Development and morphological classification of service catchments to support social facility distribution in South Africa

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Abstract

South Africa, as a developing country, is faced with a number of challenges, one of which is the provision of social facilities in an equitable and sustainable manner. The problem is compounded by uneven development arising from geographical variations in respect to resource availability and dualistic development arising from the apartheid era. This has resulted in a wide variety of development patterns and resultant settlement types ranging from well-developed neighbourhoods usually found within city limits to under-developed settlements in deep rural areas. Development patterns impact on the provision of social services as geographical dispersion and low density sprawl are major factors influencing the efficiency of service delivery. Thus, an understanding of morphology is crucial to promote equitable access of services within limited resources. Using service area analysis approach, a set of service catchments for social facilities provision were created around South African towns and settlements identified in the CSIR and SACN settlement typology. Using a range of datasets, these catchments were profiled and then classified according to their settlement morphology. This paper outlines the approach used arrive at the catchments and following this, it discusses the process used to analyse and classify these catchments according to their morphology. It highlights the nine main identified types and then provides some detail on the most common environments where these morphology types occur.

Key words: Settlement Morphology, GIS, Catchment, Service Delivery, Social Facilities

1. Introduction

The accessible provision of social facilities to citizens makes a significant difference to the quality of life of citizens. The effective provision and delivery of these services is anchored in the trade-off between service viability and efficiency; and equality of provision. On one hand, citizens want accessible services; while on the other service providers must provide services efficiently given the finite nature of financial resources. In South Africa, much of the planning and budgeting for social facility distribution is done at a municipal level. These municipal boundaries do not necessarily take service access into consideration when being demarcated and most people tend to travel to their closest facility regardless of whether it is in their municipality or not.

Thus in trying to improve service equity, that takes different settlement context into consideration, a set of service catchments, covering the whole country, were demarcated based on road distance to the closest town or village. These catchments were profiled and classified in terms of demographic factors and settlement patterns. The demarcation and profiling of the catchments supports the narrative that a better accessibility as well as understanding of how the population is distributed within service catchment areas has a potential to enable service delivery to be more efficient and equitable. This paper outlines the approach used to demarcate the catchments and to analyse and profile these in terms of a range of factors including the settlement pattern or morphology. The paper discusses nine main settlement patterns or morphologies that can be identified in South Africa, notes their prevalence and the most common environments where these occur. It concludes with a discussion of the impact of the different morphologies on the distribution of services within catchments as well as suggestions for improvements for further refinement of this research.

2. Background

According to Wild *et al.* (2012), there is growing recognition that, despite considerable increases in resourcing, service delivery is still failing in many developing countries; and political and governance factors are some of the contributors to this failure. However, where delivery of services is occurring, a better understanding of the settlement morphology (the form or structure which settlements take) can improve how services are rolled out. “Settlement morphology is the expression of the physical form of people’s activities in enhancing their social and economic functions on the earth’s surface in the quest for sustenance” (Musvoto, 2011, 33). Simply, it can be defined as the distribution or pattern of the dwellings and other structures of human development within a defined catchment or demarcation. Most democratic constitutions around the world place pressure on governments to make available the basic social services required by the citizens. This push for better livelihoods is further emphasized by the United Nations through its Sustainable Development Goals (SDGs) (United Nations, 2000).

In South Africa too, a better understanding of the varying settlement patterns and morphologies can contribute to greater accessibility in service provision and distribution in a way that facility provision more closely relates to residential development patterns. This is of particular importance in the case of non-urban settlements where the accessible provision of services is more essential (Halseth & Ryser,2006). As in the rest of the world, much of the distinct settlement development is as a result of geographical landscape, mineral resource availability, wars and other political factors (Van Schalkwyk, 1991). Security too is important, and settling on hilltops was always one of the preferred ways of making settlements defensible against potential adversaries whether this is the hillside villages of Europe or villages in the Eastern Cape and Zululand.

Uniquely, in South Africa all these factors have been further transformed and distorted by a political system that restricted where the indigenous populations were allowed to farm, live or work. The majority of large commercial farmland was reserved for private ownership for those of European descent while indigenous people were restricted homelands where access to land was held in communal tenure by chiefs and where in general only subsistence farming was possible on small pieces of land. Overtime, due to lack of land and overcrowding, population growth and lack of investment, development of unstructured and unconsolidated dense settlements was realised (Khunou, 2009). For the large part of the last century, indigenous urbanisation was restricted to so-called Townships on the outskirts of urban areas. Apart from influencing the structure of settlements, such policies also led to under provision in government services in the indigenous people’s areas since these areas did not have sufficient financial resources to provide for themselves.

Much research on service delivery, especially of social services, has focused on aspects such as facility population thresholds, distance thresholds and ranges, population density and service capacity, with limited attention given to the structure of settlement morphology in relation to the distribution and delivery of services. As set out by the Department of Public Service and Administration (DPSA) Batho Pele principles to improve service delivery, three important principles are: setting service standards, increasing access and getting the best value for money. It is the argument of this paper that for these three identified Batho Pele principles to be realized, a better understanding of space, specifically the settlement morphology, is crucial.

