Smart facility location planning for Smart Cities: Using GIS technology and facility provision standards for pro-active planning of social facilities to support smart growth

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Submission to: Preparing for Smart Cities- Concept Planning Governance
Civics BRICS Conference 2016
17-19 August 2016 Jaipur, India

Session 5: Resource Mobilisation and Capacity Building- Finance and Human Resources

Abstract: *This paper describes a rational approach to the planning of social facility provision to eradicate service backlogs of the current period as well as preparing for the future. For more than a decade a GIS based methodology has been used in South Africa to assess and plan for the provision of social facilities and to provide input to integrated social facility development plans which are not only defensible but enable smart decision making that impacts meaningfully on investment priorities. This enables the greatest impact from the least number of investment locations to maximise return on investment. To support this work the CSIR has consolidated, refined and adjusted guideline standards that not only specify a provision ratio for each facility but also define a specific distance that should be used to measure accessibility in different contexts. Planning and implementation flowing from this occurs in an environment full of pressures relating to insufficient resources to deal with the quantum of the development challenge, competing political and administrative priorities, and critical skills shortages. While not initially driven from a Smart City perspective and currently not enabled by real time data, the approach can, nonetheless, be seen as a major step toward "smart" planning processes to support smart cities of the future. A case study application in Cape Town is used to illustrate the application of the methodology of spatially matching supply and demand for facilities using GIS tools. These tools make use of guideline provision standards that combine both distance and capacity as an input to the models to achieve spatial alignment of new facility provision investment that can respond timeously to city growth. To date this analysis approach has been used to inform planning for capital budget processes in a number of cities to improve service access that impacts 28% of the South African population.*

Keywords: accessibility modelling, GIS facility planning

1. INTRODUCTION

1.1 Overview

The concept of smart cities has been taken up by many city leaders, Information Technology (IT) companies and scholars worldwide leading to a flurry of publications in recent years.

According to Geertman et al. (2015) there are two main discourses that can be traced to the origins of the concept of smart cities. The one discourse relates to the 'smart growth' of cities in order for cities to be environmentally and financially sustainable. This discourse developed in response to the development sprawl of cities due to private vehicle transport. The second discourse focuses on how Information Communication Technologies (ICT) can contribute to the more efficient planning and management of cities. Caraglui et al. (2011, p66) combines the two discourses in their definition by stating that smart cities emerge "when investments in human and social capital and traditional (transport) and modern (ICTs) communication infrastructure fuel sustainable economic growth and high quality of life, with a wise management of natural resources, through participatory governance".

Geertman (2006) defines Planning Support Systems (PSS) as geo-information technology-based instruments that are dedicated to supporting those involved in planning in the performance of their specific planning tasks. In the publication Planning Support Systems and Smart Cities (Geertman et al., 2015), PSS are put forward as providing an approach or environment where ICT is combined with geo-spatial analysis capabilities to provide smart planning support solutions to inform and guide, amongst others, the sustainable development and management of cities.

The social facility planning work done by the CSIR falls within the scholarly and professional field of PSS. The approach also has sustainability (from a cost point of view) as a key aspect in its outcomes and it uses information technology and digital communication in the process of doing so. The information that feeds into the system when doing the accessibility analysis cannot yet be defined as "smart" per se as it is not yet live or dynamic in the true sense of smart ICT systems. It is, however, something which may become more relevant and viable moving into the future in continuing with this work. The approach can, nonetheless be seen as a major step toward "Smart" planning processes to support smart cities of the future.

The use of social facility provision norms and standards, applied using advanced computer based GIS analysis and following the Service Access Planning approach developed by the CSIR has been a significant contributor to an effective and integrated means of identifying and eradicating social facility backlogs and ensuring that the cities of the future are better planned and provided with the necessary social facilities, as well as developing defensible and equitable facility investment plans in post-apartheid South Africa. It has provided a transparent platform for decision making that ensures that new facilities are constructed in locations which have the greatest impact. The approach and tools enable clear prioritisation in an environment of competing priorities and insufficient resources to help planners make informed decisions. Furthermore, this feeds directly into the recent initiative from the National Department of Treasury to improve built environment performance by spatial targeting of investment through the introduction of Built Environment Performance Plans (BEPP) that encourage densifications along key transport corridors, more efficient use of land and infrastructure and greater co-ordination of development within our cities (Van Niekerk, 2013).

This paper describes how access norms, that uniqely define both capacity provision ratios and access distance for different contexts, can achieve equitable facility provision for social services, in a just and co-operative manner, through the application of accessibility analysis modelling as customised by the CSIR. This contributes to human capacity building by means of evidence based planning.

South African city and national government authorities are faced with the daunting task of

providing services to all communities within their jurisdiction in a fair, equitable and sustainable manner. Outcome 12 of the Government Programme of Action specifically requires government departments to develop geographic access norms and set targets for minimising the distances people have to travel to reach services where appropriate (The Presidency, 2012).

