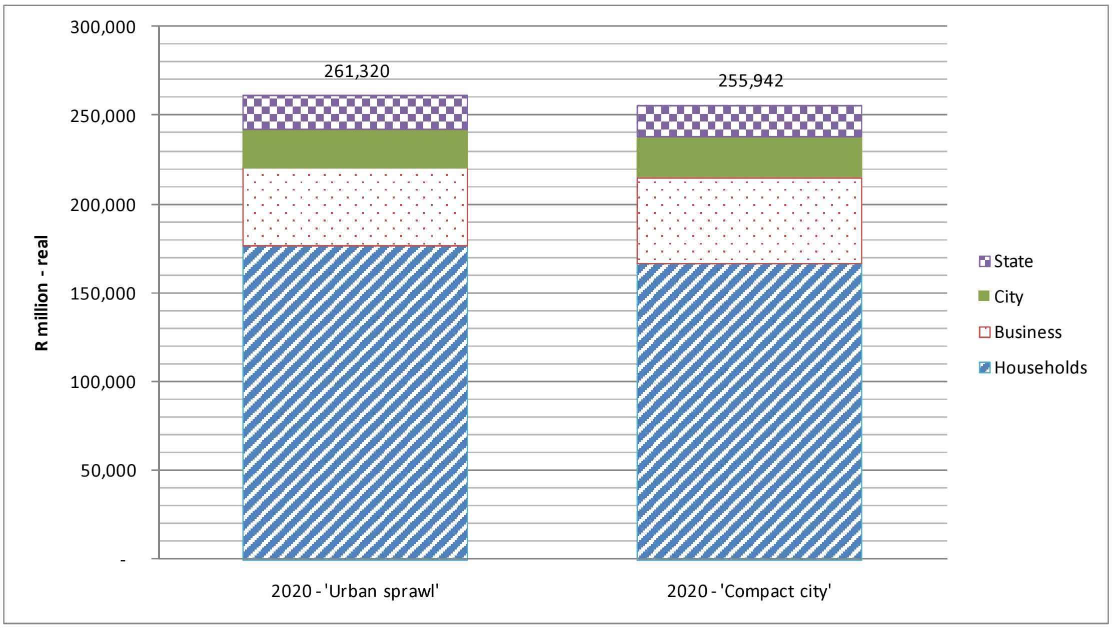

Figure 12: Total capital investment over 10 years by financial 'actor'

When the capital costs are broken down by service and financial actor, Figure 13 shows that households will pay less for housing (for reasons as explained above), more for land, and only slightly less for infrastructure in the compact city scenario. This reduction is due to an assumed reduction in water consumption with densification. The difference in capital costs for businesses is entirely due to increased land costs in the compact city scenario. Investment by the City and the state is roughly equal in both scenarios, with government paying more for housing and land, but less for transport and infrastructure.

Figure 13: Total capital investment over 10 years by service and financial 'actor'

6.3 Capital subsidies

It is important to note that the capital costs presented above are calculated based on the assumption that the subsidy regime remains constant.

Low income housing and housing subsidies

For the housing subsidy, it is assumed that the state contribution is fixed, with the remaining cost of the units being attributed to either the City or the households. Figure 14 below shows the level of capital expenditure on low-income housing[23] over 10 years. It shows that the State subsidy for housing is calculated to be R5.6 billion in the urban sprawl scenario, with a City top-up of R322 million. On top of this, it is assumed that the households themselves will contribute R1.1 billion, which includes informal housing, non-subsidised self-build housing, and owner contributions for higher density housing. Whether this level of capital input is affordable to low-income household is up for debate and requires further investigation.

In the compact city scenario the state subsidy has increased to R6.5 billion (due to more higher density units using the full subsidy and an increase in land cost assumed to be covered by the State), while the City top-up has ballooned to R1.6 billion due to the more expensive higher density units. The household contributions have also increased to R1.6 billion. The distribution of the government subsidy between the State and the City is a matter of fiscal policy and is likely to vary, but the point to be noted here is that the total government contribution increases from R6 billion in the urban sprawl scenario to R8 billion over 10 years. This amounts, on average, to an extra R200 million per annum for this hypothetical city. If one extrapolates this amount to cover the 6 metros in South Africa (based on the ratio between the

[23] Some subsidy has been assumed for medium-income housing as well (FLiSP), but is not represented here as it only represents 1-2% of the total capital for that income group.

hypothetical city population and the total metro population), this would amount to approximately R1 billion additional funding for housing.