The Council for Scientific and Industrial Research (CSIR) has for several years promoted the use of provision standards (Green, et al 2008 and 2012) and accessibility principles (Morojele et al, 2003) to promote social justice, equity and efficiency in service delivery. This is because the discussion on service delivery is not complete without a consideration of the dilemma of equity versus efficiency (OECD, 2008). “Equity is about levelling the playing field to achieve equality of opportunity...” (Tucker and Ludi, 2012; 3). Accessibility, in simple terms, is the quality of being reached. In the context of service provision, the term refers to the ease/difficulty to access a certain service due to travel distance/time amongst other factors.

Efficiency refers to obtaining great results from as little input as possible. It is basically maximising the use of available resources, while cutting down on wastage. Settlement morphology and especially the density aspects of settlement pattern, although often overlooked, has a strong impact on the distribution of services. As noted by Bidwell (2001), low density settlement morphologies create extra distribution costs for the production of any good or service. This is one of the main reasons sparse areas have often had lagging service provision. Dense areas, on the other hand, are more cost effective when it comes to the provision of services. .

Thus the understanding of morphologies in different areas becomes crucial when considering the delivery of infrastructure and distribution of services, making it possible for facility planning to respond to the unique character of each area, increasing the possibility of customising service distribution networks to the target population. This also indicates if social facility standards need adaptation and differentiation to suit the varying types of morphologies. This helps in balancing what the citizens need and what the government can efficiently provide.

In addition to the issue of morphology, there is a disjuncture and misalignment when it comes to planning units in South Africa. From changing wards to sector departments each having their unique set of boundaries, this makes planning even more challenging. This is mainly due to the fact that these boundaries rarely follow spatial logic and thus put those who live in them at a disadvantage as far as equitable and efficient service delivery is concerned. Harvey (1969) argues that geographers have undoubtedly suffered in the past because much of their data has been collected in administrative units which vary in shape and size and which are not easily comparable. His point is extremely relevant to the South African planning landscape. One of the reasons these catchments were developed was to overcome this very challenge. Since the catchments are created based on travel distance from a central place (town/settlement), the resulting catchments do not discriminate as they are based on the 'closeness' of each area to its central place (point of service) based on the road network. Thus, from a service delivery standpoint, the catchments are logical as they help define areas that can be reached from each central point across the country based on the road network.

The work presented in this paper was part of a project between the CSIR and Department of Rural Development and Land Reform (DRDLR). The key purpose of the project was to improve access to services thus the main departure point of the project was to use Geographic Information Systems (GIS) to define service catchments around 1328 towns and settlements using service area analysis, and then to profile and understand these catchments including their morphology. It is the purpose of this paper to discuss the GIS process followed in developing the service catchments for South Africa as well as their classification according to observed settlement patterns/morphologies in order to explore how these different settlement configurations affect the distribution and size of services. Given that a better understanding of settlement morphology can support improved placement and planning of social facilities, one needs to ask whether it is possible to classify and categorise a range of different patterns in South Africa using GIS, and then answer questions such as: what patterns are most prevalent? how the population is distributed amongst these types? and how this information can lead to better social facility planning?

3. Approach & Methodology

With accessibility to services being a key criterion to consider before looking at efficiency and equity, a methodology was developed to create service catchments for the whole country that allocated all areas and their inhabitants to their closest settlement. This is where the most basic level of service could be provided. The paper will thus first describe the process of the creation of the catchments. These catchments were then used as the analysis unit for profiling areas to obtain a better understanding of differing settlement structures/morphologies prevalent in South Africa.

In order to classify and understand service areas, the first step was to define their potential 'boundaries' or the extent of the service areas around towns/settlements to enable the analysis of settlement patterns and other key indicators within the defined space. The approach to demarcating the catchments drew on the concept of Christaller's Central Place Theory (King, 1984) and principles of accessibility theory. Using the assumption that people would travel to the nearest central place/settlement to access basic social services they require, all areas were attributed to their nearest town or settlement using GIS spatial analysis functions to create service catchments. Since the analysis was based on social facility provision and many of the services such a health, education and justice are planned, budgeted, administered and provided based on provincial boundaries, the analysis restricted the creation of inter-provincial catchments. It is, however, noted that in reality residents often cross provincial boundaries to access services without giving any thought to issues such as administrative boundaries. Thus in some cases service catchment boundaries have been somewhat distorted from a typical service pattern. This is especially true where people living close to a provincial border are not allocated to their closest town across the border but rather to a town further away but within the same province.

The datasets used to undertake the demarcation included the following:

- The CSIR/South African Cities Network (SACN) functional settlement typology town points (CSIR)
- National roads dataset (AfriGIS)
- ESKOM SPOT Building Count Points dataset (ESKOM)
- StatsSA 2011 Population
- A 1x1km grid of South Africa was created as the basic analysis unit for the creation of the catchments

With the above datasets and theoretical assumptions in mind, there were several analyses performed to firstly create the catchments and then the morphological classification of each of the catchments.

The first step was to create the service catchments using a 1km X 1km grid covering the whole country. The goal was to assign every square kilometre grid cell in the country to its nearest town/settlement point based on the road network (Ngidi et al, 2015). The rationale behind the use of the 1km X 1km grid for the whole country was that of flexibility. This means that the grid cells, depending on one’s intended goal, can be dissolved into any demarcation or aggregated to different boundaries if required. For the purpose of service delivery/social facility allocation, 1km X 1km proved to be highly suitable and sufficiently fine grained without over burdening the analysis and computing requirements. The data was inputted into a routing solving operation to create an Origin-Destination (OD) distance matrix.