The approach to accessibility analysis being used by the CSIR has over the past 15 years successfully assisted various metropolitan and national government departments in testing and refining their geographic access norms in the process of conducting facility accessibility audits. A key aspect of the approach is the development of integrated facility plans within and across different government departments within the same city. This integrated approach promotes city building though the creation and development of key nodes of multi-facility service provision clusters. The approach is unbiased and is based on spatial evidence to establish the most appropriate location for new investment to serve the most people in a spatially equitable manner based on current or future population distibution patterns.

These tools and approach enable a spatial assessment of backlogs and planning of new social facility provision which support cities in making smarter decisions that are defensible and impact meaningfully with respect to available resource allocation. To date this analysis approach has been used in four major metros (namely Cape Town, eThekwini, Johannesburg and Tshwane) where the outcomes have already been used for capital budget processes, the development of Integrated Development Plans and also to measure outcomes with respect to improving service access to services. This research and implementation has already impacted on social facility investment planning for over 14 million citizens (28% of South Africa's population). The projects aim to develop sustainable, integrated and rational social facility capital investment plans which enable the development of Smart Cities that timeously respond to city growth and the needs of citizens.

This approach will be illustrated by mainly making reference to a case study in the Cape Town metropolitan area which can be considered as 'best practice'. The rest of the paper discusses the developmental issues of South Africa, followed by a short impression of some of the BRICS countries with respect to social facility planning and standards. The next section discusses the Cape Town case study and ends with a conclusion and future considerations.

1.2 Developmental issues in the South African city

Prior to the establishment of a majority democratic government in South Africa in 1994, facility provision was often subject to variations in investment policy based on different implementation agencies, racial policies and the un-coordinated development and planning of facilities by different organs of state, as well as an avoidance of mixed use planning. This was exacerbated by the neighbourhood planning approach of the day which embedded facilities within neighbourhoods – making sharing difficult across areas – and facility numbers were based on a blue-print approach to facility provision standards. In many instances, provision was based on what can be called a "silo approach". This approach not only looked at each facility type in isolation but also considered the number of facilities per administrative unit, irrespective of population need or distribution within the unit. As a result, facilities were poorly located and unequally distributed. Some areas were well provisioned, while in others

there was under-provision or a gross over-supply of certain facilities. Often facilities were poorly located with respect to the broader community and the transport network.

Political changes in 1994 coincided with a new approach to planning which did away with the top-down approach to planning in favour of greater community involvement and a community-led needs approach. The new Constitution also guarantees all communities certain basic services – such as health, education and water – and this implies that communities must be able to reach such services to receive a minimum service level. It is a legislated requirement that local authorities in South Africa prepare Integrated Development Plans (IDPs) and develop performance management systems that promote development and deliver services that are accessible. The community needs driven approach did not necessarily lead to a more equitable provision of facilities and at that time little or no consideration was overtly given to standards and the technical evaluation of needs. In fact, a normative approach to planning was considered outdated in academic circles. The outcome was that in many instances those with the greater voice were able to influence investment decisions and the establishment of new facilities was sometimes used to win political votes or favour, or to avoid being seen as 'obstructing the will of the people'. The influence of the ward councillor and the needs of the ward or administrative unit became key factors in the planning process. This was problematic for achieving equitable service provision as often the wards and other sectoral administrative units:

- are unequal in area;
- are unequal in population;
- do not have a homogenous or common land use; and
- the boundaries of wards are changed from time to time.

Additionally, in the absence of any agreed future development plan for facilities or direction of growth, various bodies including national departments, foreign donors and NGOs often built facilities at locations that were not optimal in serving a wider community nor contributed to growth nodes, often leading to a mismatch in supply and demand.

For planners to play a significant role in shaping the future of South African cities and to redress the imbalances in facility provision, new ways of planning that are defensible and transparent are required to evaluate the social facility needs of all communities in municipal areas. This is especially critical in an environment with limited resources to address facility backlogs and at the same time build new facilities to meet the future development needs of a city.

1.3 Social Facility planning standards and approaches in other BRICS countries

The assessment of planning standards in BRICS countries is very superficial since the literature is limited or highly sectoral. It has not been possible to find similar standards to those published by the CSIR; namely, CSIR Guidelines for the Provisions of Social Facilities in South African Settlements. August 2012: ISBN 978-0-7988-5603-4 (Green, CA & Argue, TC. 2012) available at http://www.csir.co.za/Built_environment/pdfs/CSIR_Guidelines.pdf. This guideline document outlines both capacity threshold and access distance per facility for over 30 facility types ranging from schools and clinics, through to cemeteries and sports facilities.

In February 2016, China's State Council released a new set of urban development guidelines which aims to produce a framework to revitalize China's Cities (Shepard and Huang, 2016).

The guidelines' main aim is to stem sprawling car-dependent development, but also to improve navigability, provide better access to commercial and public areas and promote less resource intensive cities. These new guidelines apply the principles of sustainable urban development and bring several areas into focus, namely denser street networks, enforced urban growth boundaries, the increased prevalence of public transport and expanding mixed development. The latter specifically notes the objective of improved access to a diverse range of public and commercial amenities including schools, supermarkets, retirement centres, hospitals, parks and cultural centres. These principles are similar to principles used in South Africa for guiding social facility planning.

