CREATING A LAND SUITABILITY INDEX FOR THE NEW PRIORITY HUMAN SETTLEMENTS & HOUSING DEVELOPMENT AREAS: A FOCUS ON EKURHULENI, SOUTH AFRICA

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ABSTRACT

Spatial transformation has been a challenge since the dawn of South Africa's democracy in 1994. The spatial form throughout the country was designed in a racially segregative manner which led to a change in policy over the years to make meaningful efforts to transform this narrative through various strategies. Recently, the Human Settlements Department designated specific areas for developing subsidised low-cost housing to address the housing backlog in South Africa as well as channel development in these priority areas. While this may be progressive it is however unknown how much of this land located within the Priority Human Settlement Priority and Housing Development Areas (PHSHDA's) is developable and how much of it is state owned and therefore making it readily available. This study investigates the City of Ekurhuleni as a study area, which has approximately 160 000 households living in informal settlements that need to be housed. Using Evidence-Based Planning, the Multi-Criteria Decision Analysis and the Analytical Hierarchy Process (AHP) were employed to develop a Planning Support System to determine land suitability within the PHSHDA in the City of Ekurhuleni, in South Africa. The results indicate that only 33% of the land located within the PHSHDA is highly suitable for housing development, with 23% moderately suitable, 21% marginally suitable, and 23% unsuitable for housing development. The results also indicate that 35% of the vacant land owned by the City of Ekurhuleni is located on highly suitable land within the PHSHDA.

KEY WORDS: Informal Settlements, Human Settlements, Decision Support Systems, Evidence Based Planning, Multi-Criteria Decision Analysis

1. INTRODUCTION

1.1 South Africa's Spatial History

The history of spatial planning and housing provision in South Africa cannot be narrated without the mention of colonial and apartheid laws and planning practices that sought to bifurcate the society primarily on racial lines (Smith, 1992; Lemon, 1976; Cell, 1982). At the centre of apartheid planning was the creation of racial zones and 'group areas' designed to radically fragment the society on racial and ethnic lines (Beavon, 2004). The logic of racial planning saw the promulgation of laws and planning instruments that prioritised the development of the so-called 'White areas' – as these were well-serviced with basic services such as water, electricity, and other related urban amenities and infrastructures (Dewar, 1995; Mabin, 1992).

While the apartheid and colonial state provided some limited housing for Black people in towns; these bounded spaces were not only used as reservoirs for the reproduction and subsequent exploitation of cheap labour. 'Locations' or 'townships' as they were called, were designed as dormitory areas that allowed the state to effectively regulate and monitor Black people's everyday lives and activities. As Demissie (2004) avers, housing delivery during the colonial/apartheid times was used as one of the modernist technologies of 'controlling' and 'civilising' the so-called natives. The colonial/apartheid legislative and planning architecture was designed to promote radical spatial fragmentation, with racism as its fatalistic foundational logic.

Given this backdrop, it was imperative for the post-1994 government to move away from racial planning practices, towards non-racial and inclusive planning policies and practices (Huchzermeyer, 2003; Binns et. al., 2002). As such the so-called 'post-apartheid' South African planning milieu was to be predicated on the promulgation of democratic planning laws and plans aimed at spatial and racial integration. So, the discourse and practice of provision of housing, and later, the establishment of sustainable human settlements continue to characterise South African planning to this day.

Thus, it is imperative for South Africa, and the City of Ekurhuleni to continue to advocate for policies that are aimed at stitching the city's fragments together. The Priority Human Settlements and Housing Development Areas (PHSHDA) for instance, as ambitious as they are – must consider the protracted history of uneven development in South Africa, as well as other pressing challenges such as unequal land ownership patterns, and the brutality of global capitalism and its effects on local processes of urbanism.