The algorithm behind the OD matrix finds and measures the shortest distance paths along a road network from multiple origins to multiple destinations. In this case, the centroids of the grid cells were used as the origins and the town points as the destination and along the road network, each grid-cell was attributed to a nearest town (thereby inheriting that town’s ID). Once all cells where attributed to the nearest town, the grid was dissolved based on the inherited town ID to create catchments around each town, with the assumption that people located within that catchment would receive at least lowest order service from their closest town/node that was the central place in that catchment. Having created the catchments around all 1328 the towns, the SPOT Building Count

(SBC) was used to allocate population to each catchment and to undertake a review and classification of the settlement morphology.

According to Ngidi et al (2015), once each grid cell had a population value, the grid was used to evaluate population densities in the catchment to assess whether it was fairly distributed, centralised or evenly scattered. This grid contained the distance of the centroid of each grid cell to the town point in the catchment and the population total in each cell. It is noted that the road condition was not taken into consideration in the analysis as, in terms of the national access standards used for measuring access to service, only distance was considered. Thus this was applied and determined as being sufficient. In retrospect the inclusion of road condition as an data attribute for all roads would have improved the accuracy and more closely reflected actual human travel behaviour, had this data been used and more freely available.

The process is as follows:

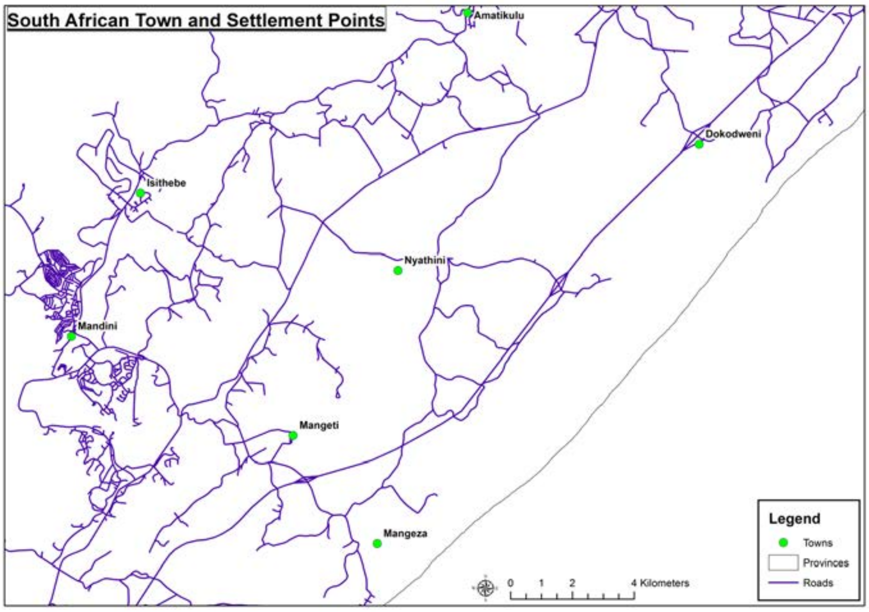

Figure 1 Central places/nodes and road networks

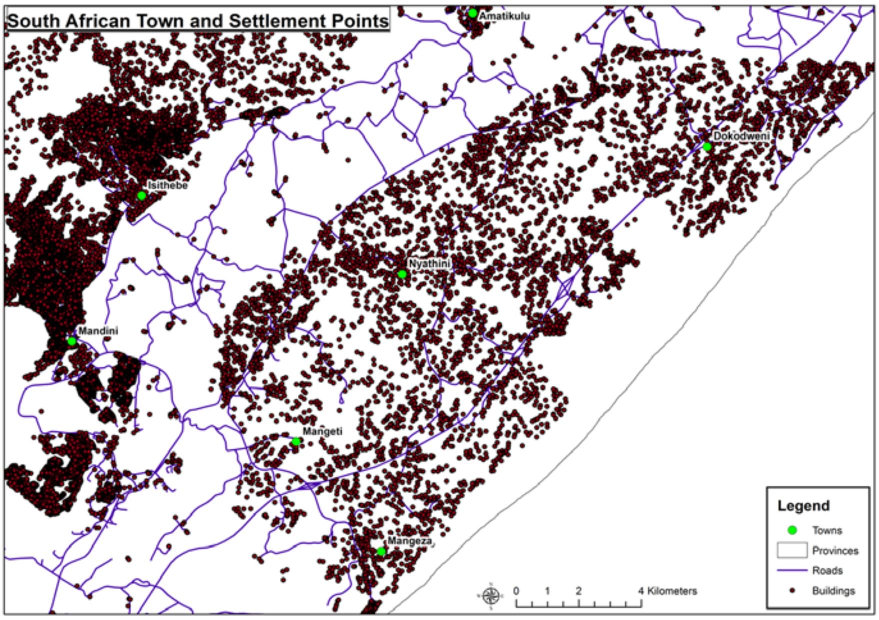

Figure 2. Settlements around central places

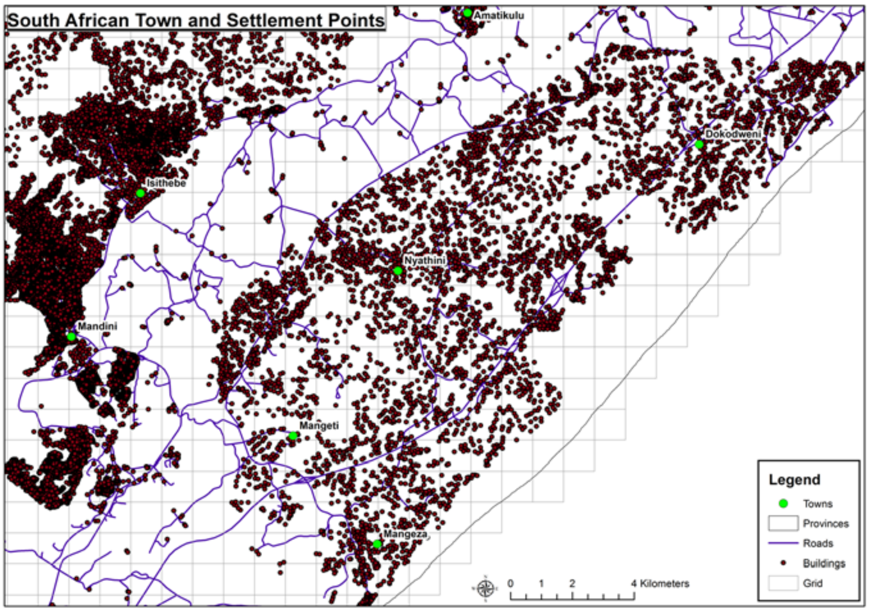

Figure 3. Putting settlements in the 1km X 1km grid

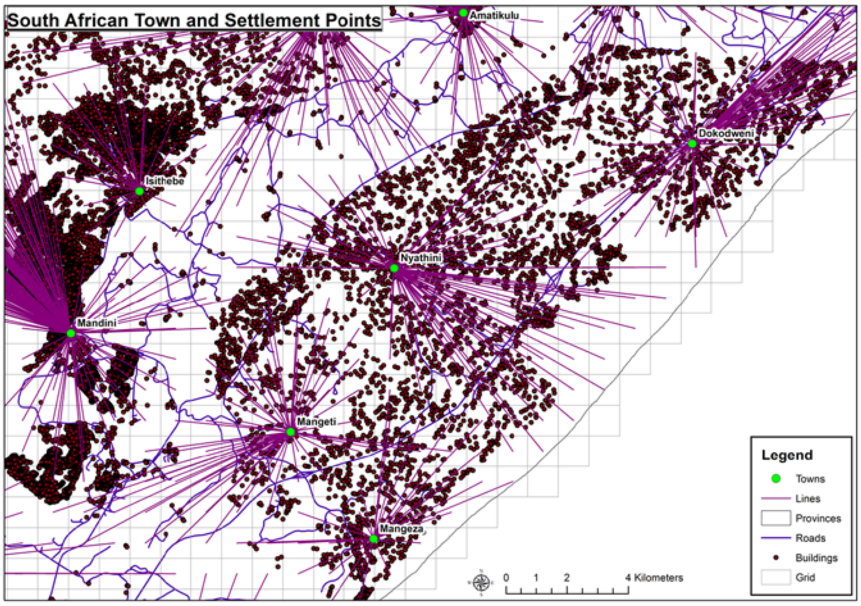

Figure 4. Origin-destination analysis

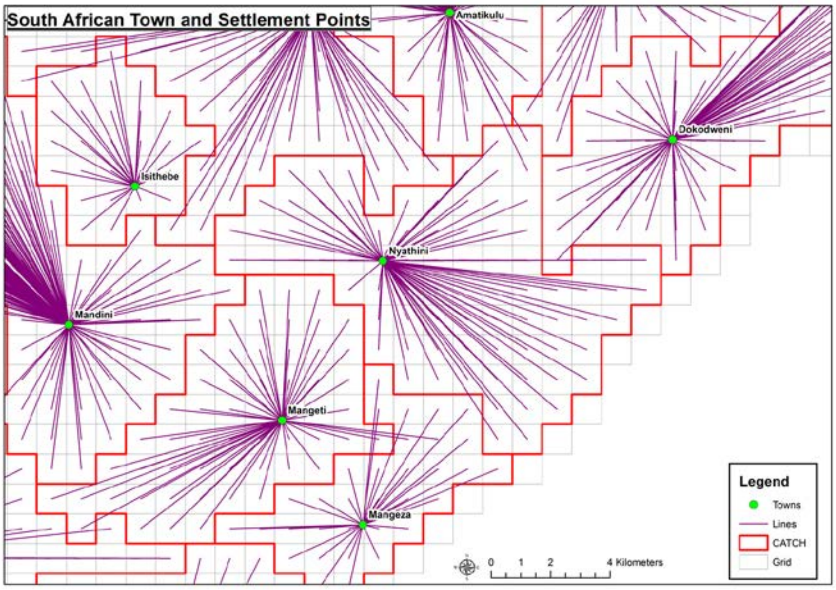

Figure 5. Catchments defined around service points.

