PAPER 6

Estimating the Capital and Operating Costs of Development Proposals in Discouraged Growth Areas

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ABSTRACT

South African city governments bear the lifecycle cost of providing municipal services to customers in outlying locations and expect to recover these costs through rates and tariffs to cover the operating costs, and development charges to cover the capital costs of bulk and connector infrastructure. Significant variation in actual costs across geographic space suggests a distortion in the urban land market and an allocatively inefficient spatial outcome. This paper explores the policy and regulatory instruments available to metropolitan municipalities to mitigate against such distortions. It introduces a spatial costing method to enable municipal decision-makers to evaluate the capital and operating cost of a given property development proposed in a peripheral location; that is, beyond the reach of existing infrastructure master plans. By applying this method to Cape Town's Discouraged Growth Area, we find that it is possible to estimate actual costs accruing to the municipality in a rational, defensible and administratively simple way, using the city's own spatial and expenditure data.

INTRODUCTION

Urban scholars describe the persistence of dispersive residential growth as symptomatic of an underlying market failure in the urban land market; that is, the actual cost of peripheral development is not fully internalised into its pricing (Brueckner 2000). The 'hidden cost' of peripheral development frequently invoked by 'compact city' advocates are generally expressed in normative-ideological rather than quantitative terms (Davies and Imbroscio 2010), with a focus on environmental and social-, rather than fiscal-, impacts. Consequently, the semantic distance between, on the one hand, the widely accepted normative argument against peripheral growth, and, on the other, the circumscribed and sector-specific set of factors considered by city engineers and budget officials, has to date inhibited metros' ability to quantify and remedy these distortions dispassionately by means of credible quantitative methods.

Having adopted a fiscal lens to the question of the true cost of peripheral growth in South African cities, we firstly observe that tariffs and development charges intended to recover the cost of providing infrastructure and services are fixed, irrespective of the actual cost of providing services to the customer. Planners tasked with adjudicating development applications in conflict with long term spatial plans are precluded from considering lifecycle infrastructure costs in their determination of the desirability of the development. Were it possible to credibly show significant variation in actual costs of providing municipal services across geographic space, it stands to reason that fixed (i.e., spatially neutral) tariffs and development charges necessarily distort the efficient operation of the urban land market. Spatially variable actual costs are not being internalised in the location decision of developers, and ultimately, the purchase and tariffs born by homebuyers.

If geographic variation of costs is shown to be significant, it would imply that landowners in high-cost areas are effectively being subsidised by those in low-cost areas. The cost advantage enjoyed by users of land in high-cost area stimulates peripheral development beyond an allocatively efficient spatial outcome: that is, where the full marginal cost of a housing unit borne by the homebuyer, the developer and the municipal pool of landowners exceeds the marginal benefit of that unit to the homebuyer.

Introducing a systematic and data-driven spatial tool to estimate geographic variation in the cost of providing municipal services on explicitly fiscal grounds, using readily available spatial and financial data, may be a first step towards closing the distance between spatial planners, budget officials and engineers.

POSITIONING THE INSTRUMENT

Before introducing a spatial costing method, we first take stock of the legislative and regulatory instruments available to metro governments to remedy such land market distortions, were they shown to be significant. In this section we do a brief review of (1) the legislative imperative for cities to promote spatial sustainability and efficiency, (2) issues of a technical and practical nature to consider, and (3) identifying three instrument options accommodated within existing legal and policy frameworks.

1.1 Legislative rationale

The Spatial Planning and Land Use Management Act (Republic of South Africa 2013) establishes a number of principles governing land use management in South African municipalities: first, the principle of spatial sustainability (s7[b]), (iv) requires the promotion of effective and equitable land markets, and (v) the consideration of all current and future costs to all parties for the provision of infrastructure and social services in land developments, and (vi) the promotion of land development in locations that are sustainable and limit urban sprawl. Second, the principle of efficiency (s7[c]), whereby (i) land development optimises existing infrastructure, (ii) and decision-making procedures are designed to minimise negative financial, social, economic or environmental impacts.