1.2 Background on Priority Human Settlements and Housing Development Areas

The PHSHDAs have legislatively been declared in terms of Section 3 of the Housing Act (No.107 of 1997) read in conjunction with Section 7 (3) of the Housing Development Agency Act, 2008 (No. 23 of 2008), the Spatial Planning and Land Use Management Act (SPLUMA) (No. 16 of 2013), and the Infrastructure Development Act (No. 23 of 2014) in South Africa. The purpose of establishing PHSHDAs was to advance human settlements spatial transformation and consolidation by ensuring that the delivery of housing is used to restructure and revitalize towns and cities, strengthen the livelihood prospects of households, and overcome apartheid spatial patterns by fostering integrated urban forms (Monama, et al, 2022) The PHSHDAs are underlain by the principles of the National Development Plan (NDP) and related objectives on the National Spatial Development Framework (NSDF) and the Integrated Urban Development Framework (IUDF) (Brand and Drewes, 2021; Green, 219; Schoeman, 2019).

1.3 The Importance of Planning Support Systems

Despite the spatial problems that South African cities face, from a global perspective, there is no doubt that cities are evolving, and technology has recently become more critical in the development of cities, to allow for more efficient and innovative solutions to be established for each city to function optimally.

Given the need for cities to become smarter, strategic planning needs to come into play. PSSs have the potential to play a role in creating smarter cities in South Africa by applying smarter and scientific planning solutions to foster long term spatial planning to transform the urban form. However, in planning for smarter cities, the willingness of planners to transform spaces as well as the current systems put in place can hinder the process of us seeing beyond the present and therefore future spatial planning as a form of transformation must be explored.

The smart city concept, big data, digitisation, and open access to government data repositories have emerged in the academic and professional work of urban planners in recent times (Geertman, et al, 2017). The use of PSS to advance planning plays a critical role in the development of cities, given the shift towards the digital paradigm (Geertman, et al, 2017). From a geomatics perceptive, a smart city can be described as fully integrating, digital cities that use cloud computed technology and the internet of things for development purposes (Li et al, 2013). Li et al (2013) further differentiate smart cities and digital cities, by saying that digital cities reside in cyberspace and smart cities belong to cyber physical space. Since cities are moving towards being smart and digital, according to research, however, this approach is rarely used in the day-to-day duties of planning professions which leaves a gap between planning communities and modelling (te Brömmelstroet, 2013). While technology is fast-growing and seeping into city development and urban planning, research indicates that planners find PSS too generic, inflexible, too complex as well as orientated not to the actual problems but to technology itself (te Brömmelstroet, 2010). Nevertheless, Planning Support Science is designed around the focus on giving support to planners rather than focusing on just the system side of planning support (Greetman, 2013; Bani et al, 2019).

1.4 Evidence Based Planning (EBP)

Evidence-Based Planning (EBP) defined as the ability to provide scientific evidence to solve a problem so that solutions may be found (Barton & Harphan, 2010), urban planners are able to move away from making decisions on mere opinions and poor judgment but a collecting and analysing data about a problem (Barton & Harphan, 2010). For example, Barton & Harphan (2010) also state that policymaking has become more reliant on evidence-based planning to allow for more quality and informed decision making. It is then observed that the nature of Planning Support Systems is the ability to provide evidence-based planning that will enable urban and regional planners to make spatial and land use decision that come from an informed place. By following this method of planning, it instils a lot more confidence in both the practitioners and the public. Often it also provides more professional political decision making and increased public trust with the citizens (Barton & Harphan, 2010). Evidence-Based Planning from a political perspective has the advantage of also increasing service delivery by providing, amongst other things, accurate, dependable and up to date data (Barton and Harpham, 2010).

As cities are moving towards being smart, digital cities can also be defined as cities that are informed by evidence-based planning. Furthermore, with all the information that currently exists on cities, Planning Support Systems are foreseen to become even more successful. Additionally, with enormous quantities of this information on cities, Planning Support Systems will channel information to be of use for decision making.

2. METHODOLOGY

This section includes our study area and provides a step-by-step approach on how the land index for City of Ekurhuleni was developed. It is a GIS-MCDA approach that is robust and able to assist planners to make evidence-based decision making. (Ching and Ferreira, 2015; Hongoh et al, 2011).