A total number of 1 328 catchments were created around their respective towns and established settlements. A key component of the catchment profiles was the determination of the number of people within reach of each potential service point. Together with the building point data set, several other processes and datasets were used to assign population to each catchment.

The next analysis dealt with assigning potential population values to each SBC point as to represent the population distribution on the ground this would assist in calculating the population and density within each catchment. The other analysis dealt with analysing the structure of SBC points in each catchment to classify its morphological structure within each catchment. The SBC was originally produced by the CSIR and Eskom in 2008 and is a geo-referenced building frame developed using Spot 5 satellite imagery. The inventory concerned contains all classifiable building structures within the borders of South Africa (Breytenbach, 2010).

To assign population to each of the catchments, a dissagregation process was undertaken using the SBC. The population disaggregation process employed principles of dysemetric mapping and areal interpolation techniques and followed a process outlined by Mans (2012), which first used a classified set of SBC points to undertake the dissagregation of population data from census tract data. This process gave each point an indicative household weight for each of the census years (1996, 2001 and 2011). "…the weight of the point would represent the probable household size of the building (household) in question" (Mans, 2012:42). These weights were used to redistribute values from the census data to the point dataset thereby producing a population/household size value for each point

The next step was to analyse the pattern and density of the SBC to begin the morphological/settlement structure analysis of the catchments. The point dataset was used as a representative for dwellings, and this along with satellite imagery was used to visually inspect, interpret, identify, analyse and classify the structure of settlements within each of the 1328 catchments in the country (This to be explained later). An interpretive approach was employed in the morphological classification of each area through visual inspection, pattern analysis and interpretation of observed building and settlement patterns in each of the catchments. Google Earth satellite imagery was also used in instances of uncertainty which also added to the accuracy of the classification.

Following the completion of the evaluation of all catchments, 12 settlement types where initially identified and were eventually narrowed down to nine major morphological classes. Figure 2 below outlines and depicts the 9 classes that were classified. They are described in Section 4.

4. Research Results

The research analysis led to the identification of nine types of morphological patterns/structures within catchments. These nine types are as follows:

a) ***Mono Centric*** **–** Such catchments have only one distinct concentrated population settlement in the catchment surrounded mainly by large tracts of sparsely populated commercial farmland (e.g. Aliwal North, Beaufort West, Cradock).

b) ***Bi-Centric*** **–** Such catchments similar to the mono-centric areas are also surrounded mainly by extensive commercial farmland but have two distinct population concentration areas settlements in the catchment.(e.g. Paulpietersburg, Virginia, Moruleng).

c) ***Polycentric*** **–** These are catchments with development forming multiple nodal concentrations and are typically found in large cities and regional centres (e.g. Johannesburg, East London, Durban)

d) ***Scattered Dense*** **–** Such catchments are made up of continuous dense development without any specific identifiable nodal concentrations (i.e. not as dense as cities but not sparsely populated, in many instances having a density of over 100 people per km^2) (e.g. Hlabisa, Coffee Bay, Sterkspruit).

e) ***Scattered Clusters*** – Numerous small settlements that form clusters of non-uniform and non-continuous dense settlements across the catchment and is typically of rural development across hilly terrain (e.g. Libode, Jericho, Hartebeesfontein)

f) ***Scattered Sparse*** – Sparsely scattered settlement points irregularly distributed across the catchment and typical of mainly arid-semi desert western parts of the country (e.g. Riebeek East, Ogies, Alexander Bay)

g) ***Dense*** – Development largely composed of continuously dense settlement with no distinguishable centres or town points typical of tribal area informer homelands (e.g. Lusikisiki, Driekop, Scottburgh)

h) ***Sparse Linear*** – Linear pattern of sparsely populated settlement; this may mean it has developed alongside a river, coast or road but where growth potential is limited (e.g. Leerkrans, Kanoneiland, Gouritsmond)

i) ***Dense Linear*** – Such catchments have a linear pattern of densely populated settlement; this is mainly found alongside a large river, road or coast with significant development (e.g. Orange River, Jeffreys Bay, Mutale, Ga-Rakoma)

