The strategically located land index support system for human settlements land reform in South Africa

Creating sustainable human settlements is fundamental in fostering spatial and socio-economic integration in South Africa. Policy makers are often faced with the problem of identifying strategically located land for human settlements land reform in South Africa. To date there is no tool or standard framework that assists the government to identify land that is strategically located for land reform. This study proposes the use of Geographic Information Systems (GIS), and Multi-Criteria Decision Making (MCDM) to develop a Strategically Located Land Index (SLLI) deployed in a web viewer to identify land that is smart for human settlements land reform. The study demonstrates that GIS, MCDM and the SLLI are invaluable tools in facilitating streamlined, coordinated, standardised and evidence-based decisions for human settlements land reform. However, there is need for capacity building in government departments responsible for land reform and development planning for the SLLI to be fully utilised.

Key words. GIS-MCDA, land reform, located, SLLI, Human settlements,

1 INTRODUCTION

The development of cities and nations is underpinned by the existence of sustainable human settlements. The quality and aesthetics of housing as well as its proximity to other related urban amenities such as schools, road networks, places of worship and open spaces, and economic opportunities form the bedrock of sustainable human settlements. In building houses, land becomes ‘an up-front component’ (Huchzermeyer, 2003, Harrison, Huchzermeyer, & Mayekiso, 2003). The availability and accessibility of land as well as its proximity or distance from other supporting physical, social and environmental infrastructure determines both the functionality as well as the desirability of cities.

In South Africa, the colonial and apartheid spatial planning practices deliberately created cities, towns and homelands (Bantustans) fragmented on racial and ethnic lines (Harrison, Huchzermeyer, & Mayekiso, 2003). The Natives Land Act No. 27 of 1913 and the Group Areas Act 41 of 1950 prohibited Africans from purchasing or leasing land outside the homelands. As a result, Africans were located in townships and hostels far removed from urban amenities such as water, electricity, schools and places of entertainment. The so-called ‘white cities’ (i.e. where white people resided) were well positioned spatially, and well serviced with amenities needed for a fulfilled urban life. The fact that black townships were located far from areas with economic potential rendered them not strategically located from a service delivery point of view. Consequently, the current urban and housing challenges in South Africa have its roots in the history of land dispossession and segregatory policies. Williams (2000) therefore argues that the cumulative impact of these racially contrived planning frameworks resulted in South Africa having “Islands of Spatial Affluence” in a “Sea of Geographical Misery. Therefore, there is a strong need to identify land that is strategically located to ensure spatial and social integration.

South Africa’s skewed land ownership patterns are further complicated by the global and local calls for sustainable environmental planning (World Commission of Environment and Development, 1986). The realities of climate change and the subsequent threats to food security and development at large, requires the state and its developmental partners to preserve natural capital. South Africa therefore finds itself in a space where demands for social justice at times compete with international obligations for protecting environmental assets. Balancing the relationship between poverty, inequitable access to resources, land reform and the protection of biodiversity, remains a challenge to the South African government (Crane, 2006). The creation of biodiversity and mega-reserves on one hand, and the demands for developments in the built environment requires a scientific approach that can assist the state to ascertain the best-possible land for these competing activities (Ramutsindela, 2003). Hence, the significance of a geographic multi-criteria approach to land identification proposed herein.

