Application of GIS at local government level

by Elizabeth Hicken

An exploratory study into the potential of GIS to contribute to the implementation and measurement of sustainability within third-world Africa. This article is a summary of a dissertation which was conducted from 2006 until 2009. Although the overall research and conclusions were broadly African, a South African case study of the municipal environment constituted the primary research.

The research topic was designed to be broad since the work was an exploratory study into the potential of GIS to contribute to the implementation and measurement of sustainability within third-world Africa. Existing global sustainability initiatives such as Agenda 21 [1] and the Millennium Development Goals [2] formed the context of the investigation. The relationship between sustainable development and GIS was explored through the common element of spatially orientated development data. Local government was the setting for the study, specifically South African municipalities. Conclusively, a bottom-up spatial model has been presented as a final recommendation for the conclusions drawn throughout the study.

The primary research was mostly qualitative and not aimed at a quantification of spatial data infrastructure across the country. Rather, the underlying factors effecting the inability of GIS to be adopted and used broadly and successfully within (rural) municipalities was explored. The methodology for the case study mostly included personal interviews with key informants within the government and business sectors of the “municipal GIS supply chain”. The informants were selected to be representative of more than half of South Africa’s municipalities by virtue of their jurisdiction or client-base. Internal government surveys of individual municipalities were also used, and in totality all provinces were included in the research (see Table 1).

<table>
<thead>
<tr>
<th>Type of Institution</th>
<th>Position</th>
<th>Type of research</th>
<th>Number of Municipal Units</th>
<th>Province of operation at time of interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS service provider 1</td>
<td>Director</td>
<td>Primary interview, plus supporting secondary material</td>
<td>22</td>
<td>EC √ FS Gau KZN Lim MP NC NW WC</td>
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<tr>
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<td>Director</td>
<td>Primary interview, plus supporting secondary material</td>
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<tr>
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<td>Unit managers</td>
<td>Primary interview, plus supporting secondary material</td>
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<td>√</td>
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<tr>
<td>Provincial government unit 2</td>
<td>Municipal managers</td>
<td>Preliminary research, including primary surveys</td>
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<td>√</td>
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<tr>
<td>Local municipalities for entire province</td>
<td></td>
<td></td>
<td>29</td>
<td>√</td>
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<tr>
<td>Local rural municipality</td>
<td>Local economic development manager</td>
<td>Primary interview, plus supporting secondary material</td>
<td>1</td>
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Table 1: Interviewees and research methods employed across South African provinces.

**Acronyms**

ICLEI – Local Governments for Sustainability (previously the International Council for Local Environmental Initiatives)

IDP – Integrated Development Plan

MDG – Millennium Development Goal

PGIS – Participatory GIS

**Background and definitions**

In theory, sustainable development is an inexact science and mostly ill-defined, but can be described as a relationship between learning communities and their environments [3-8]. Sustainable development can be described as a process rather than an end-goal [3,9], where continual feedback is required for decision-making, information sharing and communication [3,10] providing a better grasp of socio-environmental systems [3]. The
currently inadequate definitions of sustainable development prompted a redefinition as the progression of humanity towards a lasting condition of peace whereby economic growth, human expansion and changing social conditions adhere to basic human rights, the preservation of our natural environment and planet Earth as a whole. Government institutions are recognised as the underlying paradigm from which sustainable practices should originate, specifically decentralised government units or local authorities (local government) [1,11]. These local governments are best positioned to respond directly to societal, economic and environmental concerns in their communities, particularly within marginalised and underdeveloped African countries [12-14]. This refers specifically to good governance [15] and the grounding of global sustainability objectives in practice. A number of initiatives such as Local Agenda 21 and ICLEI support these concepts. Despite this, the study found little evidence of the systematic and wholly institutional integration of global sustainability objectives within African local governments. Similarly, the use of GIS in rural African local governments was limited to non-existent.

Sustainability, as well as GIS endeavours, were mostly project-based and therefore not part of integrated information and planning systems. The work provided overwhelming evidence of the link between GIS and sustainable development, as is currently evident to the geocommunity. For the purposes of this study this was mostly described as three-fold; in the application of spatially derived development data for sustainability reporting, the daily use of GIS within municipal operations like service delivery, and lastly the use of GIS and spatial data for projects. Africa

On a macro level, the continent is theoretically committed to sustainable development although the majority of its countries are unlikely to meet the 2015 Millennium Development Goal Targets [11,16]. There exists insufficient evidence of the implementation of sustainable development [11,16], particularly within local governments. Also, most GIS and development data mechanisms originate at a national level, with GIS not being used sufficiently within routine decision-support [17]. The failure of these top-down processes to provide local governments with timeous, accurate and applicable data for good governance decisions is evident. However, African governments are increasingly decentralising their public administration processes [18], in recognition that decentralisation promotes democracy and good governance practices [19,20]. Decentralisation is critically important to rural and marginalised communities where poverty is prevalent and resources limited [18,21-26]. It can logically be deduced that developmental knowledge management processes like national statistics systems and spatial data creation be disaggregated as well.

