Developing a tool to select priority wards in Gauteng

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Abstract

Government efforts to focus public funding expenditure and improve community livelihoods and service provision are often fraught with difficulties. A key challenge is how to spatially target expenditure where it is needed most. The information required to make robust and defensible decisions on which areas should be prioritised over others is frequently not available. In support of the Gauteng Provincial Government's aim to prioritise areas for development interventions or service delivery upgrading, the Gauteng City-Region Observatory investigated a method of identifying wards where development priorities should be focussed. The analysis was based on a range of indicators, with the goal being to move away from mainly income-based indicators towards indicators that provide a more holistic view of the development needs of each area. The paper describes the process that was followed to generate the indicators, presents the sources of data utilised as well as the geospatial analysis tools that were applied, and describes the subsequent development of an indicative mapping and decision support tool. The tool provides users with the option to manipulate the weighting of indicators and generate associated maps of the priority wards within Gauteng province, depicting their selected indicators. The results are hosted on the GCRO interactive GIS website and are freely available for anyone to use.

Keywords

priority wards, indicators, Geographic Information System (GIS), g-government, Gauteng

Introduction

During the first six months of 2011, the Gauteng City-Region Observatory (GCRO) embarked on a statistical and spatial analysis process to provide strategic decision support to the Gauteng Planning Commission (GPC). The aim of the project was to provide government with a data-enabled tool by which it could select the priority wards, within the new 2011 local election ward boundaries[1], on the basis of clearer, more objective and scientifically verifiable evidence. The ward selection process was approached from both a theoretical perspective, with GCRO engaging with literature and reports regarding indicators and indexes, as well as a practical perspective, where the availability and quality of data required to generate indicators and a priority index was considered.

Prioritising areas for development can be undertaken on a number of different levels, using various indicators and variables. Frequently, however, poverty remains a key focus of the analysis. When investigating the spatial distribution of needy communities a broad and multi-dimensional perspective on poverty is required. In addition to the classic income deficit approach to poverty, where average household income is the key criterion in defining which communities are poor, an array of other considerations should be taken in account. These include quality of life/standard of living, physical and emotional health, social cohesion, access to quality education, access to services, exposure to risk and the vulnerability and resilience that communities and individuals have. In addition, issues of community safety, labour absorption, equality, sustainability, promotion of food security, enhancement of environmental assets and natural resources, and active citizenship [1] should also be considered when identifying priority areas for development interventions.

The objective of this paper is to presentthe methodused tosystematically derivepriority ward indicators and assist ward-based development decision making through the development and use of publically accessible interactive tools and Web GIS applications. The paper starts with a basic description of the background of priority wards' project and selection of 18 indicators used to derive a priority wards index. A key component of the project was the identification of verifiable up-to-date spatially enabled data sets and a variety of data sets used in the analysis, including the latest available population and household income estimates, housing densities, distances to school and health facility locations, potentially dangerous land such as dolomite and service delivery variables, are presented. The calculations and processes utilised to calculate and spatially map selected individual indicators are then described. Finally, the consolidated priority wards index and interactive outputs and tools from the project are discussed.

Note 1: In the South African context, wards refer to the spatial delineation of political administrative boundaries within local municipalities, with a total of 508 wards in the Gauteng province delineated for the 2011 local (municipal) elections.

Project background

The Gauteng City-Region (GCR) is an integrated cluster of cities, towns and urban nodes, anchored by the three large metropolitan municipalities of Johannesburg, Tshwane and Ekurhuleni. The Gauteng province is considered to be the primary core of the GCR, accounting for 34% of national Gross Domestic Product (GDP) [2]. However, despite the GCR's major economic contribution, it is facing many socio economic challenges, such as: high unemployment rates (26,9% quarter 1 2011), alarming levels of economic and spatial inequality and poverty (22,3% of households living in informal or traditional dwellings), persistent public housing backlogs and mounting environmental challenges such as land and air pollution and increasing contamination of water [2].

The Gauteng Provincial Government (GPG) recognised the need to build Gauteng as a globally competitive city-region and in line with this vision, launched the GCRO in September 2008 as a partnership between GPG, the University of Johannesburg and the University of the Witwatersrand, Johannesburg. Local government is also present on the GCRO board. Behind the motivation for setting up the GCRO is a vision for South Africa's economic heartland as a region that is competitive, spatially integrated, environmentally sustainable and socially inclusive. This is only achievable through better planning, management and co-operative government. Since its establishment, GCRO has become recognised as a valuable resource for its government and academic partners by providing new and innovative data, information, analysis and reflective evaluation.