FIGURE 1: Growth management instruments

To enact the principle of spatial sustainability, South African cities have generally relied on the urban edge as a relatively simple growth management tool to protect high potential agricultural land, raise the effective cost of peripheral development through constraining the supply of land, and create certainty for technical planning. However, in her survey of three South African metros, Horn finds evidence of disregard for urban edge policies, with the spatial logic of urban development directed by ad hoc public and private housing development applications rather than formally adopted planning policy (2019). The implied shift from a regional to a case-by-case approach to land use decision making tilts the emphasis from regional environmental and social factors towards development-specific and developer-calculated economic benefits and the number of housing units provided (Horn 2019).

This shift in approach culminated in Cape Town replacing its urban edge with a new instrument in 2017; such that all unprotected developable land beyond its erstwhile urban growth is designated as a "Discouraged Growth Area" (City of Cape Town 2018:6), where both capital and operating costs associated with the development will be borne directly by the developer, in the form of on-site provision and maintenance, or through administered fees which are reflective of actual development costs given the type and location of a given development. These administered fees may include, inter alia, development contributions or spatially differentiated tariffs and rates. Whilst these provisions are available to reduce fiscal impacts associated with unplanned growth, the municipality had not developed a method or tool to quantify fiscal implications of development proposals.

1.2 Technical considerations

The key technical question which arose is how to correctly estimate actual costs and incorporate this evidence into the initial development decision.

Simple instruments (e.g. an urban edge) are cheaper and less burdensome to administer, easier to 'explain to a judge', and creates certainty for both city officials and developers. An urban edge serves to trigger a number of additional controls by virtue of a proposed development's application, placing the onus of the applicant to demonstrate desirability in terms of site-specific circumstances. Judiciously implemented, an urban edge in principle and by design should achieve cost efficiencies by preventing unplanned, leapfrog development.

However, the strength of its rationale begins to falter at site-level. It becomes assailable for being arbitrarily delineated and out-of-touch with the demands of the property market and the economy more broadly. When assessed as a remedy for land market failure, an urban edge is an untargeted, undifferentiated binary instrument.

When intervening in complex systems such as cities, instruments designed on the basis of stylised 'rules of thumb' rather than nuanced and evidence-based understanding of the causal processes driving urban development are much more likely to generate unintended consequences and perverse incentives.

On the other end of the spectrum, actual costs associated with a given development can be estimated on a case-by-case basis by engineers using a range of sector-specific models. However, this will impose significant costs on either the developer or the local authority where a degree of preliminary or detailed design is needed to properly calculate the costs of service provision. If conducted by the developer, the city official will have little control over the underlying assumptions informing the cost estimation, or the range of factors being considered. Unless the city official can provide a template for such calculations which cover all municipal services and include both capital and operating costs, developer-driven estimates may result incorrect or inconsistent results.

The middle ground between the aforementioned simple instrument, and a detailed case-by-case costing study, is a multi-sector, spatially-sensitive cost estimation method which relies on a set of explicit assumptions and calculation techniques. An overly sophisticated method requires significant and ongoing technical capacity and data to set up and maintain, can be prone to estimation error and thus vulnerable to legal challenges and may generate ambiguous signals to officials and property markets. Thus, striking the balance between accuracy and practicality should be informed by (1) the threshold of accuracy required by law and policy, (2) the availability and reliability of spatially disaggregated expenditure data, and (3) the extent to which costs can be reliably estimated given the nature of bulk engineering service provision and the operations and maintenance of the infrastructure.

1.3 Legal mechanisms

A second important dimension in positioning the instrument is its interface with the land use decision making process. There is more than one possible point of entry with regards to applying the outputs of an envisaged spatial costing tool to the land use decision-making and condition-setting process. These may be broadly categorised into 'direct' and 'indirect' mechanisms:

1. <u>Direct application of the spatial costing tool as a fee-setting mechanism</u>, including (1) setting development contributions on the basis of anticipated actual capital costs, directly influencing the developer decision; (2) applying surcharges to rates and/or tariffs on an ongoing basis to recover the actual operating cost of providing services to end-users;
2. <u>Indirect application of the spatial costing tool as a guide to planning decisions</u>, including (1) as a source of evidence to inform the assessment of desirability, specifically to strengthen to argument for refusal; and (2) as the basis upon which to specify conditions for approval, including but not limited to maintenance guarantees and the establishment of homeowners' associations.