South Africa

South Africa was found to share in the development and governance issues of the broader continent [12,27,28]. Municipalities particularly, are under a lot of pressure to deliver on broader government mandates and other development priorities [29]. However, a lack of clear policies and guidelines at this level has created confusion, weaknesses in performance and underdevelopment [12,30-32]. Although the South African Constitution and other municipal legislation makes allowance for broad sustainable development and good governance practices, these are generally not...
reflected as wholly integrated operational policies or quantitative indicators. This means that there is little foundation for true accountability or transparency in local government processes, and therefore recourse. Similarly, although the Integrated Development Planning process has improved reporting and planning mechanisms, it has not effectively aided in elevating the developmental state of communities.

On a national scale, South Africa is theoretically committed to sustainable development, and it is not only likely to achieve the 2015 MDG targets [33], but is in the process of completing a framework for national sustainability [34]. However, in practice, it is widely acknowledged that South Africa is currently classified as unsustainable [35,36], or at best experiencing status-quo [7]. Unsustainable practices refer particularly to local governments [35,37], and although the National Sustainable Development Framework provides a constructive outline for progress, the document stated that debilitating incapacities at local government level were the result of service delivery failures and therefore that constitutional objectives were not being met [38]. There are a number of causes for these incapacities which will not be expanded upon here. In general, fully established and integrated sustainable development principles and practices were not found to be sufficiently evident in municipalities. This included a limited awareness of global sustainability initiatives and the MDGs.

**The role of communities and participation**

In Africa, particularly the rural areas, communities are typically more marginalised and prone to environmental and economic shocks as well as other major challenges to development [39]. Community participation and local knowledge were identified as significant contributors to sustainable development at ground level, which is supported in the leading global sustainability initiatives and agendas. Local societies are ideally placed to be instrumental in the identification and mitigation of their own needs [10]. Practices supporting more democratised approaches to community management are intrinsic to accommodate the imperfectness of boundary-specific development data (fuzziness). Highly accurate and official spatial data often conflicts with a community's understanding of local resources, and Indigenous Spatial Knowledge (ISK) can more accurately express practical realities [40]. In South Africa, local governments are identified as part of the communities which they serve [41], and the South African ISRDS [39] explains that the role of participation and social consultation is inherent within the information framework needed for integrated rural planning. This is intrinsic to the creation of a knowledge (rather than information) base for planning decisions. The South African Municipal Systems Act mandates municipalities to conduct participation, but places the onus on local government to devise the methods to do this [41]. Participatory GIS (PGIS) is one such approach which ensures equality in information use by those who will be directly affected by it [42].

**Findings of the South African case study**

**Sustainable development**

All parties involved in the primary research lacked a conceptual understanding of sustainable development and the relevant global objectives in this regard. Also, the study produced little evidence of a
formal or systematic linkage between national development data, MDG indicator data and municipalities. Although the municipal Integrated Development Plans provide a sound foundation for the course of municipal activities during a year, they are not required to be prepared in a format which will allow their information to be aggregated numerically or graphically up to national level for comparison and trending. Maps and statistics may accompany, but are not a requirement of, the plans [43]. There currently exists no all-inclusive and integrated method of live feeds of current and maintained municipal data into a central node from which information can be accessed on which to make national policy decisions, or to measure more broadly reaching targets like the MDGs [44,45].

**Development and spatial data streams**

In terms of municipal information substructures, it was confirmed that omissions, duplication, inaccuracies and general inefficiencies in the collection, transfer and use of data impede or delay sustainable governance and development. Within a national context, the case clarified that South African municipalities currently rely on a range of non-aligned information sources from national census data to ad hoc local survey data. This means that limited information is available for baseline indicator creation, trending and analysis, and that ongoing local research is required. The municipalities are mandated to utilise and report on a set of key performance indicators [43], but these are limited insofar as there is not sufficient representation of qualitative, baseline and developmental composite indices [46]. In terms of spatial data, various high level documents exist like the Spatial Data Infrastructure Act, but do not speak of the urgent need for acceleration in data creation, data management processes or alignment of data objectives between sectors. Furthermore, it is acknowledged that a focus needs to be directed to local government in terms of spatial information and management, which is currently lacking, and there is no mention of community participation in the Act. The compilation of a National GIS Strategy is in progress [47,48].