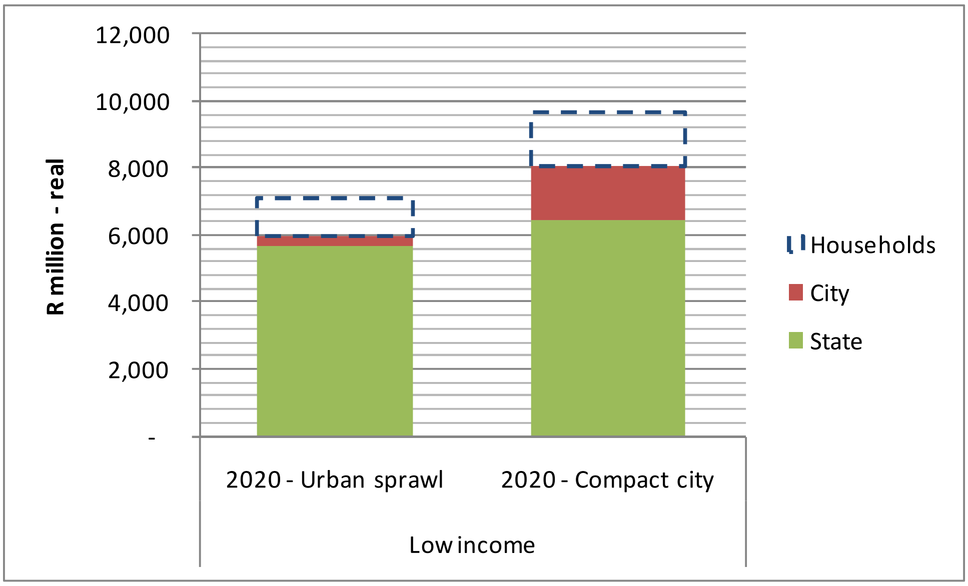

Figure 14: Housing subsidies for low-income households over 10 years for the two growth scenarios

While it is likely to be feasible for the state to provide an additional R1 billion a year, the extent to which cities can afford the 'top up' the amount of R1.6 billion is very uncertain, as is the extent to which low income households can afford the additional capital payment for housing. Yet the ability of al actors to finance higher cost housing in good locations in cities is a fundamental requirement cities are to develop along a more compact trajectory.

Transport subsidies

Transport capital subsidies are assumed only to cover rail and BRT systems. All capital for these modes is assumed to be funded by either the City or the State in a fixed ratio by mode. In addition to capital grants for new infrastructure, an assumption has been made around rehabilitation expenditure on existing and new assets. Rehabilitation makes up 45% of the City costs and only 14% of State costs. In total, the State contribution is R6 billion over 10 years, versus the City's contribution of R1.7 billion for the urban sprawl scenario. The subsidy required is 4% less in the compact city scenario, but for fewer passengers. The total subsidy amounts to R7.7 billion (over 10 years) or R897 per passenger per year in the urban sprawl scenario and R7.4 billion or R677 per passenger per year in the compact city scenario. It is interesting to note the degree to which medium- and high-income households are subsidised by the transport capital subsidy, which is due to the subsidy structure based on mode choice.