1.3.1 Spatial costing tool as a capital cost recovery mechanism

'Impact fees' are a common means to recover capital costs associated with development. Development charges ('DCs') is a local variant of impact fees. In South Africa, city policy typically provides that DCs can be increased on a geographical scale to recover costs more accurately within specific impact zones, although this is not currently being applied.

Actual costs can be calculated on a case-by-case basis where exceptional circumstances exist, such as an unprecedented scale of a development and where there is exceptional dependence or independence from municipal engineering services. However, DCs cannot be used for the purpose of achieving spatial planning or economic development objectives, and DCs should be administratively simple and transparent (City of Cape Town 2014).

1.3.2 Spatial costing tool as an operating cost recovery mechanism

Spatially differentiated tariffs internalise the true cost of providing services to prospective end users, thus enhancing citywide economic and resource efficiency by depressing the demand for development in higher cost areas. They are also more equitable and aligned to the cost of service principle, as they better account for variation in customer contributions, and reduce cross subsidies to high-cost customers. However, arguments against spatially differentiated tariffs are that they (1) raise administrative costs, (2) reduce the affordability of services for customers in some areas, (3) encourage off-grid options, and (4) undermine customer equity on a regional basis.

In South Africa, operating costs are nominally recovered through two mechanisms, property rates and tariffs. Property rates are governed by the Municipal Property Rates Act ('MPRA'), which states categorically that it is impermissible to differentiate rates on any criteria except land use categories and market value (S19), with the exception of Special Ratings Areas ('SRAs'), that allow for the levying of additional rates for the purpose of improving that area, and are thus are not suited to be applied as a mechanism for recovery of operating costs through differentiated property rates.

Tariffs are governed by the Municipal Systems Act (Republic of South Africa 2000), which empowers municipalities to establish internal municipal service districts ('IMSDs'), (S85) where municipalities may set tariffs, levies, special surcharges or increase tariffs (S85[3]). However, IMSDs must balance development needs, promote the citywide economy, contribute to integration and not entrench disparity. It may therefore be argued that the establishment of IMSDs, in furtherance of spatially differentiated operating cost recovery, is ostensibly reconcilable with governing legislation.

1.3.3 Spatial costing tool as a guide to planning decisions

Municipalities may adopt guidelines to guide decision-making in respect of applications made in terms of their Municipal Planning By-Law. Of the various criteria given for determining desirability (s99), the spatial costing tool may conceivably provide information with regards to (1) socio-economic impact, (2) impact on external engineering services, (3) impact on safety, health and wellbeing, (4) biophysical environment, and (5) transport impacts (City of Cape Town 2015). These metrics may be considered alongside motivations for site specific exemptions, and all other relevant spatial informants.

TABLE 1: Measuring desirability (Source: City of Cape Town Municipal Planning By-Law 2015)

Desirability criteria	Desirability metrics
Socio-economic impact	• Bulk capital cost / service / EDU
Impact on external engineering services	• Operating cost / service / EDU
Impact on safety, health and wellbeing	• Distance to social facilities
Impact on biophysical environment	• Distance to emergency services
Transport impacts, parking, access	• Transport-related emissions

(HOW) DO COSTS VARY IN SPACE?

The motivation for developing a spatial costing tool is underpinned by three core assumptions, which will be interrogated in this section: (a) actual costs vary in space; (b) costs in peripheral locations are greater than in other areas of the city; and (c) it is technically possible to calculate actual costs with a reasonable degree of accuracy. In examining these technical questions, it is important to differentiate between capital and operating costs. This section will discuss the costing methodology that has been applied.

1.4 Capital costs

The capital cost of infrastructure varies according to the capacity of the infrastructure (such as the size of the pipeline, or the carrying capacity of the road) and the extent of the infrastructure (i.e. its length). In order to calculate capital cost factors, we applied the concept of an Equivalent Development Unit ('EDU') as a standardised unit of demand – equivalent to a low-middle income dwelling unit. The use of standardised units of demand controls for the effect of infrastructure capacity on cost, resulting in cost variation determined solely by the extension to infrastructure required to service the EDU (i.e. through connector or link infrastructure). The location of the proposed development should be known in relation to (a) the distance to the bulk water network, (b) the distance to the bulk sewer network, (c) the distance to the medium voltage electricity network, (d) the distance to the primary road network, and (e) the distance to the nearest landfill or solid waste transfer station.