In India, the Urban and Regional Development Plan Formulation and Implementation Guidelines (Mott MacDonald, 2014) also speaks to accessibility, however, no measurable facility access criteria has been identified in the report although a proportional allocation of land per land use type is noted (Mott MacDonald, 2014, pp218-220). In South Africa there has been a move away from proportional allocations of land to rather using a specific population ratio per facility. The latter better accounts for settlement density and the number of people likely to use a specific facility. The Urban Planning Standards for Athani Town (India) does provide population ratios per facility unit as well as the land area required; however, no measurable access distance parameters are defined. It is noted that in general accessibility and percentage of land areas for social facilities and green spaces is considered as important (Shankaraling, 2014).

Comparative analyses of facility provision and access norms for Brazil and Russia have not been addressed.

1.4 Facility location planning approach

The Service Access Planning approach developed for use with GIS based accessibility analysis incorporates various aspects of relational spatial analysis and has proved to be a very effective tool. Planning in this case is not done based on planning units such as blocks or suburbs but rather on the ability to reach a facility within a desired distance. Measurement of access is undertaken across invisible administrative boundaries and thus any changes in these, which happen from time to time, will not impact on the service indicators or accessibility. The basic approach developed by the CSIR matches the supply and demand within a spatial context based on agreed upon access parameters, such as distance or time, in conjunction with provision norms, such as the population threshold per facility for a specific service. It uses the road network to measure the distance of travel rather than straight-line distance. Used together in the accessibility model, these parameters enable a spatial measure of sufficiency.

The key data requirements are the use of:

- a detailed population base layer which preferably includes profile information (such as age, income and health insurance level) as the major determining factor of demand;
- a transport network as the key accessibility input; and
- the capacity of each individual facility as the supply input.

Standards and guidelines with respect to the provision of publicly provided facilities and

services make service provision and backlog determination processes more easily quantifiable and transparent. The setting of standards which include spatial parameters allows for the more accurate measurement and balancing of supply versus demand and through this the identification of backlogs within a spatial context. The meaningful application of GIS-based accessibility is only possible when standards for provision (which include aspects of distance and a measure of capacity of supply) have been established and agreed upon (Green, Breetzke and Argue, 2008). To this end the CSIR has consolidated and published the various planning standards used by local, provincial and national governments for most social facilities provided by the government. Some of these were tested and revised while undertaking assessments in four major metropolitan areas when using the accessibility analysis tools

Besides the geographical locations of the facilities, the service capacities are used as an estimate of facility supply. In the absence of such data, other available information must be used as a proxy to estimate capacities. In general, the demand is determined based on population parameters for a group or a subgroup. For example, the people living in households who do not have health insurance have been identified as potential users of government health care clinics while the age profile of a population is the main indicator used for school demand.

In order to simulate the different transport modes such as walking, cycling, public transport or car travel, the road network distance or speed can be used per link in each instance. The most recent work has aligned all planning to distance as this can be better interpreted and is in line with government policy. In the case of emergency response services, e.g. fire and police services, a special layer is developed which is calibrated for travel by emergency vehicles.

The main tools applied for accessibility modelling and auditing are, firstly, the provision standards developed by the CSIR in conjunction with various national departments and city authorities; secondly, the service access planning procedures developed by CSIR; and, thirdly, the Flowmap software, developed at Utrecht University in the Netherlands. Key data and standards parameters are inputs to the model and the results of the analysis are mapped for visual interpretation using ESRI products.

2. CAPE TOWN CASE STUDY

We will make use of the library analysis and integrated plan in Cape Town to illustrate the methodology, tools and some of the outputs.

2.1 Context

Although Cape Town was inhabited by indigenous people for thousands of years beforehand, Cape Town's European history began in 1652 when a trading post was established there on behalf of the VOC (Dutch East Indies Company). The first European settlers were mainly Dutch, with some French Huguenots fleeing religious persecution in their home country. Immigrants from other parts arrived as well as slaves and indentured labourers from Asia. Today Cape Town is a world-class cosmopolitan city, and the second largest city in South Africa. It is the legislative capital (the Houses of Parliament are here) and the most southern city in Africa. The city boundaries extend over 59 886 hectares of land

and in 2011 was home to 3 662 955 people. It has diverse settlement development, from leafy suburbs and coastal villas to poor neighbourhoods and informal settlements. On the periphery of the City there are major agricultural areas in which many of South Africa's world famous vineyards are found. Table Mountain National Park also falls within the city boundaries. The City's management strives to plan to provide sufficient social facilities to meet the needs of all its inhabitants.