A number of frameworks and legislations to support government developmental strategies including land restitution and redistribution were introduced since the dawn of democracy in 1994 (Kepe & Tessaro, 2014). To accelerate the rate of land redistribution and restitution in South Africa, the South African government seeks to follow a structured approach to land acquisition. Cabinet decided in 2009 to implement the Comprehensive Rural Development Programme (CRDP), and use it as a blueprint for land development and use. It was determined that quality of land and its location are critical when acquiring land. Sector departments such as, The Department of Rural Development and Land Reform (DRDLR) does not have a guideline or framework that clearly outlines what land is referred to as "strategically located" for establishing human settlements. Likewise, The Minister in the then Department of Land Affairs noted that at least 50 per cent of government land reform projects have failed to make their beneficiaries permanently better off (Centre for Development and Enterprise (CDE), 2008). Furthermore, the land reform had a rural bias without making a significant impact in improving spatial integration in urban areas. Moreover, according to the National Development Plan, there is a strong desire to create smart and sustainable human settlements. Similarly, some land acquisitions where people have resettled have been un-strategic as there are little amenities present (Bradstock, 2006). Identifying this strategically located land is more than formal, nominal or constitutional validity (Williams, 2000). Therefore, the aim of this paper is to propose a Strategically Located Land Index (SLLI) using Geographic Information Systems (GIS) and Multi Criteria Decision Analysis (MCDA). This provides a powerful and smart spatial decision support system that makes it possible to identify land that is strategically located for human settlements land reform.

The remainder of the paper is structured as follows: a look into the state of Geographic Information Systems and Multi Criteria Decision Analysis (GIS-MCDA) in spatial decision support systems for land suitability followed by the methods, results and discussion on the usefulness of the SLLI.

2 GIS-MCDA IN SPATIAL PLANNING

Various methods to identify land suitable for establishing smart human settlements exist. These tools are even more useful in the 21st century where there are global problems such as climate change, sustainable development, urbanisation and land reform in the developing world. Numerous studies show that the lack of carrying out of land suitability analysis especially for human settlements can result in degradable land and settlements not being smart (La Rosa et al., 2014; Malczewski, 2006b; Pinto-Correia & Carvalho-Ribeiro, 2012; Puertas, Henríquez, & Meza, 2014; Thapa & Murayama, 2008; Zhou, 2015). Using land unsuitable for such use results in negative environmental costs (Lui et al., 2014). Assessing land suitability is crucial as every portion of the landscape is characterised by a different set of features that render it more suitable for certain uses than other uses (Heacock & Hollander, 2011; Kliskey, 2000; Marull et al., 2007; Park et al., 2011; Pourebrahim, Hadipour, & Mokhtar, 2011).

Urban Planners have leveraged the use of GIS-MCDA in identifying land that is suitable to establish communities and urban amenities (Hamzeh et al., 2015; Jelokhani-Niaraki & Malczewski, 2015; Malczewski, 2006b). It is essential to combine GIS and MCDA in developing Spatial Decision Support Systems (SDSS). Conventional MCDA techniques are often non-spatial and assume that the area under analysis is spatially uniform. Consequently, this makes MCDA unsuitable for spatial analysis and thus it is not suitable for urban planning. Despite MCDA's potential to be integrated into solving urban planning problems related to spatial entities, multi-criteria decision analysis remained in operational research and management fields for a substantial period of time as decision support systems (Phua & Minowa, 2005). It is only recently (last two decades 1990's and 2000's) as a result of improved technological capabilities that MCDA has addressed spatial problems.

Similarly, GIS technology is inadequate in decision-making capabilities (Malczewski, 1999; 2003). It cannot fully address complexities associated with resource management issues such as identifying strategic land for human settlements land reform (Laskar, 2003). Moreover GIS has limitations in representing judgements, values, arguments, combining the decision maker's preferences and heuristics into the problem-solving process (Jelokhani-Niaraki & Malczewski, 2015; Malczewski, 1999, 2006a, 2006b; Malczewski, 2006b). However, GIS remains a useful tool for handling physical suitability analysis. Consequently, there is need of combining GIS with other approaches used during land suitability analysis to create smart human settlements.