During the second half of 2010, GCRO was approached by the newly established GPC[2] to provide strategic support for GPG's 50 poorest wards project, which had earlier in the year defined a set of wards earmarked for specific development interventions to alleviate poverty. The GPC's selection was based on the ward boundaries used for the 2006 local elections. No clarity was provided by the GPC on what basis the 50 wards were determined to be the poorest, or why specifically 50 wards were selected. Fig. 1 illustrates the spatial distribution of these poorest wards, which are largely centrally located within the central urban core of the three metropolitan municipalities of Johannesburg, Ekurhuleni and Tshwane, with some overlap with GPG's 20 priority townships[3].
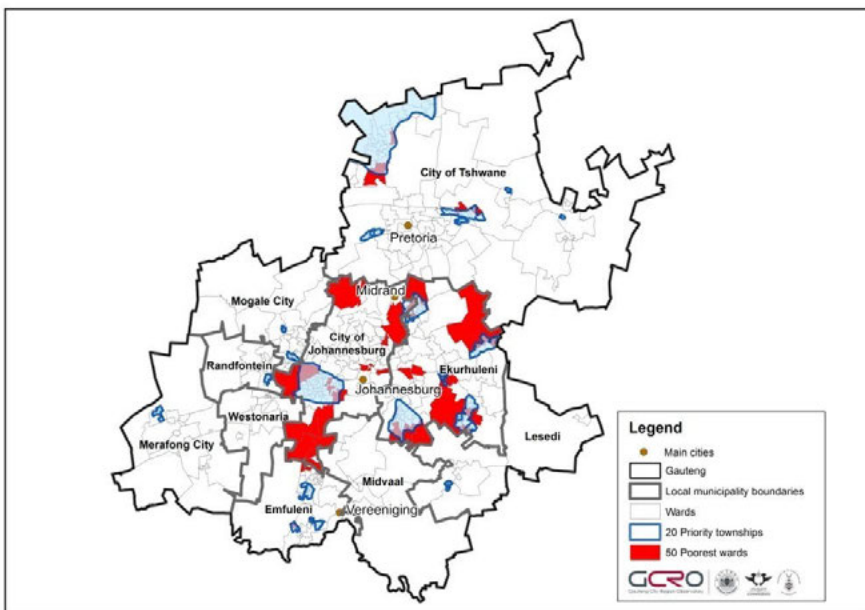

Fig. 1: Location of the GPC's original 50 poorest wards.

GCRO was requested by the GPC to provide data for the 50 poorest wards in order to establish a baseline for measuring the development impact of GPG's programmes in these wards. GCRO's response was to (a) note that the ward boundaries were about to change for the 2011 local elections and (b) begin an internal enquiry into possible indicators and data sources for a multi-dimensional view of poverty and development challenges in Gauteng wards. It was recognised that an objective and scientific set of criteria for defining the poorest wards, may establish a different set of wards from those defined by the GPG. For this reason GCRO initiated a project to systematically investigate a set of indicators and data and develop an interactive mapping and decision support tool, with the analysis based on the new

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Note 2: The mandate of Gauteng Planning Commission (GPC) is to provide long-term integrated city-region planning and monitor and evaluate provincial government's performance.
Note 3: A programme to provide and rehabilitate social and economic infrastructure in 20 previously marginalised townships.

2011 ward boundaries. So as to avoid confusion with the GPC's 50 poorest wards, GCRO began referring to the exercise internally as the "50 priority wards" project.

Selecting priority ward indicators

Various indicators that measure poverty were investigated for identifying priority wards, including the Millennium Development Goal (MDG) indicators [3, 4, 5], Oxford University's Index of Multiple Deprivation [6, 7, 8] and a poverty index developed in 2003 by the company Strategy and Tactics for the GPG poverty targeting strategy [9]. These indicators focus on different dimensions of poverty such as economic variables, education, health, standard of living or access to services. In addition, many provincial government departments have defined their own set of indicators, such as the Gauteng Department of Health's (DoH) indicators that benchmark and monitor the health status of individuals and households throughout the province. Considering each of these indexes, a set of forty indicators for potential inclusion in the priority ward identification process was compiled. This set was eventually reduced to 18 indicators, based to a large extent on the availability of accurate up-to-date data for each indicator calculation. The detailed methodology behind the selection of 18 indicators is beyond the scope of this paper.