The richest sources of empirical findings with regard to actual capital costs across space in Cape Town are the Cape Town Growth Options study (City of Cape Town 2012) and the Medium-Term Infrastructure Investment Framework (City of Cape Town 2017), which found that the main determinant of geographic variation in capital costs is the extent to which scale efficiencies have been realised by the magnitude of development within a given network or service district. In other words, capital cost efficiencies are chiefly realised through orderly growth within predefined catchments, because of the ability to correctly plan, size and phase, and thus fully utilise – bulk and connector infrastructure. Accordingly, ad hoc and unanticipated patterns of development are significantly more costly than incremental, contiguous and planned growth. Since the rate of development within a given catchment is central to the estimation of capital costs, the latter cannot be systematically and accurately estimated in the absence of a credible 20-year land use model and high level master plan. It may only be assumed that large out-of-sequence development is likely to have disproportionately high capital cost implications. It is therefore recommended that in these cases, capital costs are estimated on a case-by-case basis, closely guided and monitored by planning officials.

Table 2 shows the different bulk and connector factors and data sources that were considered when calculating the capital costs. Note that for the bulk systems, the DC's for these services had already been calculated.

1.5 Operating costs

The conceptual framework that was applied to the operating cost allocation assumes that only a portion of operating costs vary in space. The portion of costs that are spatially neutral are either determined by the number of customers on the service (called 'fixed costs' because these costs are spread among existing and future customers) or by the quantity of the service provided (called 'demand-driven costs' as these will vary directly with the quantity of the service delivered). Spatially variable costs are also divided into those that are determined by the location of where the service is provided (called 'unit driven costs'), or by

TABLE 2: Capital cost factors

	Connector infrastructure	Bulk infrastructure
Water	DGA broken into 6 zones. Added bulk pipelines, servitude, storage and pumping if required.	Water DC + marginal cost of additional capacity, if required
Sanitation	Spatial distance and elevation analysis to determine most efficient path for infrastructure to bulk network. Added gravity and rising main costs, servitude and pumping where necessary.	Sewer DC + marginal cost of additional capacity, if required
Electricity	Capacity and distance variable cost according to CCT calculator includes feeder bays, customer site building, site switchgear, and 11kV cabling.	Shared Network Charge depending on Eskom or City area
Roads	Distance to main road network multiplied by standard unit cost.	Roads DC
Stormwater	Not possible to determine at coarse scale + policy to detain stormwater on site.	Stormwater DC
Solid waste	Threshold used to determine transfer station requirement.	Waste DC

the quantity of the service that is provided in a particular location (called 'demand-driven costs').

The four cost groupings are therefore called:
(1) spatially variable demand-driven costs,
(2) spatially variable unit-driven costs,
(3) spatially neutral demand-driven costs, and
(4) spatially neutral fixed costs.

The spatial unit of analysis of spatial variation and output of the operating cost modelling is an EDU, which is located at a point in space and has a service demand profile associated with it. The unit of analysis of the existing cost data is the service district (the size of which varies by service). The entire service district budget is included in the analysis, as this represents the real expenditure in providing the service which is the basis that the tariffs are set on.

It is important to note that this actual expenditure does not necessarily represent the cost of providing an adequate level of service, but only the actual expenditure incurred to maintain the current level of service.

The concept and resulting methodology was applied to roads, stormwater, water, sanitation, electricity and solid waste. Public transport operating costs are inherently spatial in nature and have been calculated based on modelled modal splits and trip distances, rather than on the methodology described below. Municipal public services and provincial social services have not been included in the analysis because the impact of space on these services is unclear, given that different levels of services are provided at different spatial scales, and the operating costs are determined more by the number of each facility that is provided, rather than their spatial location.

1.5.1 Calculating spatial drivers of operating costs

The methodology to calculate the operating cost drivers is described below:

Identify operating cost drivers (step one)

The cost drivers are the factors that affect the costs of delivering a service. These are generally well known to line departments that are responsible for the delivery of the service. These costs can be spatially variable or fixed. The factors should be reduced to a single proxy indicator for which city wide spatial data could be obtained. For example, the mean slope of the area is taken as a proxy for the amount of pumping required to get wastewater and stormwater to the treatment works and stormwater outfalls respectively.