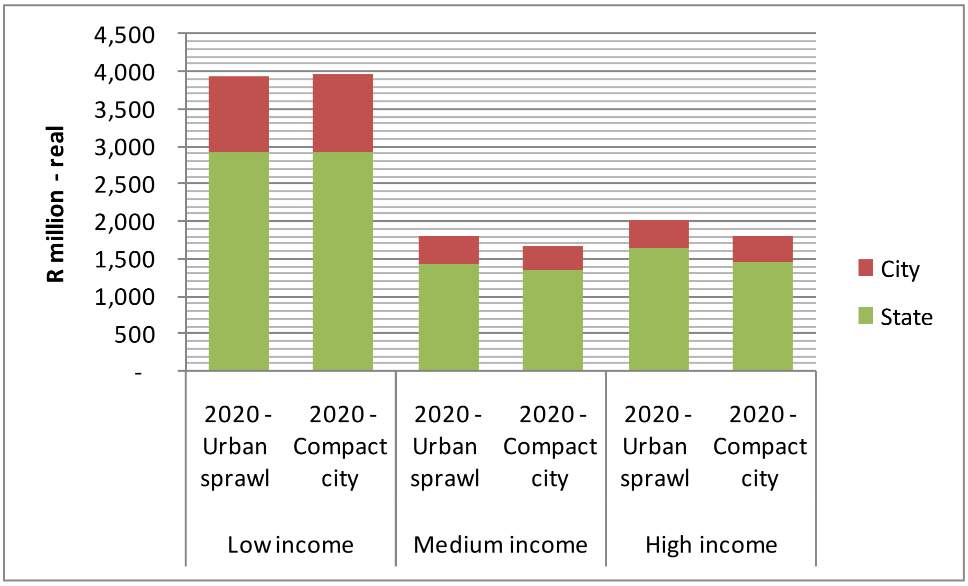

Figure 15: Transport capital subsidies over 10 years for the two growth scenarios

Once again, it is important to note that the extent to which cities will develop in a more compact form is strongly dependent on the level of funding, primarily in the form of transfers from the national fiscus, for public transport infrastructure. The numbers used for these scenarios are based on a limited understanding of what will be required and higher levels of subsidy may well be required. But the transformative impact of these capital flows cannot be ignored.

Infrastructure finance and associated subsidies

Infrastructure subsidies from the State include the portion of the housing subsidy that is used for internal services, the MIG subsidy for bulk infrastructure (assumed 80% of capital required for low-income households) and the rehabilitation of state funded assets (either through the MIG subsidy or some other mechanism). The model assumes that the City covers 20% of the bulk infrastructure costs for low-income households, 80% of the costs for medium-income households and 50% of the costs for high-income households (with developer charges covering the remainder). The City also contributes a top-op on internal services for low-income households, as well as provision for the rehabilitation of all non-grant funded assets.

For the urban sprawl scenario, the State subsidy amounts to R7.7 billion over ten years, versus the City's contribution of R17.9 billion. In addition, households are assumed to contribute R16.4 billion and business R7.4 billion, which matches the government contribution. For the compact city scenario the State subsidy is reduced by 14% to R6.5 billion and the City contribution is reduced by 3% to R17.4 billion.

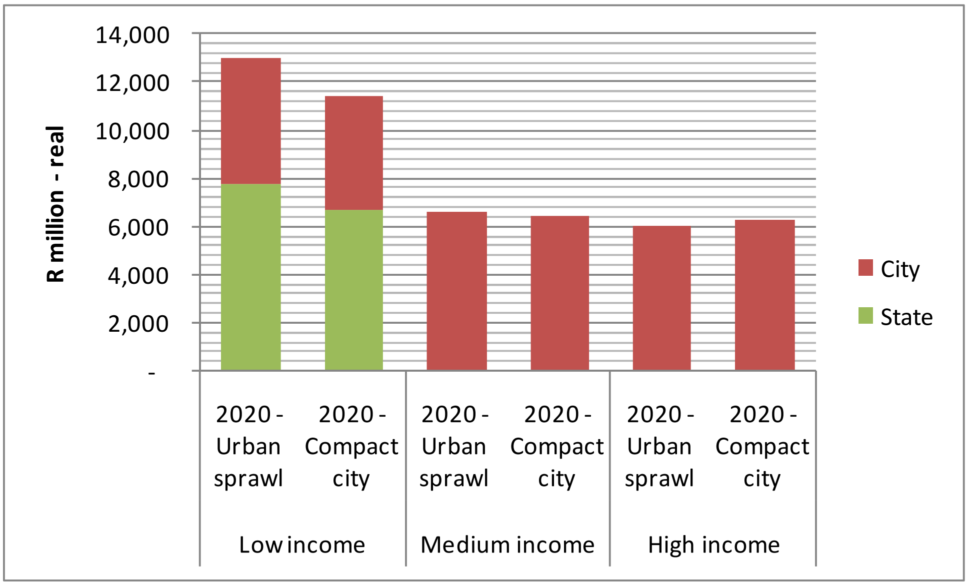

Figure 16: Infrastructure subsidies over 10 years for the two growth scenarios

Compact cities use infrastructure more efficiently. But an important question remains as to whether infrastructure finance arrangements drive changes in city structure. In this regard it is arguable that developer charges can play an important part. Based on the hypothesis that infrastructure on the periphery of cities is more expensive, developers should be faced with the full cost of property developments so that they will seek lower cost, better located, land for development.