The indicators (listed in Table 1) provide a multi-dimensional view of poverty and may be grouped into the following dimensions:

- Income and employment
- Shelter and service delivery
- Health and social development
- Education
- Disaster risk (as an example of how such risk could be included in similar indexes in future)

Indicator (per ward)	Data source
Percentage of adults receiving social grants	Lightstone 2010
Percentage of economically active adults	Lightstone 2010
Average household income (in Rands)	Lightstone 2010
Percentage unemployment	StatsSACensus 2001
Percentage of the area of each ward covered by informal housing	Eskom SBC 2008 and Gauteng Department of Housing (2006)
Percentage of individuals with one or more disabilities	Census 2001
Percentage of households without access to suitable dwellings (by RDP[4] standards)	Census 2001
Percentage of populated areas overlaying dolomite	Eskom SBC 2008 and Gauteng Department of Agriculture and Rural Development (2010)
Percentage of households without access to drinking water (by RDP standards)	Census 2001
Percentage of female headed households	Census 2001
Percentage of child headed households	Census 2001
Percentage of dwellings further than 5 km from a primary health care facility	Eskom SBC 2008 and Gauteng Department of Health 2011
Percentage of population aged 0-18 further than 3 km from a public school	Lightstone 2010 and Gauteng Department of Education 2011
Percentage of population aged 7-14 not attending school	Census 2001
Percentage of households without access to sanitation (by RDP standards)	Census 2001
Percentage of households without access to electricity for lighting (by RDP standards)	Census 2001
Percentage of households without access to electricity for cooking (by RDP standards)	Census 2001
Household density per km^2	Lightstone 2010

Table 1: 50 priority ward indicators and key data sources.

Note 4: Reconstruction and Development Programme (RDP): a programme initiated by the ANC to rebuild and develop South Africa following the 1994 elections, which sets guidelines for housing and municipal service provision standards [10].

Main data sources utilised in the indicators

A key aspect of this project was to identify quality up-to-date sources of data for generating the indicators. Census data from Statistics South Africa (StatsSA) has traditionally provided most of the indicator variables of this nature. However, the last Census conducted in 2001[5] was 10 years out of date at the time of the 50 priority wards project. Significant urban change and population growth has taken place in the past decade, with Gauteng's population increasing from 9,4-million in 2001 [11] to 11,2-million in 2011 [12]. StatsSA conducted a Community Survey in 2007 to provide an update of Census 2001 but the data was only made available at a municipal-level and therefore not applicable for the ward-level scale of analysis. Various other data sources were investigated to establish the availability of more recent statistics capable of reflecting the dramatic population growth and roll out of government's service delivery programmes. Data coverage of the entire area of analysis, i.e. all the wards in Gauteng, was a further requirement. Where indicator variables and associated data were not directly available, consideration was given to data which could be utilised in GIS spatial analysis processes to derive new and innovative ways of calculating such indicators.

The latest demographics and income data were sourced from the Lightstone Demprokey-X dataset[6], which provided the 2010 estimates of population by race and age, economically active adults (adults receiving some form of income), number of adults receiving social grants, household income and household density. The data was purchased with a licence for student usage within GCRO's academic partners, thereby promoting open access to the data for research purposes. Eskom's 2008 SPOT Building Count (SBC)[7] data was useful to map the spatial location and extent of households (in the form of a point per building) and informal settlements (in the form of polygons). The Eskom household polygons[8] were also utilised. Provincial government data was obtained from the Gauteng Departments of Agriculture and Rural Development (GDARD), Education, Health and Housing, and assisted with information regarding access to suitable housing, health and education indicators and exposure to disaster risk (in terms of location on dolomite). In the case of ten of the 18 indicators, Census 2001 data had to be utilised, as this was the only data available at a ward-level. These ten indicators include: access to services (such as water, sanitation and electricity), unemployment, persons with disabilities, female and child headed households and school attendance.