Once identified, the range of relative impact of each spatial cost driver on total cost should be estimated by officials and external professionals, which should be the starting point for the iterative analysis (step three).

The cost drivers considered for each service are shown in Table 3 below.

Analyse actual expenditure per district (step two)

The only quantitative evidence for spatial variation in operating cost is the actual expenditure incurred by line departments in different locations in the city. The only spatially referenced expenditure is that which is recorded against the various districts for each service. This data source is limited in the following ways: (a) not all expenditure is recorded against the spatially located cost centres – some cost centres are centralised, but expenditure is dispersed differentially throughout the city; (b) districts are relatively large with wide variations in spatial characteristics; and (c) expenditure is not equal to the actual cost of providing a proper level of service, as operating budgets are inevitably constrained.

The simplifying assumption is that all areas are underfunded equally, which enables the determination of spatial variation despite under funding; (d) district expenditure is determined by the budgets made available, which may be determined in a range of different ways, which may include historical reasons, or differing operating practices of the district managers, which are unrelated to spatial characteristics of the districts. While this issue is recognised, it has to be assumed that the district expenditure is generally related to the cost of providing the service in that district and has been revised over time to be equitable across the city.

While acknowledging the above limitations, district expenditure is the best data available and is used as a starting point to test the impact of each of the cost drivers. Detailed actual operating expenditure for the most recent financial year should be obtained for all the services, and each line item categorised according to the conceptual framework categorisation.

Spatially neutral fixed costs for the entire municipal service are divided by the number of customers in the city to derive a unit cost (R/unit), while spatially neutral demand-driven costs are divided by the total amount of the service provided in that financial year to obtain a unit cost (R/unit demand). Spatially variable demand-driven costs are divided by the

TABLE 3: Spatial drivers of operating costs, per service

		Water	Waste water	Electricity	Solid waste	Roads	Storm-water
Spatially neutral	Service level	X	X	X	X		
	Land use	X	X	X	X	X	X
	Density	X	X	X		X	X
Spatially variable, unit-driven	Distance to depot/landfill	X	X		X	X	X
	Age of fixed infrastructure	X	X	X		X	
	Intensity of land use	X	X	X	X	X	
	Mean slope		X				X
	Extent of infrastructure			X			X
	Bursts / blockages	X	X				
	Outsourced service provision				X		
	% Vacant erven adjacent to service			X			
Spatially variable, demand-driven	Elevation	X					
	Mean slope		X				

amount of the service consumed in each of the relevant spatial zones to obtain a unit cost (R/unit demand per area).

The calculation of the spatially variable unit-driven unit costs is the result of a further step described below.

Calibrate cost factors to match actual spatial variation in expenditure (step three)

This is the most complex of the steps in the methodology and has four sub-steps:

1. Calculate the total spatially variable unit-driven operating cost per district. Line items in operating budgets that are classified as spatially variable unit-driven costs and allocated to a district (or depot within a district) are summed to obtain a district total;
2. Gather spatial data to populate zonal attributes for each existing transport zone which encompass the existing built fabric. Spatial data can sourced from the city, or derived by performing spatial queries on the city's spatial data using GIS software;
3. Multiply the assumed spatial cost factor for each spatial cost driver by the spatial characteristics of each and the number of units in each transport zone to generate a theoretical cost per district. The initial estimates of the impact of each cost driver are used to initialise the iterative process. An assumed base unit cost (R/unit/year) is multiplied by a land use factor, and then by the product of all the spatial factors for a particular transport zone to obtain a spatially variable unit cost per land use for that zone. This is multiplied by the current number of units of each land use to obtain a total operating cost per transport zone. The operating costs of all transport zones within a district are summed to get a theoretical (modelled) cost for that district which could be compared with the actual costs;
4. Calibrate the cost factors within the permissible range to match the actual district expenditure as far as possible. Once the possible range of each of the spatial cost factors is defined, Microsoft's Solver function is used to vary each spatial cost factor to solve for the lowest variance between the modelled and actual costs per district. The Solver function uses a Generalised Reduced Gradient algorithm for this process, resulting in a regression analysis solving for a minimum sum of least squares of the difference between the modelled and actual expenditure. Once the optimum solution is obtained, variances between the modelled and actual district costs will still be observed, but these variances are deemed acceptable given the constraints to the district data methodology described above.