6.4 Public transport operating subsidies

The results show a reduction of 33% in the public transport operating subsidies required under the compact city scenario, assuming no change in subsidy policy. This comes about because of shorter aggregate travel distances on currently subsidised modes: rail and bus. This is a substantial saving and is also indicative of the overall improvement in efficiency of passenger transport in the compact city.

But this conclusion masks some serious shortcomings in the public transport subsidy system which can, however, be recognised by looking at the results for individual zones. For communities living in zones which have access to subsidised modes, the costs of public transport borne by households is low in relative terms, compared with those zones which do not have access to rail and subsidised bus services. Yet a large proportion of the poorest people in cities relies on taxis which are not subsidised and they, therefore, spend very high proportions of their household incomes on transport.

It has been beyond the scope of this analysis to deal with the complex issues associated with transport operating subsidies, but it is important for this work to be done and the CECM model provides a tool for testing policy options.

6.5 Environmental costs

The environmental costs were assessed in terms of carbon emissions (measured as tons of CO_2 emitted by all transport modes per year), total electricity and water consumption by households and businesses per year, and total volume of solid waste (refuse) generated by households and business per year. These costs were calculated for the base year and for year 10 under both of the growth scenarios.

Figure 17 shows that there is almost no difference in the volumes of electricity and water consumed and waste generated between these scenarios. The major difference, however, is in the volume of carbon emissions, with the compact city scenario resulting in 22% less carbon emitted than in the urban sprawl scenario. This is due to more efficient public transport and shorter travel distances. An increase in travel time of 15% has been included in the compact city scenario, and while this would have an impact of the carbon emissions, this has not been included in this round of modelling, as figures quoted in the literature for carbon emissions are typically given per vehicle km, and not by time spent travelling. This increase in travel time means an average difference of 6 minutes per commuter per day (34 minutes in urban sprawl scenario vs. 40 minutes in compact city) and increases the total travel time (by all commuters) by 357,477 hours per day. This is significant when looking at the qualitative benefits of the compact city. Economic estimates for the monetary value of travel time could be applied to this figure to quantify the benefits of reduced travel time in money terms, but would have to be the focus of further research, as this is beyond the scope of this study.