**GIS infrastructure/spatial data infrastructure**

Although most urban centres and certain municipalities appear to be operating GIS units sufficiently well, outlying and rural municipalities generally are not. Most texts explain that the main limitations of GIS are not hardware and software specific, but rather institution and people specific [49-51]. This was reflected strongly in the case study, along with the fact that municipal GIS environments severely lack structure and more specifically, the underlying legislation and policy to provide this structure. Furthermore, GIS activities in South Africa are still top-down [52], and spatial data structures hierarchically exclusive. South African municipal GIS infrastructure was found to be generally weak and a number of critical failure factors were identified as core to this failure. From these, a set of secondary (or resulting) factors were derived. For example, while there is considerable reference within most literature to a lack of resources for South African municipal GIS, this was not listed as a critical failure factor since in several of the case study examples, more than sufficient budgets were available for GIS (and had been for years), but the infrastructure still did not exist. A lack of resources was therefore listed as a secondary factor.

**Critical failure factors (in no particular order):**

- Overall issues of municipal failure (e.g. management issues, poor staffing policies, technical illiteracy, political interference, poor fund management).
- Lack of clear GIS objectives at municipal level.
- Insufficient top management understanding and support of GIS.
- Lack of GIS and spatial data legislation (and policy) at a local level.
- Existing spatial data drivers top-down.

One of the main obstacles to municipal GIS infrastructure was found to be weak coordination in GIS activities and objectives, both horizontally across municipalities and vertically within government hierarchies. A general lack of understanding of GIS exists, which is particularly evident at managerial level. This creates an environment of decision-maker disinterest and jeopardises top-down managerial support. Furthermore, the resources allocated to GIS are not aligned with the overall municipal objectives and solutions are not designed to fit the problems at hand. In general, issues of the municipalities became those of the GIS implementation process, such as understaffing, politics, administrative restructuring, corruption and poor management. Central to these concerns is a deficiency or inaccessibility to key basedata for decision-making and planning. South Africa generally employs a top-down data approach, not only for spatial data but also for development and census data. Unfortunately, the study concluded unequivocally that top-down data creation methods are not suitable for local government use.

The critical failure factors created a set of resultant conditions in municipal GIS infrastructure, and are typically those more commonly referred to. For example; insufficient GIS resources, limited usage and understanding of GIS within municipalities, GIS being seen as an expensive luxury and technically difficult to use, a lack of GIS skills and incorrect staffing procedures, insufficient or poor spatial data and systems not appropriate for the solutions required. Insufficient resource allocation for GIS typically creates substandard systems which perpetuate its negative perception and contribute towards isolated (or discontinued) project development. This results in GIS becoming an isolated function rather than a fully integrated decision-tool across departments. On the whole, it currently appears that there is a struggle for municipalities to adapt to GIS rather than GIS being applied to suit municipalities. Although a number of trends are driving the use of GIS in South African municipalities, the potential for this to continue into a fully integrated national enterprise remains uncertain.

**Recommendations**

Existing insufficiencies in municipal knowledge management prompted the recommendation of a spatially orientated bottom-up development data approach (see Fig. 1). This model describes how locally derived spatial data should be a compulsory requirement of annual IDP reporting, according to a predefined set of
criteria. These criteria would satisfy the development data requirements not only of the municipalities but also of higher government units (like the national census), and other indicator reporting demands. These spatial datasets would conform to national metadata specifications within a set of categories such as fundamental, population and housing, state of environment or services and infrastructure. Integrated within this spatial data model would be a set of municipal GIS objectives driving GIS usage within municipal procedures (see Fig. 2). Intended to be reflected and expanded upon within the municipal mandates, these objectives would serve to increase the everyday use of GIS in local government business. Furthermore, Fig. 2 shows how these GIS objectives would work together with a set of sustainable development objectives for municipalities. In line with existing planning processes, the IDPs would also be required to report on a set of sustainability indicators, as part of a broader set of municipal indicators. Many of these indicators could be derived from the spatial datasets. The application of the relevant hardware, software and GIS procedures would become incidental to these objectives and mandates. For example; a municipal GIS objective could be to maximise the use of PGIS practices, and one method to do this could be to engage local women to verify service delivery. From this combined data, municipal and sustainability indicators would be calculated, for reporting, trending and analysis.