Using this method, we found that the extent to which operating costs vary in space depends largely on the type of service. Whereas over 90% of stormwater-related operating costs are spatially variable, over 90% of electricity-related operating costs are spatially neutral. In general, however, operating and maintenance costs per EDU may be determined in part on the basis of proximity-based and location specific (e.g. topographic) attributes. Therefore, it is technically possible to estimate operating and maintenance costs across space, even in absence of master plans, but for some services, the benefits associated with introducing spatially differentiated operating cost recovery may be too marginal to justify the costs associated with differentiated fee-setting.

Preparation of cost surface for peripheral study area (step four)

A grid cell of zonal attributes covering the peripheral study area is required in order to calibrate actual expenditure to spatial factors. The first step is the delineation of developable land beyond the city's growth boundaries into regular spatial units. In the case of Cape Town, a grid of 1x1km (100ha) cells is created using GIS software. Zonal attributes that impact on capital and operating costs are calculated, using cell centroids for spatial queries.

All spatial queries are performed using a combination of open source QGIS3 tools, including Raster Terrain Analysis, Point Sampling, QNEAT3 Pointcloud, Distance Matrix, Distance-to-Nearest-Hub and QChainage.

The table of attributes and corresponding data and methods used, are provided in Table 4 below.

Once calculated, these values are generalised to the grid cell. In other words, the entire cell assumes the attributes of the centroid of the cell. Where it is found that a connection from cell A's centroid to an adjacent cell B's centroid is less expensive than direct connection to bulk or road network, it is connected to the neighbour instead.

Apply unit costs to peripheral study area (step five)

Actual operating and capital cost factors calculated for each service within the existing urban area are transposed to the zonal attributes calculated for each grid cell in the peripheral study area, to arrive at an operating and capital cost surface. Once this has been created, it is possible to estimate the capital and operating lifecycle costs for a notional development in any developable, peripheral location.

TABLE 4: Table of spatial cost factors to be calculated per grid cell

Type	Attributes	Spatial data	Spatial method
Terrain	• Slope, ruggedness, and elevation	• Digital elevation model	• QGIS3 Raster Terrain Analysis plugin • QGIS3 Point Sampling Tool plugin (to extract elevation from DEM)
Network distance	• Depots, public transport hubs and landfills	• Facility point data • Road network (class 1-3 only)	• QGIS3 QNEAT3 Pointcloud • QGIS3 Distance Matrix
Straight line distance	• Nearest higher order roads, water treatment works, bulk water mains, electricity substation and gravity sewer	• Facility point data • Bulk water reticulation (where diameter >300mm and <1000mm).	• QGIS3 Distance-to-Nearest-Hub (Points) • QGIS3 Point Sampling Tool (to extract elevation from DEM) • QGIS3 QChainage – create vertices every 1km along line, and calculate elevation per vertex
Conditional paths	• Of which rising main, landfill or refuse transfer station	• Digital elevation model • Facility point data	
Vertical distance along path	• Bulk main or wastewater treatment works	• Digital elevation mode • Facility point data • Network line data	
Catchment data	• Electricity authority	• Electricity catchment data	• QGIS3 Join attribute by location

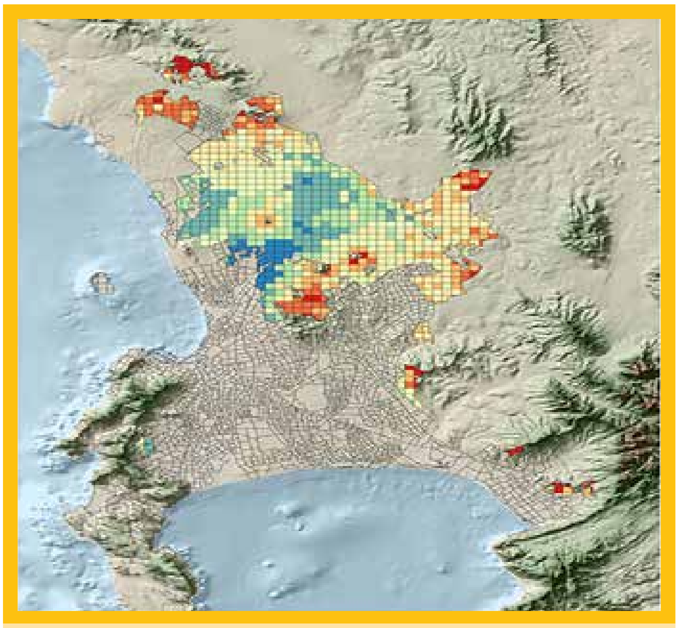

FIGURE 2: Operating cost surface (to City)