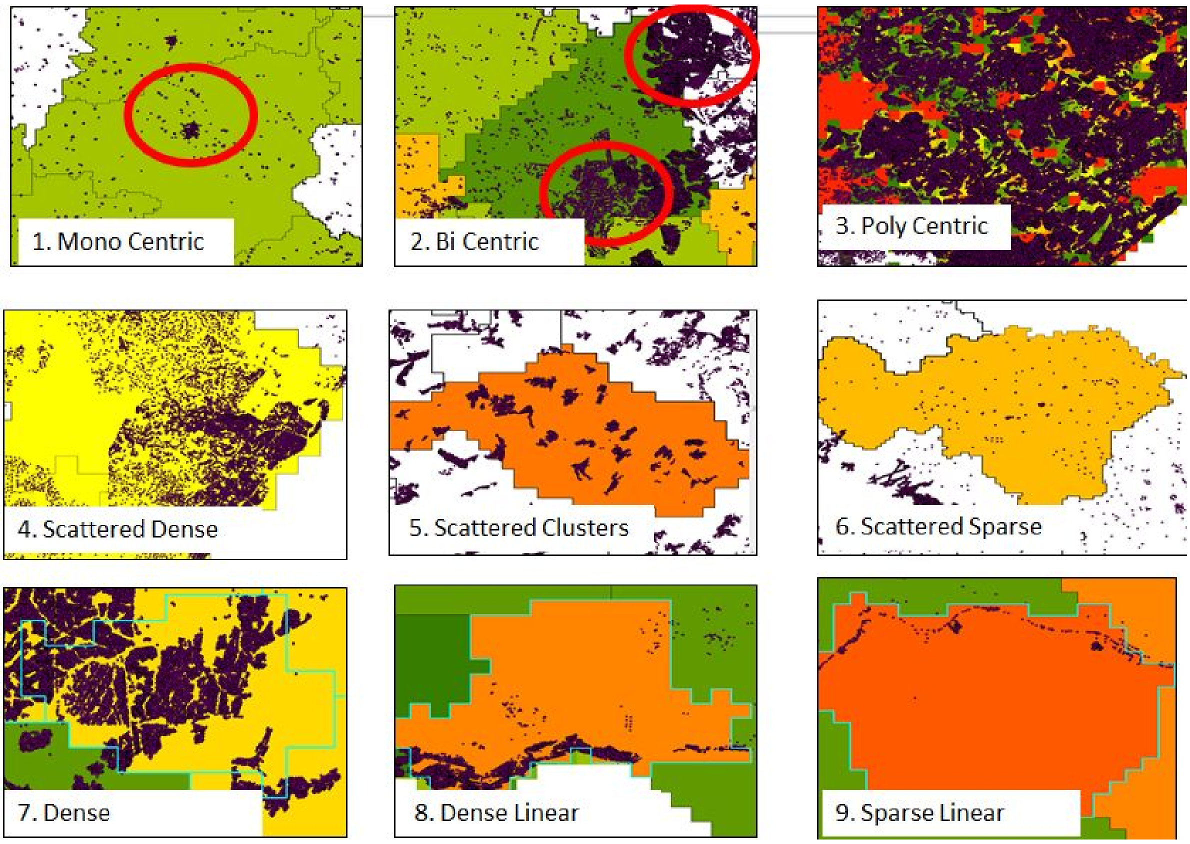

Figure 6. Nine types of settlement structures

At this stage in the analysis, each catchment had an ID, town settlement name, type of settlement morphology and population variables allowing for the review of different settlement sizes, patterns, catchment area size, population densities, population growth or decline. The table below indicates the number of catchments that fall within different morphological classifications. The very first column in the table shows a ranking of towns/settlements in according to size and type from order 1 being a metropolitan areas to order 10 being a catchment of less than 5000 people served by a small village or hamlet. The town orders were defined in the following manner:

- Order 1 – City regions (e.g. Cape Town, eThekwini, Ekhuruleni, Johannesburg, etc.)
- Order 2 – Cities (e.g. Pietermaritzburg, Richards Bay, East London, Nelspruit)
- Order 3 - Regional Centres (George, New Castle, Kimberly, Upington, uMtata).
- Order 4 - Service town / sizable or remote LM or DM Seat or contextually significant in that area, e.g. Springbok, Calvinia, Caledon, Sasolburg, Madibogo, Orkney, Tafelkop, Manguzi.
- Order 5 – >60 000 population with no significant role in its regional context
- Order 6 – > 40 000 BUT < 60 000 Catchment population
- Order 7 – > 20 000 BUT < 40 000 Catchment population
- Order 8 - > 10 000 BUT < 20 000 Catchment population
- Order 9 - >5 000 BUT < 10 000 Catchment population
- Order 10 - < 5 000 Catchment populations.

The analysis shows that about 48% of all the catchments in South Africa can be classified as being monocentric (see bottom cell in the 6^{th} column from the left). This monocentric morphology is widely distributed across small and larger catchments and is the type of catchment most easily planned for as most facilities can be placed at the single node with people accessing the services by public or private transport; or in the worst case, mobile services can be dispatched from a central point. Monocentric, Bi-centric and Polycentric are catchments where it is generally easy to distribute facilities to and make up 57% of all catchments in the country. This means that the distribution of service or social facilities in these areas should potentially be considerably more efficient in comparison to the other types of morphologies. This is due to the distribution of the population, with people living close to each other. In addition to these, Dense catchments (2%) also make it possible to achieve greater efficiencies in the distribution of services as dwelling units are close together.