Generating individual priority ward indicators

The majority of the indicators were calculated using spread sheet formulae, spatially enabled using GIS joins to the ward boundaries. An example is the percentage of female headed households calculated from Census 2001 data as (Eqn. 1):

$$Ifhh = \left(\frac{Nfhhh}{Thh}\right) * 100 \tag{1}$$

where:

$Ifhh$ = Percentage of female headed households
$Nfhhh$ = Number of female headed households
Thh = Total number of households

In low income communities, female headed households are generally regarded as more vulnerable. Fig. 2 depicts the 50 priority wards and "worse than mean" wards[9] for this indicator. The map shows the highest concentration of priority wards in Soweto, Bekkersdal and Mohlakeng (in the Randfontein/Westonaria boundary area) and Orange farm (in southern Johannesburg). Interestingly, a number of wards in the northern Johannesburg suburbs of Houghton Estate, Linksfield, Norwood, Parkhurst and Parktown form part of the 50 priority wards selection. These suburbs are generally wealthier, possibly indicating well-supported divorcees. Drilling down toward level may be interesting for an indicator

Note 5: The fieldwork for the latest Census 2011 was completed in October 2011 by Statistics South Africa [13], after the completion of the 50 priority wards project.
Note 6: The Demprokey-X data models demographics at an enumerator area level, using the Community survey 2007 and StatsSA mid-year population estimates together with property data from the Deeds office, Geo TerraImage building counts and Global Insight income distribution, to provide a 2010 update of the Census 2001 data [14].
Note 7: The Eskom SPOT Building Count (SBC) or dwelling inventory dataset captures the underlying built environment across South Africa. The locations of formal dwelling units and non-dwelling structures were digitised using SPOT 5 natural colour satellite imagery (2,5 m resolution; acquired in 2005-2008). In areas where individual dwellings could not be distinguished at the permissible mapping scale (e.g. dense informal settlements), informal polygons were captured [15].
Note 8: Eskom derived a household polygon layer using the 2008 SBC point layer by buffering all the dwelling points, then dissolving the buffers, to produce a polygon layer that approximates the housing coverage or populated areas [16].
Note 9: In the priority ward maps, the priority wards are depicted in red, with the worse than mean wards drawn in orange. The "worse than mean" wards are calculated by selecting the wards that are not part of the priority wards selection but worse than the mean value for all the wards.

such as this one, but does not always correctly reflect the location of priority communities for development interventions. A combination of indicators is therefore required to average out anomalies or data errors and ensure the different dimensions of the priority ward index are taken into consideration.
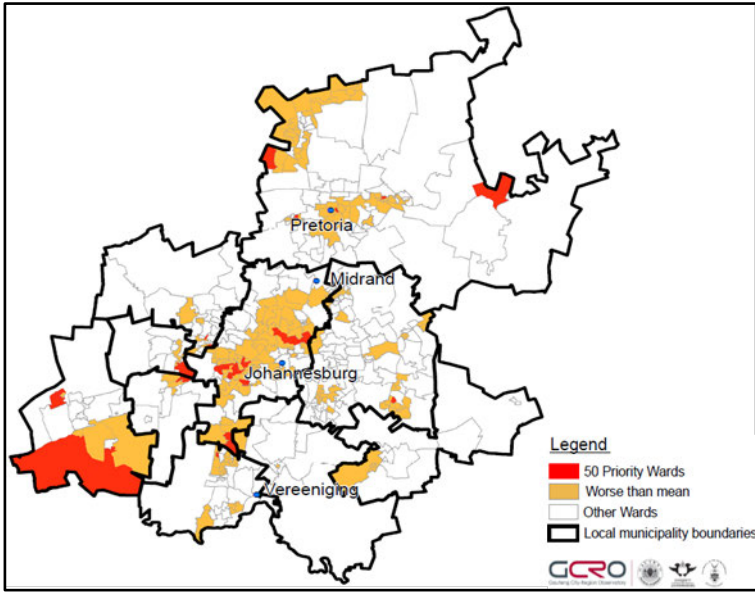

Fig. 2: 50 priority wards indicator: percentage of female headed households.

Four of the 18 indicators had to be calculated through the combination of multiple data sources and GIS tools to derive the indicator's variables. The first example is the percentage of dwellings further than 5 km from a primary health care (PHC) facility, this being the furthest acceptable distance for households in urban areas to be away from a health care facility according to the World Health Organisation [17]. The Gauteng DoH was consulted regarding the methodology for this indicator, as they consider other variables when selecting health care facility locations, such as excluding mobile clinics from access to PHC calculations, due to their constantly changing location.