2.1 Study Area

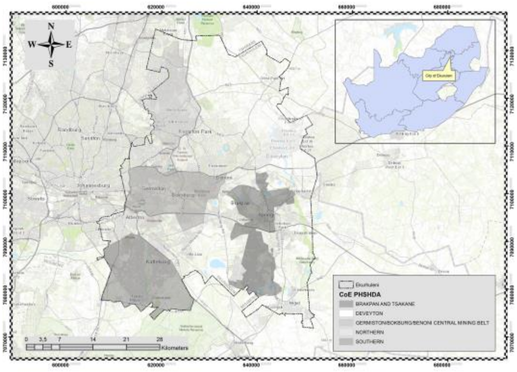

Figure 1: Study Area - City of Ekurhuleni

The City of Ekurhuleni area consists of an amalgamation of nine towns that incorporate former black townships. City of Ekurhuleni is located within the Gauteng Province of South Africa and is located next to the City Johannesburg and City of Tshwane (Figure 1). Each town or Central Business District (CBD) comprises of suburban areas, industrial areas, and townships with a surface area of 1975 km2 and a population of 3,178,870 inhabitants (City of Ekurhuleni 2020).

2.2 Criteria Selection

Selection of the criteria was guided by literature on human settlements, urban planning, smart cities, national policies such as the National Development Plan (NDP), and the needs of the City of Ekurhuleni (UN-Habitat 2010; National Research Council 2009; NEAT GIS Protocols 2010; Kumar, and Shaikh, 2013; Xia and Dong, 2019). The criteria were condensed to 13 so as to reduce complexity and redundancy. Similarly, the criteria had to be logically sound and consistently relate to the objective of identifying developable land in the City of Ekurhuleni.

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2.3 Computing the Land Suitability Index

To generate the Land Suitability Index, the Weighted Linear Combination (WLC) in ArcGIS software was utilized where S*i* is the total score of the developability for a land unit is calculated using the following equation:

$$S_1 = \sum_{i=1}^{n} W_i P_i$$

Equation 1: Weighted Linear Combination

where W*i* of each criterion is calculated using the AHP, P*i* represents the value of each criterion based on corresponding standards and n is the number of criteria. The Land Suitability Index was reclassified to a range6 of 1–10 where 1 is unsuitable and 10 is highly suitable land. Field validation visits were also conducted to determine the accuracy of the Land Index.

2.4 Assigning Criteria Rule Sets and Mapping

This section involved collecting spatial data for the criteria and assigning rule sets. The spatial data for this research was mostly collected from the Council of Geosciences, and the City of Ekurhuleni.

Table 1: Criteria Rule Sets

Thereafter the data were then stored and processed in a geodatabase. Subsequently the rulesets for each criterion were identified from literature (Musakwa et al. 2017). Consequently, using the rule sets maps for each, criteria were categorized using a suitability scale of 1-4, where 4 is highly suitable, 3 is moderately suitable, 2 is marginally suitable and 1 is unsuitable. Literature was used in the categorisation of rulesets (Wang et al, 2019). From the criteria and the rule sets one can then define suitable land for developing well-located smart and sustainable human settlements in cities.

Criteria	Weight (%)	Rank
Dolomite	21.1%	1
Shallow Undermining	17.6%	2
Mining Areas	15.7%	3
Degraded Areas	11.3%	4
Hydrology	8.3%	5
Rivers	5.6%	6
Elevation	4.6%	7
Integration Zones	2.8%	8
Informal Settlements	2.9%	9
Major Towns	2.7%	10
Roads	2.5%	11
Train Station	2.5%	12
Airport	2.5%	12

A consistency ratio of 1.6 for the pairwise matrix was realized indicating that there were no significant logical inconsistencies in the matrix.

Table 2: AHP Pairwise Comparison Results

Criteria	Highly Suitable	Moderately Suitable	Marginally Suitable	Unsuitable
Dolomite	Areas without dolomite	N/A	N/A	N/A
Shallow Undermining	>3km	1-3km	1-2km	<1km
Mining Areas	>15km	10-15km	5-9km	<5km
Degraded areas	>3km	1-3km	1-2km	<1km
Hydrology	>3km	1-3km	1-2km	<1km
Rivers	>3km	1-3km	1-2km	<1km
Elevation	1200-2000m	200-400m	401-1200m or 2001-2500m	Sea level, <200m or N2500m
Integration Zones	>1km	1-2 km	2-3 km	<3 km
Informal Settlements	>2 km	2-4 km	4,1-6 km	<6 km
Major Towns	>5 km	5-9 km	10-15km	<15 km
Roads	>1km	1-2 km	2-3 km	<3 km
Train Stations	>1km	1-2 km	2-3 km	<3 km
Airport	>5 km	5-9 km	10-15km	<15 km

3. RESULTS

Figures 2, shows the land index on a scale of 1–10, where 1-3 is defined as unsuitable for development, 4-5 as marginally suitable, 6-7 as moderately suitable and 8-10 highly suitable.