Figure 1: Location of Cape Town, South Africa

2.2 The approach

In the process of planning to best accommodate growth, the CSIR was approached to apply its technology to assist the City in developing a plan to eradicate facility backlogs for the current period as well as ensure the proactive development of facilities to meet the City's growing needs up to the year 2032. The project involved access modelling of a range of different public facilities to spatially identify facility backlogs and identify potential optimal sites for new facilities to meet the requirements for 2014 and 2032. The City of Cape Town undertook its own growth projections for 2032, although the CSIR could have used Urban Simulation modelling to simulate and allocate growth for the City. The growth projections were used as input to the accessibility model in order to evaluate the location of the facilities' shortfall and to subsequently develop an integrated strategy to address the backlog. The study relied on the City's GIS staff to provide the data regarding the current provision and supply of facilities. The facility and population data were all disaggregated to a fine-grained hexagon layer for analysis. These were then linked via a connected movement / road network that realistically reflected the possible travel movement and took account of topography, direction and distance of travel while enabling the shortest path allocation. Cleaning and verifying facility data was and generally remains a major challenge.

The analysis mainly focused on social facilities and the requirement to site facilities near residential areas and on the public transport network to limit travel costs. Access distance was measured only from places of residence.

For each facility type, service standards relating to access distance and capacity were set and agreed upon. These were based on the standards drawn up by the City of Cape Town's own departments as well as the CSIR National Guidelines.

The study objectives were to:

- Conduct an audit and assessment to evaluate the spatial match of supply and demand for 2014 in terms of six service sectors each having one or more facility types. Sectors included those of Health, Education, Libraries, Parks, Sport & Recreation and Fire & Emergency Services.
- Evaluate the need for the future provision/supply or upgrading of the social facilities in terms of sufficiency with respect to the 2032 population forecast from the Land Use Model.

In seeking locations for new facilities, preference was given to sharing, co-location and integration of sites and buildings by different departments as well as rationalisation where possible to achieve fewer, larger facilities of a higher quality. Slightly longer travel distances were considered to support larger facilities and achieve a greater concentration of facilities at nodal points and along the main travel network and especially within the Integration Zones identified in terms of the Built Environment Performance Plans. The latter supports the National Treasury approach to outcomes driven planning.

2.3 Data Preparation

The entire study area was tessellated into hexagons to achieve the fine grain analysis required for spatially accurate facility location planning. Three main data sets are required for this:

- Road network layer that has been cleaned and verified. This links each hexagon to every other hexagon and is used to assess distances to facilities.
- Facility data with attribute data indicating the capacity of facilities which is used as the measure of supply.
- Population data (stratified by age & income) and disaggregated to the hexagons and used for calculating demand.

In this study two population data sets were used, namely the 2011 population (as proxy for that of 2014) and the 2032 population forecast in terms of the Cape Town *Pragmatic Densification* Scenario.

An assumption included in the *Pragmatic Densification* Scenario was the containment of growth within the current urban edge while the rate of growth was based on current trends and planned government housing projects. The scenario did not consider changes in the policies regarding land use management other than the continuation of the existing densification policy along main corridors and selected areas. The City produced two other population forecast models to be used for Integrated Public Transport Network modelling, namely *Business as Usual* and a more specific *Transit Orientated Development* scenario. All line departments were required to work on the *Pragmatic Densification* scenario for the 10 to 20-year master planning.

2.4 Audit and planning approach

The first step in an audit is to define the current catchments or the areas of influence of existing facilities. This is done using a set of basic catchment area analysis procedures. The Flowmap model allocates the demand to the closest facility which still has available capacity, but which is within a selected travel distance. This is done in competition and no double counting occurs. Choices regarding the transport mode, the maximum acceptable travel distance and facility size constraints or limitations, if applicable, need to be determined before embarking on an analysis for each facility. Unconstrained, fully constrained and distance or time-only constrained catchment area analysis techniques can be used. In the case of libraries, a distance constraint of 5km for local libraries and 10km for regional facilities was set in Cape Town. The standards that are applied need to be adapted for local context and standards may differ between areas that are sparsely populated and densely built-up areas.

Based on the analysis, a set of indicators is produced that reflects the current service provision of areas and the utilisation rates of specific facilities. The indicators include:

- average travel time to reach a facility with capacity;
- number and percentage of persons served for the city ;
- area and percentage of land area served; and
- number of persons allocated to each individual facility.

Making use of the catchment area analysis process, the study area can then be divided into sufficiently served areas and unserved areas as shown on Figure 2, which represents the served and unserved areas for community libraries in Cape Town.