Concerning the specific literature on MCDA, a Scopus search returned 1286 articles whereas when limited to GIS-MCDA 39 articles were found (Figure 1). There has been a significant increase in the GIS-MCDA research since 1996 as a result of advances in the field of GIS and MCDA, which makes integration possible. Integration frameworks combine GIS capabilities of data acquisition, storage, retrieval, manipulation and analysis and the capabilities of MCDA techniques for aggregating geographical data (spatial) data and the decision maker's preferences into a one-dimensional value to make a decision (Hamzeh et al., 2015; Jelokhani-Niaraki & Malczewski, 2015; Pourebrahim et al., 2011). Combining MCDA and GIS techniques reduces complexity in the decision-making process. Effective multi-criteria decision analysis in solving complex problems such as land reform is only possible with input from GIS analysts, decision makers, and professionals in the spatial planning domain (Van Niekerk, 2008).

[Insert Figure 1 here]

The increase in the volume of GIS-MCDA research can also be attributed to a number of reasons. According to (Malczewski, 2006a), this was because of, first, a wider recognition of decision analysis and support as an essential element of GI science initiatives on 'Spatial Decision Support Systems (SDSS)', secondly the availability of low-cost and easy-to-use MCDA software and mathematical programming techniques and thirdly, the proliferation and availability of MCDA modules in such systems as IDRISI (Eastman et al. 1993).

Studies in which spatial decision support systems technology has been used for land management are well documented in the literature. Arnold et al. (2000) designed specific tools to address urban sprawl. These tools were designed to understand what effect land use change has on water quality. Sanders and Tabuchi (2000) provided local planners in the United Kingdom with an SDSS to analyse flood risk. Some spatial decision systems have been developed as standalone programs, while others are solely web-based. These include the 'What

If?' system (Klosterman, 2008) and the Wide Bay-Burnet Regional Information System (WBBRIS) respectively (Pettit, Shy & Stimson, 2002). Petit et al., (2015) extended the 'What If?' as an online tool that can be used for scenario building as well as a tool for walkability analysis in neighbourhoods for Australian cities. Other systems have been developed mainly to visualise potential spatial developments. Such systems include GAME and Key to Virtual Insight (K2vi) (Geertman & Stillwell, 2004). GAME was developed to evaluate plan-based scenarios on land development in New Jersey USA, whereas K2vi allows users to manipulate and analyse two-dimensional and three-dimensional data within a virtual reality environment to assist in sustainable urban design in Auckland, New Zealand. Likewise, Abdullahi et al (2015) designed a GIS-MCDA to evaluate mixed land use development for a compact city in Malaysia. Van Niekerk et al., (2016) used GIS-MCDA to develop a planning support system to model growth potential in towns of the Western Cape province in South, Africa. Despite the proliferation of GIS-MCDA tools in land suitability there are limited GIS-MCDA studies and tools that have been explicitly developed to support and inform decisions regarding land reform. Although esteemed institutes such as the Gauteng City Region Observatory (GCRO) and African Centre for Cities (ACC) in South Africa have GIS systems, they hardly do focus on land suitability and urban land reform in particular. Notwithstanding this, the GCRO, ACC and Todes et al., (2015) are instrumental in stimulating robust debate in urban policy issues.

3 APPROACH AND METHODOLOGY

This section provides a step-by-step approach on how the SLLI for human settlements land reform in South Africa was developed. Identifying land suitable for land reform is a complex process. The approach taken to develop the SLLI involves using GIS-MCDA. A consultative, participatory, anticipatory and collaborative approach was employed to improve user acceptance within the DRDLR (Figure 2). The process involved criteria identification, criteria weighting, mapping and assigning rule sets and generating the strategically located index. The mapping, assigning of rule sets and computing of the SLLI was done using ArcGIS 10.2 and the model builder tool in ArcGIS 10.2

[Insert Figure 2 here]