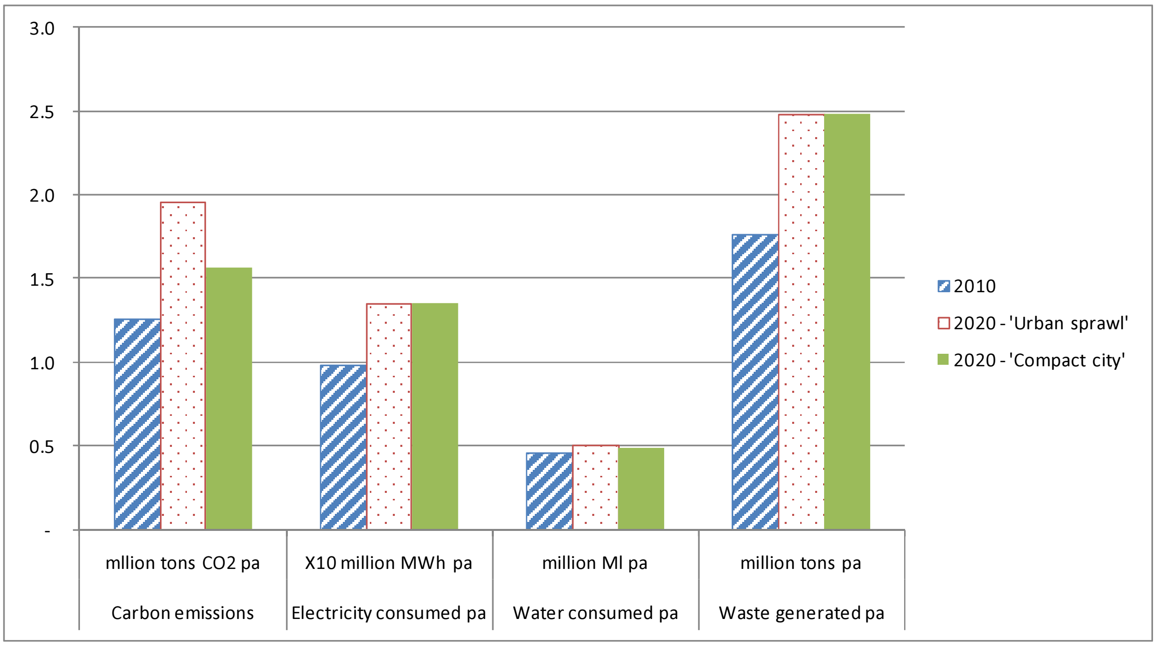

Figure 17: Environmental impacts of the two growth scenarios

7 Conclusions and recommendations

The background literature to this study has drawn on the fact that, by international standards, South African cities are inefficient. The low densities and fragmented and inequitable land distribution patterns lead to high social, financial and environmental cost. This research project has sought to quantify this cost, and to illustrate how current financial frameworks impact on the spatial form, and distribute that financial cost to the various 'actors' in the city.

Overall finding on recurrent cost

A compact city model shows a 7% saving in recurrent costs per year after 10 years of development. While, at first glance this may not seem substantial it is notable that this applies to the city as a whole including all households and businesses which were present in the base year. Further, this has a cumulative impact, with the benefit existing in all future years. Most of this saving is to households and to the state, with equivalent, but lesser, levels of expenditure required by businesses and the City.

While all households are, on average, likely to be better off under a compact city model, the benefits are greatest for medium-income households, largely due to savings on transport. In contrast, if the sprawl scenario applies, low-income households are exposed to the biggest negative impact on their household budgets. Low-income households have the most to benefit from a compact city growth scenario, with a 24% difference in recurrent household expenditure between the two scenarios after 10 years.

For low-income households the ratio between housing costs and transport and infrastructure costs is particularly relevant in the debate around informality. Households in informal settlements spend the least amount on housing, but a considerable portion of their monthly income on transport. The argument for providing subsidised housing in well-located areas is made on the basis that transport costs will be reduced. For households living in informal settlements, this argument only holds if the transport cost reduction is equal to, or greater than the increase in housing and infrastructure costs that the household will incur as a result of accessing formal housing. If not, then the household is likely not to be able to afford the cost of the formal housing and be driven back to informality.

Overall finding on capital cost

One of the most interesting findings of the hypothetical city model is the fact the capital investment required for the two scenarios is almost equal. Consider this from the perspective of individual capital components:

- Infrastructure costs are almost the same. The additional length of connector infrastructure required in a sprawl city scenario is not significant compared with the costs of internal and bulk infrastructure that is required in both scenarios.
- In the case of housing and buildings, the capital cost is slightly lower (6%) in the compact city. This is driven primarily by the assumed lower cost per unit for high-income residential units. In contrast, the case of low-income units, the cost per unit in the compact city is higher. However, the capital cost of land in the compact city was assumed to be significantly more, resulting in a 91% cost difference. But because land is a relatively small portion of the total capital cost, for land and housing combined, the impact on total capital cost

of the urban sprawl scenario is not significant. Further work with better data will allow this relative scale of investment in housing to be better understood.

- Public transport infrastructure investment is marginally lower in the case of the compact city scenario. This preliminary result is related firstly by the assumption that there will be investment in mass transit systems in both scenarios. Secondly, the overall difference in levels of investment between the scenarios is driven in the model by the level of investment per zone, with lower density zones requiring greater lengths of mass transit routes, but with lower capacity. Thus the cost per commuter in the urban sprawl scenario is 33% higher than for the compact city scenario, illustrating the relative decrease in benefit for the same amount of investment. Further work on this, with an improved understanding of actual transport systems, will allow this to be better analysed and better explained. However, an important conclusion remains: public transport infrastructure investment is relatively small in relation to the impact it has in relation to reducing the overall recurrent cost of cities, particularly costs incurred by the poor, and making cities more environmentally sustainable.

Observations relating to housing and land

In much of the literature it is assumed that a key driver of the current urban form is the greater affordability and availability of land on the periphery combined with a housing subsidy structure that promotes the lowest capital cost of the product (cf. Biermann and van Ryneveld, 2006). However, the land cost is a small portion of the total cost of the housing product and, with higher density units, this capital cost per unit is further reduced.