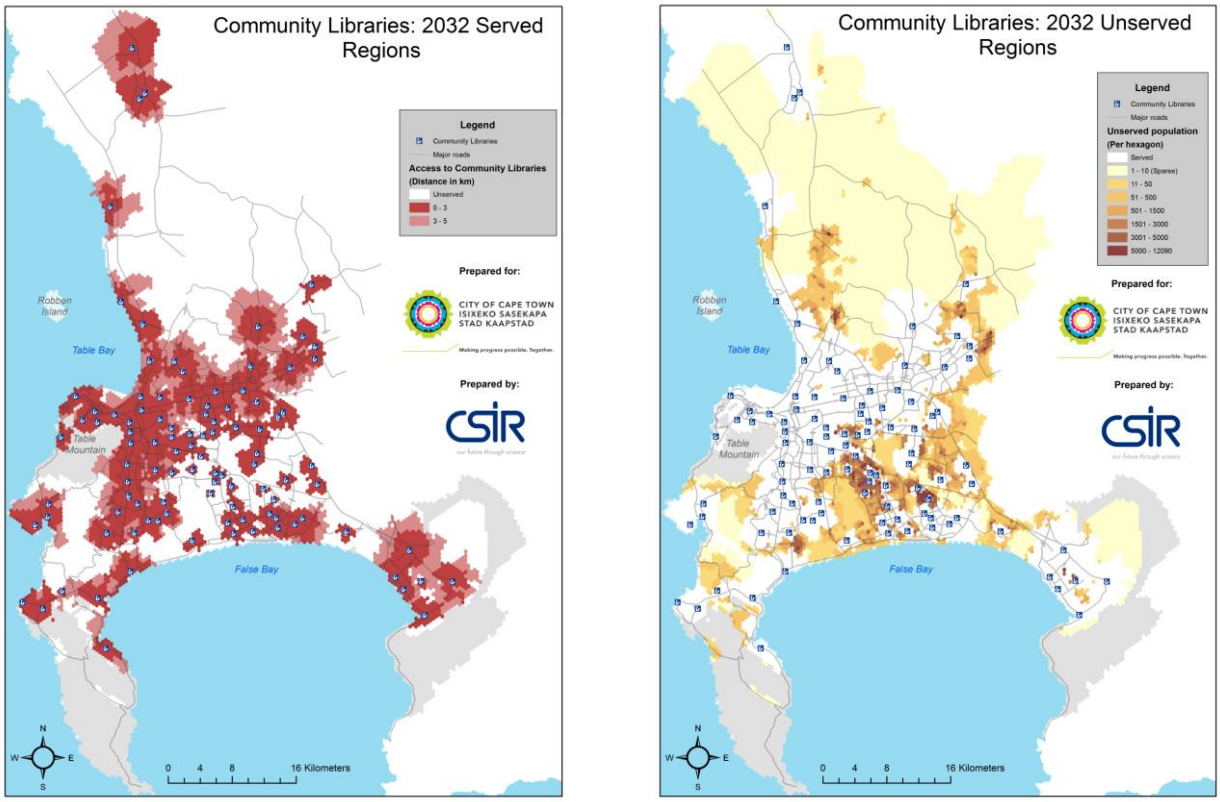


Figure 2: Served and unserved population – Community Libraries 2032

The production of maps showing served and unserved areas is invaluable for community and councillor interaction as well as for in-house communication regarding needs and/or future development plans. These maps, alongside the map showing only travel distance to the closest facility but ignoring capacity, are useful informants in the decision making process and for adapting access standards to the local context.

The analysis enables the categorisation of residential areas in terms of:

- “Well-served areas” where facilities are well located, users are within an acceptable access range and there is sufficient demand above the minimum threshold for a viable facility; and
- “Poorly-served areas”– areas where facilities are out of reach or overburdened and all demand cannot be met due to capacity constraints.

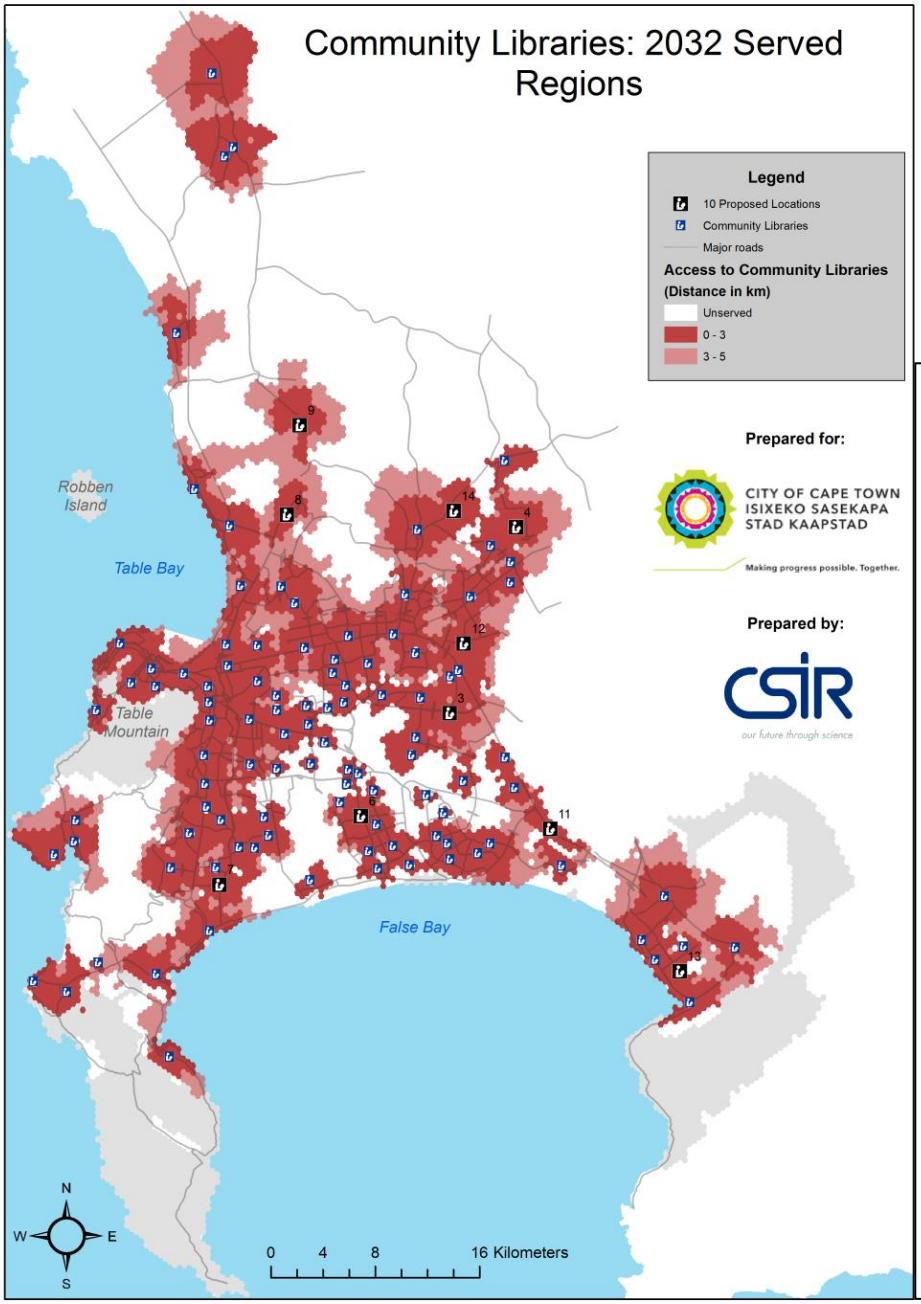
Some areas may in certain cases be indicated as “over-serviced areas”. This is where facilities do not reach full capacity due to there being too many facilities too close together and competing for the same market share. In this case, a reduction routine can be used to test a range of closure options.