3.1 CRITERIA IDENTIFICATION

Criteria identification for identifying strategically located land was carried out through participatory planning workshops (Figure 2). An initial workshop was conducted in September 2013, which consisted of professionals in government departments, consultants, and policy makers. Most of these were officials from various sector departments such as DRDLR, Economic Development, Human Settlements, Agriculture and Cooperative Governance and Traditional Affairs. Selection of the criteria was guided mainly by national legislation and policy documents such as the National Development Plan. The workshop resulted in criteria which were grouped into seven broad themes namely proximity to Economic Development Corridors (EDCs), proximity to Strategic Infrastructure Projects (SIP), proximity to infrastructure, linkages to social amenities and markets, land with unique resources features that provide a competitive advantage, vital infrastructure for social and economic development. These themes produced over 60 criteria, which would make it impossible and complex to develop a GIS tool. Accordingly, a core team comprising academic experts in GIS and town planning, professionals such as Town Planners, GIS professionals, Environmentalists, built environment professionals, Agronomists, Economists from various government departments together with civil society were appointed to streamline the criteria. Literature and human settlement guidelines were also consulted extensively in criteria selection (Bradstock, 2006;

Jelokhani-Niaraki & Malczewski, 2015; Marquet & Miralles-Guasch, 2015; Marull et al., 2007; UNHABITAT, 2010; Van Niekerk et al., 2010). Consequently, the number of criteria was reduced to 14 (Table 1) to make a well-informed decision and also to reduce complexity and redundancy. Table 1 clearly shows that criteria relating to proximity have greater weight because proximity dynamics have a wide array of positive outcomes which include; reduction in vehicle emissions and improving the wellbeing of citizens (Marquet & Miralles-Guasch, 2015). Similarly, the criteria have to be logically sound and consistently relate to the objective of identifying strategically located spaces for human settlements land reform. Likewise, the workshop deliberations also made sure that criteria are realistic, transparent and simple (Saaty 1987).

[Insert Table 1 here]

3.2 CRITERIA WEIGHTING

During a sequel set of workshops with the core team[1] participants engaged in an Group Analytical Hierarchy Process (GAHP) for weighting each criterion using a pair wise comparison matrix for the 14 criteria (Malczewski, 2006b; Saaty, 1987; Satty, 1980). The GAHP was chosen for comparing criteria, because it is a comprehensive method of multicriteria decision analysis (Malczewski & Rinner, 2015). Consequently, the pair wise comparison matrix asks how important one criterion is relative to another based on a 1-9 scale (Table 2).

[Insert Table 2 here]

Workshop participants were given a template with 105 pairwise comparisons of the 14 criteria to complete. This template was computed using the GAHP calculator by Goepel (2014). Consequently, the participants used the GAHP calculator software to create an overall weighting matrix, which involves synthesizing each of the individual's judgments and combining the resulting priorities using a geometric mean (Malczewski & Rinner 2015). This approach is better than the group consensus-reaching model because it relieves the group[2] of the need for a moderator who may be biased, through the use of an automatic feedback mechanism (Dong & Cooper, 2016; Grošelj et al., 2015). The pairwise matrix had a consistency ratio of 0.025, which implies that there were no logical inconsistencies in the matrix. Similarly, the sum of the weight for all the criteria should add up to 1(one) to ensure consistency.

3.3 MAPPING AND ASSIGNING OF RULE SETS

Mapping of the 14 criteria was divided into two parts (1) data collection and geodatabase development and (2) developing rule sets for the each criterion. The spatial data was collected from the DRDLR, the National Geospatial Inspectorate and other government departments. This data was stored into a geodatabase, which was divided into themes, namely environmental/physical and socio-economic GIS layers. This data was assigned Hartebeesthoek_1994 Geographic Coordinates Systems. Rule-sets for each criterion were identified from literature (Durand & Gonzalez-Feliu, 2012; Fafchamps & Wahba, 2006; Leite et al., 2014; Marquet & Miralles-Guasch, 2014, 2015). Accordingly, maps for each criterion were classified using suitability scale of -1 to 2 were 2 is highly suitable, 1 moderately suitable,

[1] Experts in GIS and town planning, professionals such as Town Planners, GIS professionals, Environmentalists, built environment professionals, Agronomists, Economists from various government departments together with civil society y.