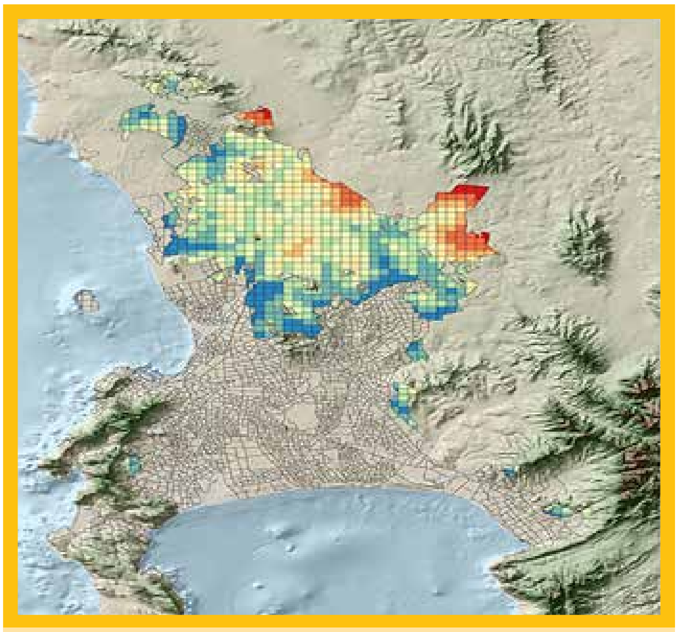

FIGURE 3: Capital cost surface (to developer)

MODEL OUTPUTS

1.6 Operating and capital cost surfaces for notional development

The map on the left shows geographic variation in operating costs for a notional development, accruing to the city. The range of operating cost differences within the Discouraged Growth Area is fairly small, varying by approximately 10% chiefly due to water pumping costs and distance to existing connector infrastructure.

On the right, the map shows geographic variation in capital costs for a notional development, accruing to the developer. The range of geographic variation within the Discouraged Growth Area is comparable to the city as a whole. The highest cost location is between five and six times more expensive than the least cost location, for an identical development. By applying a notional development (with given land use characteristics) to the cost surface, it is possible to generate the Net Present Value of (a) operating cost to the City, (b) capital cost to the City, (c) revenue to the City, (d) net financial position to the City and (e) capital cost to the Developer.

1.7 Assumptions

The spatial costing method and the corresponding results are contingent upon the following assumptions: (a) all developments are calculated in isolation (i.e. no cumulative effects are considered); (b) costs are based on the infrastructure layout as per the baseline year, (c) new bulk infrastructure are calculated at marginal cost based on development demand; (d) notional future developments are assumed to connect to the City network, except for sanitation capital costs which are capped at the equivalent cost of tankering septic tank waste to a given location. Package plants for water and sanitation are assumed to be unacceptable, and all new developments are assumed to become the City's electricity customers; and (e) public transport costs are excluded due to inadequate trip generation data.

CONCLUSION

In this article we describe a spatial costing method to estimate the capital and operating costs of a notional property development located in a peripheral area beyond the reach of infrastructure master plans. Although the method abstracts from some aspects of reality, it strikes an appropriate balance between accuracy and practicality, using spatial and expenditure data readily available in most South African cities.

The article highlights the potential for evidence-based tools to support cities' ability to evaluate land use applications in conflict with its structure plans, and as a credible evidence base to motivate for and spatially target the establishment of internal municipal service districts which reflect geographic variation of actual operating costs associated with providing municipal services. On the capital cost front, the analysis also highlights the likely gap between undifferentiated development charges unit costs and actual capital costs. Finally, the article highlights the importance of cities taking a clear policy position on the question of off-grid infrastructure.

We find that metro governments will derive efficiency benefits from coupling efforts to enhance data-driven decision-making capacity with ongoing refinements to the setting of tariffs and the adjudication of peripheral land development applications.

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