In considering the total cost of housing, with land included, the impact of the subsidy framework needs to be considered: in this run of the model, the capital subsidy amount has been assumed to be constant for all housing products. Therefore, for higher cost high density products, the difference is assumed to be borne by the City and the household. As mentioned previously in this paper, this may not, in fact, be viable in reality as low-income households may not be able to afford the difference in cost of acquiring a better located – and more expensive - housing unit in a more compact city. Some further thoughts on the housing subsidy are included below.

If the capital costs of the two development scenarios are almost identical, as the model results suggest, then why has the compact city not developed as a rational response to market forces? Part of the reason lies with incentives for low-income housing development, alluded to above: the subsidy mechanism which remains, primarily, a fixed amount per housing unit, does not favour the development of better located areas of land where costs are higher. With regard to middle and high-income property development there are other considerations of property developers that include the technical, political and bureaucratic difficulty in undertaking infill development, and the economies of scale that are achievable on large tracts of greenfield land on the periphery. Experience of urban growth patterns in post-Apartheid South Africa have made it clear that the urban form is driven largely by capital investment decisions associated with housing developments, and without an intervention to change this, no shift is likely.

Subsidy conclusions

The subsidies that the City Efficiency Costing Model has taken into account comprise:

- Recurrent grant for free basic services (Equitable Share Grant)

- Recurrent grant for public transport (Public Transport Operating Grant)
- Capital grant for housing and land (Integrated Housing and Human Settlements Development Grant – top structure portion only)
- Capital grant for public transport (Public Transport Infrastructure and Systems Grant)
- Capital grant for infrastructure to low-income households (Municipal Infrastructure Grant (Cities), Internal infrastructure portion of the Housing Grant, and the Integrated National Electrification Program Grant)

The way in which these subsidies are currently applied has been assumed to be constant for the 10 year model period. The implications for these grants in the two scenarios are shown in the table below.

Table 15: Summary of state contributions (subsidies) in year 10

	Recurrent (Rm per annum - real)		Capital (Rm per annum - real)*		
	Public transport	Infrastructure	Housing and land	Public transport	Infrastructure
2020 - Urban sprawl	1,527	1,773	580	600	774
2020 - Compact city	1,039	1,795	670	572	668
Difference	-32%	1%	15%	-5%	-14%

In addition, the City is assumed to provide the following contributions, comprising:

- Transport operating subsidies
- Housing and land capital subsidy top-up on national subsidy
- Public transport capital contribution
- Capital investment in infrastructure, including rehabilitation of assets.

Note that the City is shown to make a surplus on infrastructure, but this depends on the level of cross-subsidy in the particular city. The impact of the different growth scenarios on these contributions are shown in Table 16, below.

Table 16: Summary of City contributions in year 10

	Recurrent (Rm per annum - real)		Capital (Rm per annum - real)*		
	Public transport	Infrastructure	Housing and land	Public transport	Infrastructure
2020 - Urban sprawl	141	-1,843	32	175	1,793
2020 - Compact city	85	-1,916	157	170	1,745
Difference	-40%	4%	387%	-3%	-3%

The static subsidy regime that has been assumed is not realistic, and the fiscal responsibility for the different cost components can be shifted between State and City (and households) by changes in policy. For this reason, it is informative to combine the two tables, above, into a single table for overall government contributions for the two scenarios (Table 17).

Table 17: Summary of total government contributions in year 10

	Recurrent (Rm per annum - real)		Capital (Rm per annum - real)*		
	Public transport	Infrastructure	Housing and land	Public transport	Infrastructure
2020 - Urban sprawl	1,668	-69	612	775	2,566
2020 - Compact city	1,124	-122	826	742	2,412
Difference	-33%	75%	35%	-4%	-6%

It can be seen from the above table that for an equivalent capital expenditure on public transport, the compact city scenario requires less transport operating grant, assuming no change in subsidy policy. Recurrent costs are largely covered by households, and the government contribution in this regard is not significant compared with the level of capital investment that will continue to be required. As has been discussed earlier, the compact city would require a 35% increase in contributions from both tiers of government for housing and land to affect a more compact city structure, notwithstanding the additional capital contribution that would be required from low-income households.