[2] Aggregating using an automated algorithm was utilised because it avoids using a moderator or judge who may be biased (Dong & Cooper, 2016. Moreover reaching consensus is almost impossible in the real world, hence utilising the algorithm by Goepel (2014) that ensures consistency and avoids biases.

0 marginally suitable and -1 unsuitable (Table 3). Assigning these rule sets enabled statistical analysis using the Weighted Linear Combination (WLC) to derive the strategically located index. In addition, the classification scale of -1 to 2 enables comparisons, normalisation and simplifies interpretation of the results.

[Insert Table 3 here]

3.4 GENERATING THE STRATEGICALLY LOCATED INDEX

The WLC was chosen to calculate the (SLLI) where S_l total score of strategically located land for a land unit is calculated using the following equation (1)[3].

$$S_l = \sum_{i=1}^{n} W_i \quad P_i \qquad \textit{Equation 1}$$

Where W_i of each criterion is calculated using GAHP, P_i represents value of each criterion based on corresponding standards and *n* is the number of criterion. This approach was selected because it is a risk averse and full trade off solution (Van Niekerk et al. 2016). Nevertheless, when more control is required over the trade off one can apply the Ordered Weighted Average (OWA) (Van Niekerk et al. 2016).

The final SLLI was a raster; however, for ease of use the SLLI values where extracted to points and accompanying criteria justifying each point was attached using structured querying language. The points were also converted to theisen polygons of 500m X 500m containing the SLLI and accompany criteria to improve visualization. Lastly, these polygons where calibrated or reclassified to improve usability using a range of 1-100 where 0-25 represents unstrategic locations, 26-50 marginally strategic, 51-75 moderately strategic and 76-100 highly strategic land to establish human settlements. Extensive validation and accuracy assessments were also carried out to determine if the SLLI and accompanying criterion corresponds. The theisen polygons where later plugged into the SLLI web viewer that mangers could use as a SDSS.

4 RESULTS AND DISCUSSION

Figure 3 shows the strategically located land index for human settlements land reform while Figure 4 shows strategic location for human settlements land reform according to strategic location (suitability classes). From Figure 3 it is clear that land strategic for human settlements (SLLI of 60-100) is mostly located along activity corridors and close to urban areas. Gauteng and Mpumalanga provinces possess the majority of land; however they are also the two smallest provinces in the country. It is necessary for the DRDLR and mangers to identify land for human settlements using the SLLI so as to ensure that people are resettled where there are necessary supporting services and also avoid mistakes of the past where people where settled far away from economic opportunities. Moreover, the SLLI can be used to make comparisons and motivate decisions objectively, unlike the current ad-hoc and subjective manner of acquiring land.

[Insert Figure 3 here]

[3] The summation using weighted linear combination (WLC) was chosen because it can easily be applied within a GIS environment using map algebra operations and the approach is also intuitively appealing to decision makers (Malczewski & Rinner 2015).

In Kwa-Zulu Natal (KZN) the highly strategic land in a dark green shade (SLLI 90-100) is also along development corridors. Likewise, the most strategic land in the Eastern Cape is in the central Eastern Cape. Similarly, in the Western Cape the most strategic land is on the Western Cape seaboard and in the South Western Cape known for their picturesque vineyards.

[Insert Figure 4 here]

Table 4 gives an overview of the amount of strategic land available to establish human settlements in South Africa. Only 7% of the country is highly suitable (SLLI of > 75) for human settlements and 18% moderately suitable. These areas have to be targeted, as they are highly accessible, already contain infrastructure and services as well as supporting land uses. This also confirms the high disparity in South Africa as only few areas are well endowed (Bradstock, 2006). This will most likely lead to further densification and congestion in already established areas, which can ultimately lead to inability to promote sustainability and smart cities. The question therefore becomes, can more growth in these areas be sustained or should growth be channelled elsewhere? Perhaps a paradigm shift in the county is required which focuses on high-rise and high-density buildings as opposed to owning a land parcel.