The indicator utilised the point locations of the PHC facilities, obtained from the DoHand the Eskom SBCpoint dataset to identify the number of dwellings, hostels and residential complexes beyond a 5 km buffer generated around each primary health care facility. The indicator was then calculated as (Eqn. 2):

$$Idphc = \left(\frac{Ndphc}{Td}\right) * 100 \tag{2}$$

where:

Idphc = Percentage of dwellings further than 5 km from a PHC facility
Ndphc = Number of dwellings, hostels and residential complexes outside a 5 km buffer of PHC facilities per ward
Td = Total dwellings, hostels and residential complexes per ward

The 50th ward on the list of priority wards for this indicator has 15% of dwellings in this ward further than 5 km away from a PHC facility, with the majority of the 50 priority wards for this indicator located on the fringes of the Gauteng province (Fig. 3).
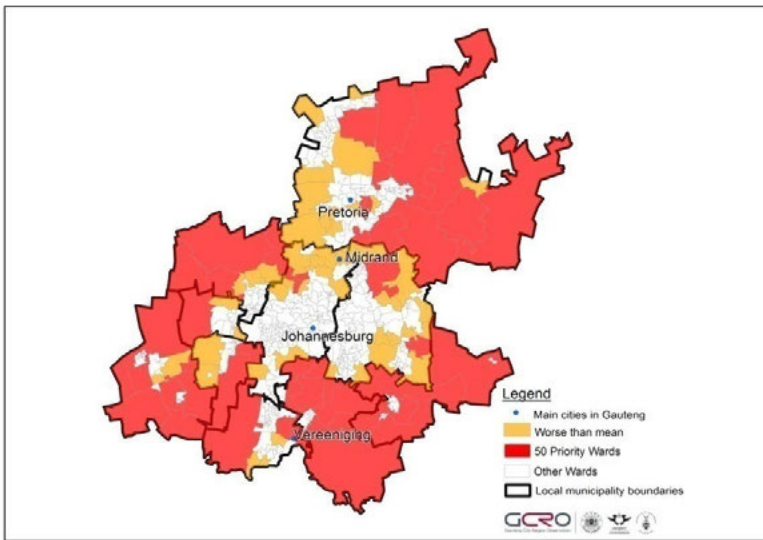
Fig. 3: 50 priority wards indicator: percentage of dwellings further than 5 km from a primary health care facility.

The percentage of populated areas overlaying dolomite indicator highlights the vulnerabilities of communities living in dolomitic areas. Dolomite is a geological form which is often subjected to subsidence and sinkholes. This indicator utilised the 2008 Eskom household polygons layer (which map populated areas) and the dolomite layer provided by GDARD. Using the 'Intersect' tool in ArcGIS, the populated areas intersecting dolomite were identified and the indicator calculated as (Eqn. 3):

$$Ipdd = \left(\frac{Pdd}{Wa}\right) * 100 \qquad (3)$$

where:

$Ipdd$ = Percentage of populated areas intersecting dolomite
Pdd = Populated areas overlaying dolomite in m^2
Wa = Ward area in m^2
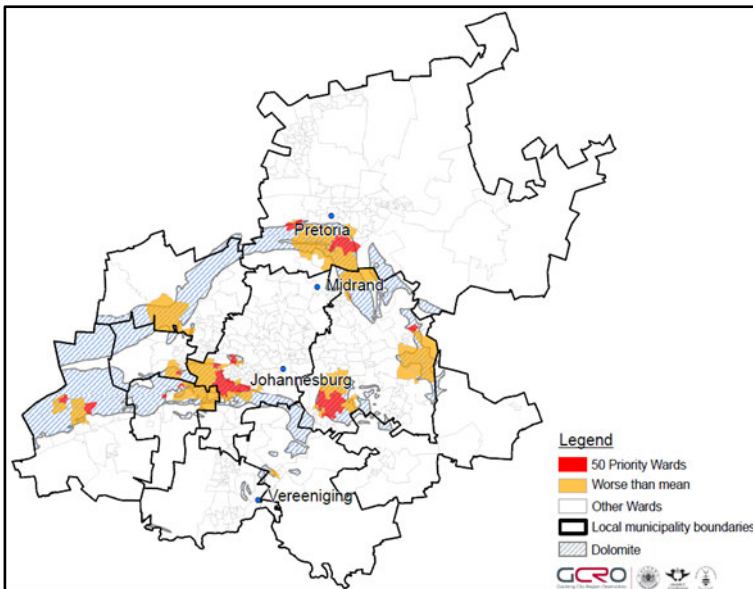
Fig. 4: 50 priority wards indicator: percentage of populated areas overlaying dolomite.