The next optional step, but using the same modelled outputs as above, is to classify each facility based on utilization (allocation) rates by comparing the current capacity to the modelled allocation of the demand. Some facilities may have spare capacity while others are over burdened

The next requirement is to identify and analyse the unserved areas and population to assist in identifying locations for new facilities. The unserved demand for each facility type is analysed by mapping density of the unserved demand. This is done by undertaking proximity counting to identify concentration of unserved demand within a set distance and by the running of an optimization routine, as appropriate. The outputs enabled the identification of those locations where there is a sufficient concentration of unserved demand to support new facilities of a specified size.

While the proximity count provides a rough estimate of the number and location of new facilities that may be viable, it is not accurate. For greater accuracy, an optimisation analysis is used to locate a select number of facilities that are required to achieve a desired coverage, i.e. 100% or 80% target coverage solution. If the budget is constrained it is possible to use the optimisation process to identify the best sites for an affordable number of facilities for each facility type. The optimisation analysis specifically allows ranking of the demand which is critical for investment prioritisation.

Optimisation is a procedure undertaken with the Flowmap software where the model routine seeks out the optimal placing for possible new facilities based on the principal of maximising the number of unserved people that can then reach the new locations, based in this instance on average travel distance. The model uses a looped process to seek the top locations that meet the criteria in competition with existing facilities.



Note: For each number on the map, indications are provided about the library capacity required for the two time periods. The information is differentiated with respect to complete new facility requirements and those where expansion of current facilities is possible.

In summary, before 2022, 4 new facilities of a specified capacity and type should be developed and 6 facilities should be considered for expansion to better serve the community in their direct vicinity.

For 2032, 6 new facilities of specified capacity are required and 3 more libraries should be expanded.

Figure 3: Map of new Library interventions for 2032

Where there is insufficient demand to fully support a new facility within an area which has unmet demand, other options need to be considered. These could include questions of whether:

- existing facilities can be increased in size, operational capacity or hours of service;
- A longer access distance should be considered; or
- mobile or piggy-back services should be considered.

2.5 Development of integrated facility plans and communication

To make implementation practical and affordable, an integrated approach to the planning is then possible and is followed. An analysis similar to that discussed for libraries can be undertaken for any number of facilities from fire services to parks, and from health facilities to education. Every facility type needs to be individually analysed to determine the level of service achieved in terms of the target population year. Once all the proposed new facilities to meet the backlogs have been identified using optimization, the integrated plan can be developed and communicated to stakeholders. This can be done for any period for which a detail spatial land use projection has been developed.

Following this, a process to identify suitable available land will be required. This can lead to some adjustments to the specific locations, although new legislation does allow for easier expropriation for specific uses. The latter is likely to be a last option. Where possible, a facility cluster should be developed, i.e. an education or sport precinct, or in other cases a multi-purpose facility or cluster can be considered. This should be located close to residential areas and should encourage mixed-use development where possible to limit trip making. A key element in the development of multi-facility centres is to examine the location of existing facilities including transport facilities that can form part of such clusters.