Forty six per cent of the country is largely unsuitable for human settlements. This poses a challenge in distribution of resources and can have implications in migration patterns as well as hampering plans of creating smart cities. As a result, areas such as Cape Town, Durban and Johannesburg continue to receive migrants and are plagued with service delivery issues and these cities are known to be hotspots for service delivery protests (Tapela, 2013). This may as well suggest that metropolitan cities in South Africa have reached a tipping point.

[Insert table 4 here]

It should be noted that the suitability for human settlements land reform is not evenly distributed within the provinces (Table 5) further highlighting the inequalities in South Africa 20 years after independence.

[Insert Table 5 here]

Gauteng contains the largest (69%) of highly suitable land for human settlements per province, because it is the country’s economic hub, highly urbanised area and yet it is the smallest province in land size (Statistics South Africa, 2011). Continued resettling of people in Gauteng is less costly as Gauteng contains infrastructure and services suitable for human habitation. However, there should be caution as pressure on Gauteng will result in congestion, overcrowding, and damage to the environment and strain on services which can lead to reduced carrying capacity if necessary improvements and adjustments are not made. Gauteng is also identified as highly suitable for agriculture (Musakwa et al. 2014); therefore there is conflict between resettling for agriculture and or human settlements. Consequently, there has to be a tool that facilitates decision-making amongst competing objectives.

Kwa Zulu-Natal contains 30% of highly suitable land and offers a better solution than Gauteng, as it is much larger and also contains infrastructure and services necessary for human habitation, particularly along the coast. The Eastern Cape, Western Cape and Northern Cape are generally harsh environments mainly due to climatic reasons as they have 53%, 57% and 70% of unsuitable land. The highly suitable land in the Cape provinces is mostly along activity corridors and already established towns along the coastline. For example, the City of Cape

Town receives migrants from the Cape provinces as a result of its suitability and strategic location (Kok & Collinson, 2006). This is mainly because the neighbouring provinces (Northern Cape and Eastern Cape contain only 1% and 2 % of highly suitable land. Perhaps there is need to attract investment and to channel development in these areas to improve suitability for human settlements and minimise migration to other provinces.

It is important to note that the above statistics and maps are indicative of where to target areas for land reform to establish human settlements. The SLLI therefore provides a scientific procedure of targeting land for human settlements as opposed to the current ad hoc systems (Hall, 2009). The objective of this study is to propose using GIS-MCDA, a technique that is scientifically grounded in systematically identifying land for human settlements. This is unlike the current systems available at the Housing Development Agency (HDA) that are small scale, which do not employ a structured GIS-MCDA. Furthermore, with the SLLI undesirable and disastrous consequences under the Reconstruction and Development Program (RDP) that established human settlements far away from infrastructure, economic opportunities and services can be avoided. Land reform ultimately needs to make its beneficiaries better off (CDE, 2008). Little or nothing is gained in the long run if justice turns out to be purely symbolic, leave people poorer, or even worse off (CDE, 2008). Accordingly, the SLLI is crucial to complement the political aspect of land reform as it makes sure that land used is suitable for human settlements land reform, leads to spatial integration, densification, does not perpetuate poverty as well as enabling access to opportunities. Tshikotshi, (2009) notes that the post-apartheid government's resettlement programme still locates the urban poor households on the peripheries of the cities, a pattern similar to the apartheid era. Therefore, in light of this, the SSLI 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 as well as ensuring the potential of urban areas is maximised when people, jobs, livelihood opportunities and services are aligned (Integrated Urban Development Framework, 2014).

It should be recognised however that deciding on a piece of land is an optimising procedure, as other factors have to be taken into account. For example the carrying capacity, land uses, dolomite status, conservation, spatial targeting and issues of global climatic changes. Accordingly, the SLLI was deployed on an ArcGIS server to aid in decision-making.