Table 4.1. Number of catchments within identified morphology types

Town Order	**Catchment Count**	**Cumulative Catchment Count**	**Avg Density/ km2**	**Catchment Population (2011)**	**MonoCentric**	**Bi-Centric**	**Poly-Centric**	**Scattered Clusters**	**Scattered Dense**	**ScatteredSparse**	**Dense**	**SparseLinear**	**DenseLinear**
1 (Metros)	6	6	1342	18 837 765	0	0	6	0	0	0	0	0	0
2(City regions)	7	13	370	2 686 354	1	0	6	0	0	0	0	0	0
3(Cities)	44	57	194	4 600 818	35	3	5	0	1	0	0	0	0
4(Significant towns)	128	185	100	5 622 883	87	9	7	7	10	2	3	0	3
5 (High density areas)	27	212	371	3 234 814	9	5	6	2	4	0	1	0	0
6 (Small towns)	67	279	202	3 147 762	19	2	5	15	15	2	6	0	3
7(Small towns)	257	536	120	7 086 866	87	19	7	57	61	5	16	0	5
8(Small towns)	270	806	74	3 872 091	121	26	4	59	34	18	4	0	4
9(Small towns)	262	1068	43	1 929 206	150	7	1	40	23	32	0	0	8
10 (Very small towns)	261	1328	20	736 567	124	9	3	15	6	89	0	4	2
Total	1328		0		633	80	50	195	154	148	30	4	25
				51 755 126	**48%**	**6%**	**4%**	**15%**	**12%**	**11%**	**2%**	**0%**	**2%**

Catchments that have a morphology structure classified as Scattered, Sparse or Clustered present a greater challenge to service delivery. In these catchments, a much greater understanding of the local residential pattern, mobility, income levels, needs and service demands and age breakdown is required before finalising both the service capacity and distribution. In such areas, larger facilities such as 24-hour clinics and Home Affairs offices can be located at the central node and still serve the whole area within an acceptable travel distance. However, with respect to more local facilities such as schools and clinics, which typically have a much smaller service reach of less than 5km, a good interpretation of the morphology can help to ensure the correct size and placement of facilities close to where people live while avoiding ‘white elephants’ where there is not sufficient demand. The morphology is also extremely useful to plan service points for mobile and periodic services.

5. Discussion

The classification of service catchments according to morphology, amongst other classifications, has a direct impact on how facilities can be planned for and distributed within each catchment. It grants planners more information to plan according to a localized context and especially assists those developing plans in national or provincial offices far from the actual implementation area. Non-urban areas are not uniform, and with a detailed classification of morphology down to a settlement level, it is possible to have more insight into the context of each area throughout the country. This knowledge results in a more ‘people orientated’ approach to planning, while also allowing for greater efficiencies from the service provider’s perspective.

Much of the planning for social facilities in South African municipalities is done on ward level. This has a major drawback in that the ward boundaries are subject to change leading to a greater risk of service overlaps, redundancy, duplication or even over-provision or under-provision of services and facilities. Municipal boundaries too are not always rational in their demarcation and people on edges of municipal areas are often closer to towns in other municipalities. Khumalo *et al.* (2003) attests that the process of municipal service delivery in South Africa takes place within administrative and financial constraints, amongst other factors. Consequently, there is a potential for an imbalance between equity and efficiency.

The service catchments developed by CSIR and described here are a set of fixed catchments that are based on travel distance from all parts of South Africa to the closest town or village that then forms the node (central place) within each catchment. The catchment hinterland is made up of all land closer to that town centroid or node than any other node, based on the road network. In terms of the central place theory and the assumption that people would want to access services in their closest service point, the catchments developed by the CSIR make a strong case for efficient service delivery or social facility allocation. Byaruhanga (2011) states that principles of efficient and effective service delivery should be emphasised and maintained in every developing country and every state should ensure that such principles are successfully implemented by each responsible person.

Consider these two catchments (Jacobsdal and Enyati) which have approximately the same number of people within each, 10103 and 10137 respectively. Knowing how large each catchment is (the land extent) and how people are distributed in each catchment is key to providing an optimal number of services for both these areas. Both catchments could support a basic clinic if one only looks at the total population. However when armed with the morphological information, one can identify the most central place where almost everyone would have approximately equal access to the clinic. Jacobsdal happens to be a Monocentric catchment and one would not have difficulties in planning for the placement of social facilities or services as over 80% of the population lives within 10km of the town and thus all the facilities can be effectively placed at the central place. On the other hand, if we look at Enyati which is classified as Scattered Sparse, the approach that must be adopted for placing facilities should differ. There is no single dominant place of concentration within the catchment and only 30% of the people live within 10km from the town node in this catchment.

To overcome this challenge, one would have to place 30-50% of the facility’s capacity at the node and then identify subsidiary local nodes that are accessible to groups of people in the remainder of the catchment, then adapt the size of those facilities to match the settlement pattern of the catchment. The other option is to consider longer travel times for some facilities and then support this with suitable public transport or the use of mobile facilities. Thus, understanding of the morphology is crucial for rolling out services that involve the deployment of mobile units like health clinics. With the morphological information, the Department of Health can, for instance, determine where to place a fixed facility from which mobile facilities can be deployed as well as suitable stopping point for the mobile facilities. The case study applications in the field (from the DRDLR project) and the examples support the narrative that services cannot be uniformly provided across settlements by merely considering the population and administrative boundaries

Another important attribute included in the morphology classification of catchments is that of the number of people within distance bands from a catchment’s central point. Its practical applicability comes into play when deciding what size a facility should be and who will be served by it. With the morphological information, any service provider will be able to know how many people are within 5, 10 or 15km of the main node, within the catchment. With this information, they will more accurately gauge the size of a facility to carry out service provision in a more efficient manner.