With regard to public transport operating subsidies the saving of 33% is substantial. But, this is not to suggest that the level of subsidy should be reduced. As mentioned earlier in this paper the public transport operating subsidy arrangements applied currently are highly inequitable and, most importantly, do not serve to compensate the poorest people who do not benefit from gaining access to well located properties within cities.

Environmental considerations

While the financial benefits of a compact city versus urban sprawl are not extreme, the most significant difference appears to be in the environmental impact, with 22% saving on carbon emissions from transport. In addition, there are other environmental measures, such as loss of agricultural land and biodiversity, which are likely to show even greater environmental benefits from a more compact city

Implications of inefficient cities

This study has sought to determine the financial and economic cost of inefficient land use patterns in South Africa. The City Efficiency Costing Model indicates that in 10 years' time a theoretical South African metro developed in a sprawling spatial form will be marginally more expensive in recurrent and capital cost terms compared with a compact growth pattern. The total cost implication of this is a 7% difference in recurrent costs and a 2.1% difference in capital costs. To draw some conclusions on the national implications for South African cities, it is necessary to extrapolate these conclusions to all 6 South African metros. A ratio of the base year population of the hypothetical city to the total population of all 6 metros was used for this calculation. The total cost difference in year 10 is calculated to be R57 billion, or 1.4% of projected GDP[24](see Figure 18). The total difference (capital and recurrent) over 10 years amounts to R219 billion. It has already been noted that this gap is likely to widen over time, but what shape the projected cost curves shown in Figure 18 will

[24] GDP for 2010 of R2.7 trillion was projected forward to 2020 using the BER long-term economic growth forecast

be is uncertain. Does a sprawling city become more and more inefficient? Or do dense, compact cities become more efficient up to a point and then less efficient due to congestion and lack of land availability? These questions will need to be answered by further research.

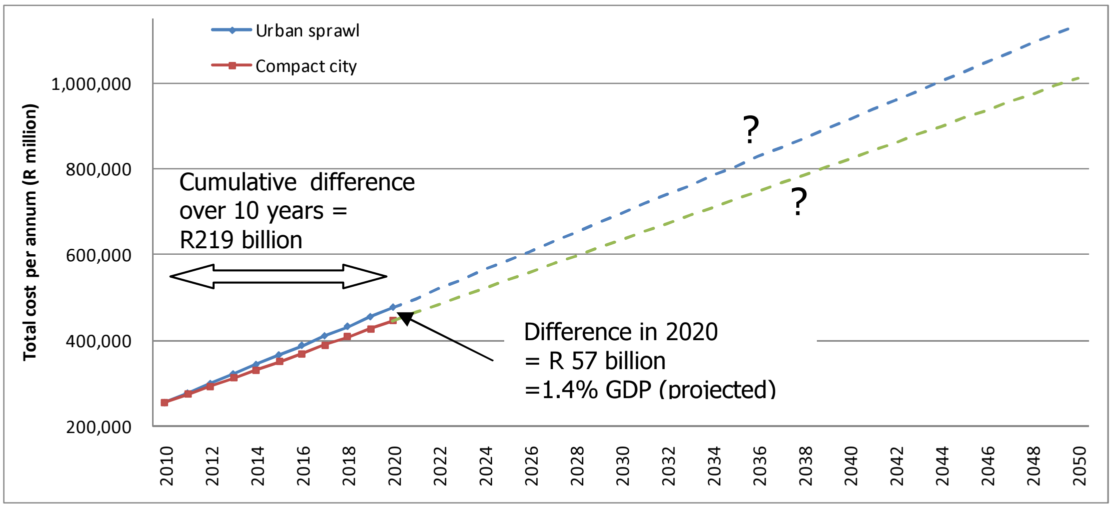

Figure 18: Projected total capital and recurrent costs for 6 South African metros under two growth scenarios

A further implication of an inefficient city is inequality, as the results of this study show that the heaviest impact of urban sprawl will be on low-income households. This is expressed in financial cost terms, and does not take into account the continued spatial, social and economic segregation and marginalisation that is characteristic of South African cities. The compact city model that has been assumed for this study incorporates the economic and spatial integration of the poor through the prioritisation of low-income high-density housing on well-located land.