4.1 SLLI VIEWER

The SLLI was deployed as a web application, developed in Adobe Flex and works across browsers with a flash plug-in. This is the first step in centralising and coordination of information within the DRDLR and across government departments. Unlike the raster-based information it is vector based and it is meant to simplify information to facilitate decision-making and increase usability. Moreover, most managers at provincial level are familiar and work with vector (cadastral data) in their day-to-day activities. The SLLI viewer consists of two main layers containing both the agricultural index (Musakwa et al., 2014) and human settlements index with supporting criterion. The purpose of the SLLI viewer is to simplify the daunting task of searching relative information on what land can be best used for. The solution makes available answers to key questions to be asked in order to make the decision on land use.

Figure 5 shows the SLLI viewer-landing page.

[Insert Figure 5 here]

The main functionality of the SLLI viewer is the search function and reporting function. There are two main functions, namely the search by parcel key, and detailed search (Figure 6). For this function Land Managers can search for the index overlaid on national cadastre wherein decision makers can search for a land parcel using the unique land parcel key known as the 21 digit code (Figure 7). Once the search is completed it collates the average index for that particular parcel as well as accompanying criteria. The viewer also has a reporting functionality that allows users to generate pdf reports and Excel file for further analysis (Figure 8).

[Insert Figure 6 here]
[Insert Figure 7 here]

In addition, the detailed search allows users to search for SLLI for human settlements using attributes that are used to filter to the necessary land parcel. This also allows minimizing the results to be returned for reporting and to improve performance on the viewer. Province, District Municipality, Local Municipality are compulsory fields to select before a user can search. These fields are also used to narrow the search to a subset of data and zoom into the area selected.

[Insert Figure 8 here]

The SLLI viewer also contains standard functions such as, identification and measuring tools that can enhance the decision-making process. The SLLI viewer compares well with planning support systems such as the What If? (Petit et al, 2015) in that it is built for Planners. However, the SLLI does not support scenario building like the What If? system. Therefore, in future, there is potential to include scenario building, which would improve the functionality of the tool. Furthermore, both systems (SLLI and What If?, are policy oriented, collaborative systems and utilise cadastral data at a local level which most Planners are familiar with. Additionally, the interface of the SLLI viewer is simple and developed in consultation with the planners to improve user acceptance (Geertman, 2008). Unlike other sophisticated systems such as WBBRIS, the SLLI has potential to be deployed in other developing countries battling with land reform as the SLLI employs replicable standard GIS-MCDA processes. Likewise, there is scope for use of the SLLI not only in human settlements land reform but also as an enabler in sound land use management as what the Spatial Planning and Land Use Management Act (SPLUMA Act of 2013) envisages.

4.2 LESSONS LEARNT AND CHALLENGES

The SLLI viewer has several limitations. Firstly it is a web-based application, only accessible at the DRDLR head office. This can lead to the SLLI system not being readily used throughout the country. A solution is packaging all the data used, the SLLI grids, and supporting data that can be used for querying into a geodatabase digital video disk (DVD). This can then be distributed to managers at provincial level to start using the SLLI tool to assist them in identifying strategically located land. Moreover, the geodatabase requires only ArcGIS software that is available within the DRDLR and other government departments. This will mean that the SLLI will be employed more for day-to-day decision-making, as it will not be dependent on the viewer, and it also requires minimal capital outlay, which is often an impediment to the use of GIS in developing countries (Klosterman, 2001). Further training perhaps is needed to train particularly non-GIS experts on how to navigate and query the SLLI geodatabase. Distributing, training and usage of the SLLI geodatabase will mean decentralisation of functionally and it will also be part of capacity building. Managers will be able to make quick decisions instead of relying on the head office.

Potential users of the SLLI pointed out that the criteria are broad as they are to be utilised for a national geospatial tool to identify strategically located land for land reform for human settlements. However, it was established that there is potential to develop specific sub-criteria for various land uses in cities such as industrial uses and recreational uses. Consequently, there would be a need to develop new tools or viewers that are context specific such as for industry use or recreation. Nevertheless, there was broad consensus that the SLLI is a huge step towards improving identification of strategically located land. Another challenge common to developing countries is the access and availability of data. As a result users are advised not to alter the current state of the SLLI viewer or the desktop package. Users can only query and obtain results for use. However, with time, when required the SLLI index can be updated using new data obtained. For example, it is anticipated that in the future data such as roads and towns are to change, therefore it becomes critical that the index be updated using such data.