The implications of this morphological classification of catchments on service delivery are extensive and the morphology classification of areas provides a framework to guide investment. Governments and other decision makers will now have rationale-based information to support their decision-making with regards to the placement and distribution of facilities and their capacity. Please refer to the table below for a summary of each morphology category’s impact on service delivery:

Table 5.1. Settlment morphology implications on service delivery/distribution.

Morphology	**Implications on service delivery**
Mono Centric	Due to the nature of monocentric catchments, providing services to these areas is not cumbersome. This is because the majority of the population is within a short distance from the town/settlement centre.
Bi-Centric	These types of settlements do provide benefits that are similar to mono-centric catchments. The population is always concentrated around a node or two nodes in this case. This allows for social facilities to be viable efficient as most people are close to the points of service.
Polycentric	Polycentric catchments have more than two points of concentration. When it comes to social facilities, they also provide the benefits mentioned in the previous two categories.
Scattered Dense	These types of settlements allow for a ease of reach of services by the population. When facilities are smaller in size, the continuous dense settlement arrangement can lead to these facilities being overburdened and consequently being run down. However, if the facility is of the right size, planners need not to worry about facilities being underutilized.
Scattered Clusters	Scattered clusters present a challenge in service delivery. This is because, even though each cluster is dense concentration of settlements, each cluster alone doesn't usually meet the requirements to warrant a viable facility. Thus planners are forced to group them so as to get the population to be big enough to warrant a facility. However, distance usually emerges as an issue because all facilities have distance constraints.
Scattered Sparse	These types of settlements are one of the most challenging when it comes to service provision. The sparseness of the population means social facilities cannot get enough population within a reasonable distance for them to be viable. These areas are usually serviced with mobile facilities.
Dense	Dense settlements are good for service provision and high densities allow for efficiency and shorter travel distances to the facilities.
Sparse Linear	Settlements that fall into this category are the most challenging to provide services to. Their linear and sparse nature plays a huge role in facilities not getting enough people within shorter distances so as to be viable. Mobile facilities are usually used to overcome this shortfall.
Dense Linear	The linear nature of these settlements presents challenges when it comes to distance to a facility. The density compensates for this shortfall by providing enough people to support a facility.

This information has been prepared for catchments across the entire country. This information is available as an online toolkit which is designed to help in planning for service delivery. The toolkit can be accessed at: www.socialfacilityprovisiontoolkit.co.za. To ensure morphology is used to inform service delivery, training and roll out of the results have been undertaken but still requires more formal adoption to ensure that planners are obliged to consider morphology when planning social facility development. The toolkit incorporates a planning application guide (also available in the above mentioned online tool); that provides a step by step guide on how to apply planning standards for social facilities placement/distribution, and how the morphology should be taken into account to assist decision makers in making informed decisions to better serve communities.

Research Contribution

Each catchment was classified according to the mentioned nine morphological classes. These nine classes also informed the application guidelines developed along with the differentiated facility provision standards for use in rural areas developed by CSIR for DRDLR (Available here: https://www.socialfacilityprovisiontoolkit.co.za/attachments/Guidelines_for_differentiated_provision_of_social_services_web.pdf?etag=true). The morphology and the catchment profiles provide a better informed framework for service delivery that speaks to both equity and efficiency. Prior to this study, no evidence of similar morphological classification of service catchments for the whole country could be found. The results presented in this study provide evidence for more informed decision making with regard to facility location as it more closely relates to settlement morphology and service delivery.

6. Concluding Remarks

Service delivery is one of the duties of every government around the world. Rural areas have been relatively overlooked. Where development has occurred it is often reactive to service protest or a result of ill planned but well-meant very local donor investment. Efforts to deliver services in these areas have been met with challenges as the absence of sufficient information and lack of understanding to adequately respond to settlement patterns has often undermined service provision. Consequently, one finds that facilities are not optimally located to best serve the wider community. Poor facility location and delivery is exacerbated by limited financial resources as well as development of facilities that are too large and cannot be efficiently operated and become white elephants and operational burdens.

In light of this challenging task of delivering services efficiently to sparse areas, the CSIR has developed a scientifically sound approach and provided a framework to support informed decision making that has the potential to make planning for social facilities more spatially aware. This paper presents an advanced GIS approach to analysing spaces which puts emphasis on the morphology of settlements as this is viewed as the key informant in service delivery for any area. The analysis identified nine types of settlement morphologies common in the South African landscape. With this information, service providers and planners can be better positioned to achieve efficiency in the distribution of services while not neglecting equity. The morphological information has the potential to have an important input to facility location planning in rural areas where detailed accessibility planning is not affordable or possible. The use of the morphology to guide location and size of facilities is outlined in the application guide (found in the toolkit) which is designed to assist planners in planning for service delivery and addressing any morphological challenges.

The key limitation in the research is that the best available dataset of buildings in South Africa, the SBC, does not take into account the type of building, i.e. high rise vs single dwelling, residential vs commercial buildings, or the population per dwelling. The SBC is based purely on observed building patterns. Constraints on computing power available also meant that it was not feasible to use a more detailed grid, though we do not believe that it affected the results significantly. We did not use road condition and this would have affected some catchments where some road are very good and others extremely bad. Currently, the catchments have no indication of where the actual settlements are within the catchments. A data set that marks out only the inhabited areas would help improve the use value of the catchments.

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