Table 3 shows the percentage areas of the highly suitable land in the City of Ekurhuleni. The result indicates that only 29% of the land in Ekurhuleni is highly suitable, with 26% being marginally suitable, whilst 22% is moderately suitable and 24% unsuitable for development. From Figs. 2 it is derived that the bulk of highly suitable land is in the north-western and south-eastern part of city and around the major CBDs and activity corridors in Ekurhuleni such as Kempton Park, OR Tambo international airport, Springs, Brakpan and Tsakane.

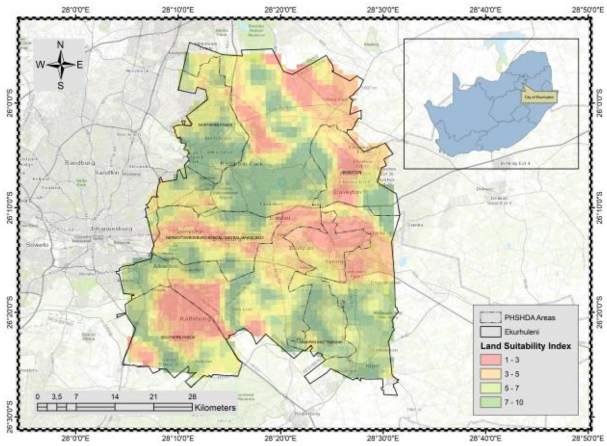

Figure 2: Land Suitability Classes Map

Table 4 also indicates that only 33% of the land located within the PHSHDA's is highly suitable for development, while 23% is moderately suitable, 21% marginally suitable and 23% unsuitable. The most thought-provoking results are derived from Table 6, illustrates that the Southern PHSHDA, although very well connected in terms of rail transport, with immense potential, it is found that 43% of the land is unsuitable for development, with only 14% highly suitable. We also see from Annexure A and table 7 that the Daveyton PHSHDA has the highest percentage of highly suitable land at 62% and only 10% unsuitable, with 22% marginally suitable and 6% moderately suitable for housing development.

Table 3: Land Suitability Classes in Ekurhuleni

Land Suitability Classes	Suitability land Index	Percentage Area	Hectares
Unsuitable	0-3	24	58495,84
Marginally suitable	3-5	22	53514,93
Moderately suitable	5-7	26	63695,31
Highly Suitable	7-10	29	71128,18
Total		100	246834,25

Moreover, it is also found that only 35% of the vacant land owned by the city of Ekurhuleni within the PHSHDA's is located on highly suitable land, with 23% located on moderately suitable land, 17% on marginally suitable land, whereas 25% is located on unsuitable land.

It is vital to note that the above statistics and maps as are only an indication of where suitable and well-located land is located for low-cost subsidised housing development, in Ekurhuleni. The Land Suitability Index therefore provides a structured and scientific procedure of identifying land for future development unlike the current ad hoc systems.

Table 4: Land Suitability PHSHDA percentage

Land Suitability Classes	Land Suit-ability index	PHSHDA Percentage Area	Hectors
Unsuitable	1	23	47088,14
Marginally suitable	2	22	41625,0
Moderately suitable	3	23	47564,96
Highly Suitable	4	33	71128,18
Total		100	202763,40

Table 5: Vacant Land Percentage in PHSHDA

Land Suitability Classes	Land Suitability index	Vacant Land Percentage Area	Hectors
Unsuitable	1	25	46958,62
Marginally suitable	2	17	32956,25
Moderately suitable	3	23	43962,26
Highly Suitable	4	35	66095,663
Total		100	189972,79

Table 6: Southern PHSHDA Percentage

Land Suitability Classes	Land Suitability index	Southern PHSHDA Percentage Area	Hectors
Unsuitable	1	42	14191,22
Marginally suitable	2	15	5201,08
Moderately suitable	3	28	9547,20
Highly Suitable	4	28	4750,33
Total		100	33689,83