Assessing the myriad requests for new facilities emanating from line departments (and from consultants preparing plans on their behalf), as well as from councillors and communities, is very time consuming and is a challenge given skills shortages at the municipal level. The availability of the accessibility modelling results enables these to be more rapidly evaluated against backlog priorities and needs, and the GIS maps enable viewing of a proposed facility in relation to all other facilities, the road network, the population densities in the area and the quantum of unserved demand that exists. It enables locational maps to be used for communicating and debating the location of new facilities or for withdrawing support from facilities which have been shown to have limited impact.

In the case of Cape Town, the backlog plans which highlighted facility demand for 2032 were aligned to the Integration Zones and proposed building programme of public sector housing. The Integration Zones were identified in terms of National Treasury Neighbourhood Support Programmes which provide financial incentives to a) spatially aligned development and investment; b) densify around transport and other infrastructure for greater efficiency; and, c) densify selected areas of the city to eliminated inefficient urban sprawl (Van Niekerk, 2013).

Notwithstanding the priority and need for the facilities shown on the plans, all of the investment priorities indicated would be budget dependent.

Figure 4 is a consolidation of the results of the identified new locations for facilities based on the optimization analysis. These newly planned facilities can be located within the Integration Zones and will be eligible for Neighbourhood Development Programme grant funding. This figure indicates where key facility backlogs can be aligned with the identified high density public transport corridors. It, furthermore, provides clear strategic direction to local planners, sector departments, private developers, donors and provincial and national government departments responsible for local facilities (such as health, education and library services) as to where the greatest social facility needs are and where the greatest impact or return on investment is achievable in the construction of well serviced and accessible neighbourhoods.

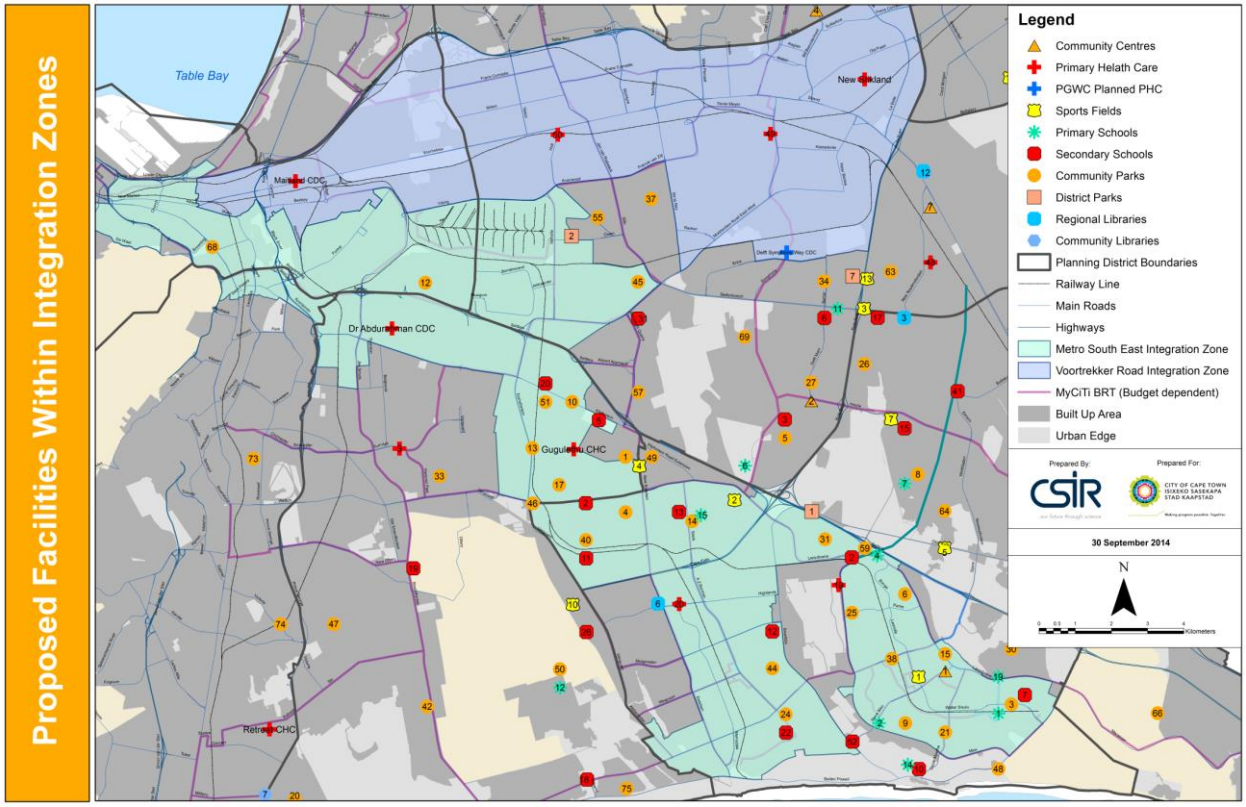


Figure 4: Joint plan of investment in Identified Integration Zones supported by National Treasury