The most significant implication of pursuing an inefficient spatial growth path is a 55% increase in carbon emissions from transport in 10 years. In a more efficient city, this increase can be reduced by approximately 22%. With States, and even cities, now committing to carbon reduction targets, these targets are likely to be difficult and costly to achieve. Can the cities afford to follow a growth path that results in 22% higher emissions?

What fiscal and financial measures can be put in place to produce a more efficient urban spatial form?

One of the primary mechanisms for altering the efficiency of spatial form through public investment is by investing in public transport infrastructure. This investment not only impacts on the spatial layout of the city through creating movement spines and stimulating development, it also significantly affects the cost of cities. The preliminary results, which are based on actual data, show the scale to which saving on recurrent expenditure in public transport can be realised with a move compact city: a 33% reduction is possible, amounting to some R9 billion a year in recurrent expenditure after 10 years – for a single large city. In proportional terms this has by far the greatest benefit to the poor. If sprawl continues they will have to spend increasing proportions of their household budgets on transport; if the compact city scenario prevails this proportion will reduce.

In order for these benefits to be realised the way the public transport system is subsidised requires urgent attention. On the capital subsidy side the introduction of the Public Transport Infrastructure and Systems (PTIS) grant has been really important. This grant is a necessary intervention, if properly scaled, to promote compact cities. But the current public transport operating grant system does little to incentivise improvements in city structure. An investigation of ways to improve this system is important, but is beyond the scope of this project. However, the model does provide a basis for testing options.

A second means of effecting positive spatial change is through public intervention in the housing market. The findings of this research point to two possible financial instruments to effect this change: higher housing subsidies for higher density developments in specific locations; and incentives for developers to undertake the type of development that generates a compact urban form. With the results from the modelling, one can determine what sort of incentives, including subsidy, the State can offer. However, this is not dealt with in this preliminary application of the model.

A further mechanism that can affect capital investment decisions, but which has not succeeded to date, is tighter regulation on urban development, but this debate falls outside the scope of this report.

Further developments and application of the methodology

The hypothetical city is only a test case for the methodology that has been developed. Two sets of variables have been selected for the scenarios, but any number of these variables can be altered to create alternative scenarios. However, it has proven that the costing methodology produces consistent results and explains the drivers behind the cost of urban development under an alternative of spatial patterns. The results produce some much needed empirical evidence to anchor the debates around city efficiency, including the impact of financial frameworks on spatial form and vice versa. Ideally, the CECM should be applied in the contexts of real cities to aid State and City strategies around making South African cities more efficient and sustainable. Where urban theory has failed to elicit a shift in the inefficient urban form in South Africa, the financial and environmental arguments presented by this methodology may provide a new impetus for change.

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Appendix 1 – Scenario assumptions

	SCENARIO 1 Urban sprawl	SCENARIO 2 Compact city
Densification factors:		
LI informal	1.10	1.20
LI flat	1.05	1.50
LI 3 storey	1.05	1.20
LI semi	1.05	1.20
LI single formal	1.00	1.05
MI flat	1.00	1.50
MI 3 storey	1.00	1.10
MI semi	1.00	1.10
MI single formal	1.00	1.10
HI flat	1.10	1.20
HI 3 storey	1.05	1.20
HI semi	1.05	1.20
HI single formal	1.00	1.10
Vacant	1.00	1.00
% vacant land to use	50%	80%
Order of housing allocation		
1	HI flat	LI flat
2	HI 3 storey	LI 3 storey
3	HI semi	LI semi
4	HI single formal	LI single formal
5	MI flat	MI flat
6	MI 3 storey	MI 3 storey
7	MI semi	MI semi
8	MI single formal	MI single formal
9	LI flat	HI flat
10	LI 3 storey	HI 3 storey
11	LI semi	HI semi
12	LI single formal	HI single formal
Land cost premium	100%	500%
Housing mix		
LI flat	5%	20%
LI 3 storey	5%	30%
LI semi	10%	30%
LI single formal	80%	20%
MI flat	10%	20%
MI 3 storey	15%	20%
MI semi	15%	20%
MI single formal	60%	40%

HI flat	10%	20%
HI 3 storey	15%	20%
HI semi	15%	20%
HI single formal	60%	40%

Reduction in car use	10%	20%
Travel time increase factor	0%	15%
% potential passengers taking mass transit	60%	75%
Split passengers to BRT (vs. rail)	35%	35%