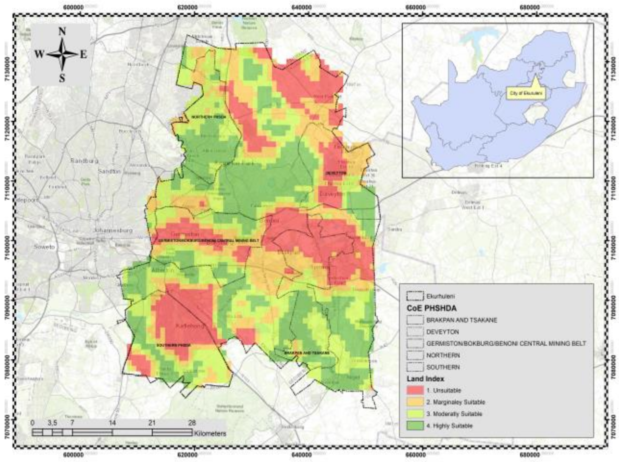

Figure 3: Land Suitability Index

Table 7: Daveyton PHSHDA percentage

PHSHDA	Land Suitability Classes	Land Suitability index	Percentage	Hectors
DAVEYTON	Unsuitable	1	10	5053,39
	Marginally suitable	2	22	11608,57
	Moderately suitable	3	6	3242,07
	Highly Suitable	4	62	32439,44
	Total		100	52343,46

4. CONCLUSION

This research therefore looked at how the development of a land suitability index can assist the City of Ekurhuleni in identifying suitable and well-located land for low-cost housing purposes within the newly declared Priority Human Settlement and Housing Development Areas. This was done using the Multi Criteria Decision Analysis (MCDA) and the Analytical Hierarchy Process (AHP) tools to develop a Decision Support System. This was done using criteria such as, dolomite, shallow undermining, road connectivity, wetlands, informal settlements, train stations, major town, airport, rivers etc.

Although the Priority Human Settlements Development Areas were established by the Department of Human Settlements, the results demonstrate that only 33% of the land located within the PHSHDA's is highly suitable for development with 23% unsuitable for development. The Southern PHSHDA has the highest percentage of unsuitable land for development, at 42%.

The Land Suitability Index, therefore, is a tool that may assist planners in
streamlining decision making as well as making evidence based decisions that can lead to attaining smart city status and reversing spatial planning effectively brought about by the legacy of apartheid.

Given these results, there is also great opportunity for new housing construction and engineering technology to be developed on land that is deemed to be unsuitable due to various constraints such as dolomite, wetlands, and shallow undermined land in the city.

Assuming this, the land suitability index can be viewed not only as a technical tool but an enabler that ensures that mistakes of the past in land identification and settlement creation are not repeated while ensuring that the potential of urban areas is maximised when people, jobs, livelihood opportunities and services are aligned (Integrated Urban Development Framework 2014).

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ANNEXURE A

PHSHDA	Land Suitability Classes	Land Suitability index	Percentage	Hectors
SOUTHERN	Unsuitable	1	42	14191,22
	Marginally suitable	2	15	5201,08
	Moderately suitable	3	28	9547,20
	Highly Suitable	4	28	4750,33
	Total		100	14191,22
NORTHERN	Unsuitable	1	8	4216,73
	Marginally suitable	2	7	3856,38
	Moderately suitable	3	32	17665,56
	Highly Suitable	4	53	29187,92
	Total		100	54926,59
DAVEYTON	Unsuitable	1	10	5053,39
	Marginally suitable	2	22	11608,57
	Moderately suitable	3	6	3242,07
	Highly Suitable	4	62	32439,44
	Total		100	52343,46
BRAKPAN TSAKANE	Unsuitable	1	28	18507,50
	Marginally suitable	2	28	18171,28
	Moderately suitable	3	17	10949,54
	Highly Suitable	4	28	18382,91
	Total		100	66011,24
GERMISTON BOKBURG BENONI CENTRAL MINING BELT	Unsuitable	1	24	23497,28
	Marginally suitable	2	21	20509,13
	Moderately suitable	3	17	16943,92
	Highly Suitable	4	39	38933,10
	Total		100	99883,42

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