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

Walter Musakwa [a,*], Rebone.M. Tshesane [a], Matheri Kangethe [b]

[a] Department of Town and Regional Planning, University of Johannesburg, Johannesburg, South Africa
[b] Agizo Solutions, Midrand, Johannesburg, South Africa

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ABSTRACT

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.

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 on Environment, and Development, 1987). 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

* Corresponding author.
E-mail address: wmusakwa@uj.ac.za (W. Musakwa).

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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% 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, Barbarossa, Privitera, & Martinico, 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 (Liu, Zhang, Zhang, & Borthwick, 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, Pino, Mallarach, & Cordobilla, 2007; Park, Jeon, Kim, & Choi, 2011; Pourebrahim, Hadipour, & Bin Mokhtar, 2011).

Urban Planners have leveraged the use of GIS-MCDA in identifying land that is suitable to establish communities and urban amenities (Hamzeh, Ali Abbaspour, & Davalou, 2015; Jelokhani-Niaraki & Malczewski, 2015a, 2015b; 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, multicriteria 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). 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, 2015a, 2015b; Malczewski, 1999, 2006a, 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 (Fig. 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, Ali Abbaspour, & Davalou, 2015; Jelokhani-Niaraki & Malczewski, 2015a, 2015b; Pourebrahim, Hadipour, & Bin Mokhtar, 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).

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.

Studies in which spatial decision support systems technology has been used for land management are well documented in the literature. Arnold, Civco, Prisloe, Hurd, and Stocker (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, Shyy, & Stimson, 2002). Pettit, Barton, Goldie, Sinnott, Stimson, and Kvan (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, Pradhan, Mansor, and Shariff (2015) designed a GIS-MCDA to evaluate mixed land use development for a compact city in Malaysia. Van Niekerk, Du Plessis, Boonzaaier, Spocter, Ferreira, Loots, and Donaldson (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