Similarly, it also emerged that there were over-expectations as some users deemed the SLLI as a tool that is supposed to make the decision for them. It should be cautioned that the SLLI viewer is supposed to aid or facilitate decision-making not making the decision for the user (Geertman & Stillwell, 2004). As a result many supporting datasets that enhances querying were included. The SLLI is not the panacea to land acquisition. However, it goes a long way towards making sure that correct, appropriate, smart and suitable land parcels are acquired. It also ensures consistency and objectivity in land acquisition

An additional challenge faced was creating a common ground as well as the need to provide a history of how the SLLI was developed, explaining what it can and what it cannot do. Overall, the users generally acknowledged the utility of the SLLI during the training workshops. However, key issues that have to be solved are capacity and management constraints. Some users indicated that they are not familiar with spatial decision support systems and GIS. Consequently, they found the system intimidating which may hamper its use. This scenario is not only common within DRDLR, but in other government departments and developing countries (Göçmen & Ventura, 2010)

Another issue that was identified is the issue of propriety where it was identified by users that the SLLI could be useful for various government departments with a stake in planning for cities, as the SLLI would add value in their operations. The SLLI viewer has been identified that it could be potentially useful for the Housing Development Agency (HDA). However, at present, functionality across government departments is not available as it is strictly proprietary to one department. Sharing information across departments has been cited as an impediment to the development process (Klosterman, 1995, 2001). Perhaps other departments can make arrangements, as this will greatly facilitate coordination and streamlining of decision-making, which will ultimately lead to efficient utilisation of resources and creation of smart cities. Similarly, a challenge with the SLLI is that it was developed at national level, which possibly implies that municipal powers are usurped and it may mean unwillingness of local government to utilize the SLLI. Therefore, it requires coordination between national and local governments for successful implementation and buy-in. Nevertheless, the political, administration and operational challenges of universal use in government departments is hampered by political interest, operational deficiencies, and general lack of tools to ensure meaningful coordination and successful implementation of land use management tools in South Africa and Africa in general. Ultimately the successful implementation of the SLLI depends on the interaction of macro-level processes with local-level factors, overlapping legal and governance frameworks and, power relations (Lombard, 2015)

Despite the identified technical, operational and political challenges, the SLLI has been generally accepted as a useful tool in identifying land for land reform. However, the success of the land reform program goes beyond using a tool, as concerns of pressure groups with vested interests have to be navigated. The continued success and implementation of the SLLI rests on political buy-in from various stakeholders. Currently, it appears that the SLLI has weathered some of the political storms as it is used as a standard tool within the DRDLR to identify land for acquisition and as a general land use management tool. We also acknowledge that politically connected people who can delay the adaptation of sound land use management tools to their advantage may hamper the universal use of the SLLI.

5 CONCLUSION

This study aimed to develop tools that help identify land suitable for human settlements land reform. A consultative and participatory process using GIS-MCDA was utilised to develop the SLLI. A key component of the SLLI is that it enables streamlining and better decision making based on a scientific basis, unlike the current systems. Consequently, the SLLI can assist through acquisition of appropriate land, which enables creation of smart cities. The SLLI can also be adapted and applied in countries with land reform problems. Similarly, the SLLI can be applied to solve other problems such as identifying land potential. However, the SLLI viewer only guides but does not make the decision. Other factors such as government policy, human judgment and internal process have to be taken into cognisance. Lastly, a multitude of challenges such as capacity issues and political interests have to be navigated for the SLLI to be fully used in practice. Nevertheless, it is a step in the right direction towards a more structured process in establishing human settlements to ensure that cities are smart and liveable for all.

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