The study found that it was often the case that outlying rural or smaller municipalities could not support robust GIS infrastructure for several reasons, which would be required in the aforementioned spatial objectives and mandates. In these instances, shared service models (or service centres) as well as the assistance of the private sector are encouraged. Furthermore, within the municipal units, it was ascertained that various types of user interface (database to point-and-click) were required as well as various data delivery types. Consequentially, this suggests that not only a range of GIS interfaces be made available, but various training approaches be designed to suit these levels. For example, non-technical high level interfaces for general staff and politicians as well as technical environments for GIS operators. The study confirmed that custom-designed GIS education and training for municipal GIS operators is required to suit the unique requirements of municipal GIS objectives. This would solve a number of existing staffing issues such as inappropriate training and high attrition rates. Finally, a better common classification of rural areas (often informal and tribal) needs to be implemented, or alternatively the broad adoption of a small area layer. This serves to establish a basic operating framework which goes beyond municipal revenue generation on rated land to environments where socio-economic and environmental data could eventually be collected for MDG reporting.

### Rationale for recommendations

The localisation of the Millennium Development Goal Targets and Indicators is the key to the translation of global sustainability initiatives at the community level. However, although these targets provide impetus and benchmarking for sustainable development, this data is also required to be meaningful at a local level. This implies looking beyond the Goals of 2015 (which South Africa is likely to meet) and dealing with ongoing issues of poverty, infrastructure and service delivery. Hence, the motivation to develop a set of municipal indicators designed to address not only local sustainability but other aspects of municipal business. The cyclical collection and dissemination of spatially derived development data would mitigate existing municipal data shortcomings, as well as provide baseline data for higher level reporting. These data aggregation methods are anticipated to support the implementation, institutionalisation, monitoring and measurement of sustainable development, as it is currently prescribed in leading global documentation. The most fundamental shortcoming of GIS as a developmental tool is that it is essentially a technological system and therefore a facilitator, not a true agent, of change [42,53]. Without sound institutional systems and relevant policies and legislation to drive sustainability forward, functions like GIS fall victim to underlying weaknesses within local governments and their communities. The amalgamation of spatial and municipal “business” activities has been identified as crucial to the true integration of GIS into municipal processes.

### Conclusion

In summary, the recommendations aim to place intent before implementation so that GIS infrastructure may become an applied technology rather than an underutilised function, as is currently the case. It was apparent that general municipal operational issues are the biggest factor impeding successful GIS usage. The study was most concerned with the right application of GIS particularly towards the ends of sustainable development and global MDG reporting, rather than any use of GIS at all. It was concluded that despite significant evidence that GIS can facilitate much of a municipality’s business, that it is first and foremost a tool and not a solution in itself. Overall, it was ascertained that GIS implementation does not currently exist at a rural local government level to a suitable degree to warrant its application as a method to achieve sustainable development. Current instances of GIS remain project-based, function-specific or externally driven. Municipal GIS in South Africa has become a victim to the order of local government priorities, where immediate municipal matters come before GIS, creating the perception that it is a separate technology. In general, institutional and human issues outweighed technical issues and left little room for true analysis of ideal municipal systems, or
level in South Africa does need to be conducted with a high degree of indigenous and cultural sensitivity in order to address the legacies of the past and the existing socio-economic and environmental conditions which this has created. This means that institutional GIS should be extended into locales through techniques like PGIS, to not only capitalise on GIS but also on participatory practices. GIS (or any municipal function) cannot in essence be separated from political and social paradigms, and will always be subject to general municipal realities. Therefore, for any new process to take effect, it is important to create systems within this structure (like the IDPs), to which municipalities are mandated to conform. The inclusion of spatial data with the IDP submission process is therefore anticipated to be a good method to produce bottom-up data aggregation structures. The premise for this concept is that legislation overrides political, administrative and other municipal difficulties. Subsequently, this would necessitate top-management to become familiar with the technology and increase overall awareness and usage. The decentralisation of municipal information processes could improve the quality and timelines of information transmission for better and quicker decisions. As the smallest unit of autonomous government, local authorities are ideally suited to act as the collectors and communicators of electronic development data. The use of spatial information technologies and processes would facilitate the collection, analysis and sharing of this data.

Leveraging community involvement within this process would provide the qualitative participatory democracy required for good governance and therefore sustainable development into the future. Many parallels were drawn between the case study and African academic texts, and it is anticipated that the model could be applied in African rural local governments, at least conceptually.

References


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