The Investment Guide produced for the City provides significant input to the development of a Social Facility Investment Plan. It highlights the optimal location for future capital investment in social facilities required to meet citizen demand by 2032 and considering anticipated gravity points of need. The information presented reflects the prioritization of capital investment for community facilities and gives a metropolitan perspective on priorities per sector thus promoting smart decision making into the future to support the demands of a growing city. All locations were linked as far as possible to public transport networks and nodes and intermodal exchange points. Final locations of facilities identified for capital investment will be affected by the final nature of the new development and on available vacant land. The study also confirmed the need to retain sufficient municipal owned land for community use to accommodate social facility requirements rather than selling the land for private development. A similar approach to planning has been used in eThekwini (Durban) since 2004, was applied in Johannesburg in 2012/13 for 8 national departments and 4 local facilities, and the results of a similar study were presented to the City of Tshwane (Pretoria) in June 2016 to indicate priorities for social development for 2021 for the capital city.

3. CONCLUSION

The case study shows how the Service Access Planning methodology, when used in an environment with advanced computing, significantly enhances both current and longer term urban and regional planning and decision making. Furthermore, the goal of accessibility to services for all citizens can be accurately measured, thus achieving both equity and

transparency. Planning officials are provided with solid decision support in an environment where a range of stakeholders all clamber to have their needs meet and where funds for capital investment need to be considered against the operational requirements and the necessity of the service.

Recommendations derived from the modelling results have been incorporated into the medium and long term planning of the respective service sectors investigated in Cape Town, eThekwini (Durban) and Johannesburg while the results for Tshwane (Pretoria) will be used as input to the 2016/17 development plan. The results and maps are used in stakeholder meetings and budget planning to support and prioritise technical planning requirements. The results support planners' recommendations which had previously been difficult to defend to politicians and communities who may be concerned with their parochial needs without consideration of the more deprived situation in neighbouring areas.

The implementation of the integrated long term plan of social facilities will make a major contribution to the development of more sustainable and well provisioned living environments where future development is supported by well-located social infrastructure within the urban fabric. The plans also provide guidance to all developers, private and public sector, in terms of where facility investment is most critical and where it can significantly reduce the construction of white elephants or under-utilised facilities. A key factor in the quality of the spatial analysis is the enhanced computing power that enables the development of fine-grained analysis which is spatially accurate; thereby, supporting detail local level planning that was not possible 15 to 20 years ago. This can have a major impact on planning for integrated service delivery. The optimisation tools used also better inform the budgetary process for facility provision to maximize impact.

Equitable strategic level spatial facility location plan can be developed because of the following:

- Norms and standards have been consolidated and agreed to. These are currently being differentiated for use in small towns and rural areas in South Africa.
- The GIS tools enable accurate spatial disaggregation of population demand data at a fine grain, while greater computing ability enables use of complex algorithms that simultaneously match thousands of origins (supply) and destinations (demand).
- Using a transport network for simulating movement patterns for modelling, approximates real links and accounts for topography and/or major barriers as opposed to defining catchments by drawing circles around facilities.
- The approach and tools provide a defensible empirical base for the determination of facility needs amongst different wards and planning regions and sectors.
- The approach enables the co-location of different facility types as part of a multi-purpose centre or priority investment hub since a common analysis base is used.
- The approach enables backlogs to be spatially determined in relation to population need. The outputs support the planning of facilities where they are needed and where people live irrespective of ward boundaries and political processes.
- Longer term monitoring and planning is possible based on established procedures thus progress can be monitored.

Notwithstanding the major contribution of the approach and the use of its associated tools, there are some constraints to its widespread use if the facility databases do not exist or are not maintained and updated. Most of the problems experienced with the application of the models were related to data collection and verification.

The use of the service access planning approach described in this paper is most cost-effective if the activity can be sustained over a reasonable period of time (3 to 5 years), and if there is at least a certain degree of in-house capacity building and technology transfer.

As illustrated by this case study, the GIS accessibility analysis together with the availability of facility provision standards and guidelines are major elements in supporting planning. However, the process followed in government to implement the results and ensure these results impact on capital budget choices are critical steps in ensuring that development needs are addressed in pragmatic, efficient and sustainable ways. The approach indicates how past imbalances in service provision to specific communities can be identified and redressed thus significantly supporting the planning and governance processes within cities.

The Service Access Planning approach using accessibility analysis and used for facility location has been developed by the CSIR over more than a decade. These tools and processes have been applied to assist South African provinces and cities to make smart decisions. They provide capacity to planners and other decision makers to enable them to make better rational spatial investments that aim to eliminate service backlogs of key social facilities. Facilities planned in this way over the past decade cover schools, clinics, hospitals, crèches, libraries, cemeteries, community halls, home affairs offices, multi-purpose government service offices (called Thusongs Centres), fire and ambulance stations, police stations, social grant (SASSA) application offices and pension pay points as well as selected recreational facilities.

A major improvement in this type of modelling will be possible if comprehensive real time data on facility provision and size is available. Currently the time and effort required to obtain, clean and verify data results causes project delays and rework that could be avoided through the application of more technologically enabled facility data capturing and updating.

ACKNOWLEDGEMENTS

- City of Cape Town
- eThekwini Municipality
- City of Tshwane

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