The wards with populated areas that may be affected by the hazards associated with dolomitic ground are depicted in Fig. 4, with the ring of dolomite in the central regions of Gauteng clearly visible. A full description of the calculations used to derive all the indicators is available from the 50 priority wards project page on the GCRO website [18].

Calculation of the consolidated priority wards index and analysis

A consolidated index was produced by combining the 18 individual priority ward indicators. For each of the 18 indicators in the GCRO index, every ward was given a rank, scoring from 1 to 508, with 1 representing the "best off" ward and 508 representing the "worst off" ward. Every indicator was mapped to depict the 50 wards, with the highest or worst scores in red. The remaining wards that scored worse than the mean value for the specific indicator were mapped in orange, as depicted in Fig. 2, 3 and 4. The consolidated index was then calculated by adding the wards' rank numbers for each of the 18 indicators (Eqn. 4).

$$ConsInd = \sum_{i=1}^{18} Ii \qquad\qquad\qquad (4)$$

where:

Cons Ind = 50 priority wards consolidated index score
Ii = individual indicator's rank score

The ward with the highest total score (the sum of their ranks for each indicator) represents the worst off, or highest priority, and the ward with the lowest score represents the best, or lowest priority. Using this consolidated index, all 508 wards in the Gauteng province were ranked from highest to lowest priority, with the 50 priority wards(or those 50 with the highest summated scores) mapped for the purposes of GPG's original request.

Fig. 5 illustrates the consolidated map of the 50 priority wards, highlighted in red. The far north (Tshwane), west (Mogale City), south-west (Merafong City) and pockets in the central formerly black townships such as Orange Farm, Kathlehong and Tembisa are identifiedas priority areas. A partial overlap with GPC's wards (overlaid in blue) is visible in some areas such as Tembisa, Kathlehong and Orange Farm. However, the 50 priority wards identified by GCRO are generally located in different areas with a broader distribution across both the rural and urban extent. In contrast, GPC's 50 poorest wards have more of an urban focus, centred on the provincial government's 20 priority township areas.
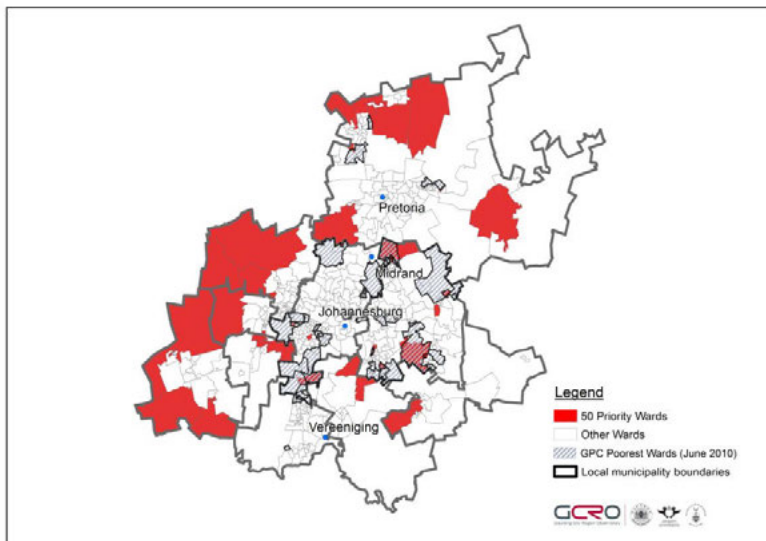

Fig. 5: GCRO's 50 priority wards (consolidated index).

Priority wards interactive outputs

One of the strategic roles of the GCRO is "the collection and storage of strategically useful data, surveys, development of new data sources, GIS mapping and analysis work, and assembly of information into innovative data products" [19]. With this in mind, instead of a static report and set of baseline data, project outputs were designed to reflect this innovation, as a publically accessible interactive tool. The first phase of outputs were delivered under a tight GPC deadline and consisted of a set of static maps in a power point presentation and an interactive spread sheet. The second phase focused on the development of anointer active 50 priority wards Web GIS theme.

Priority wards interactive spread sheet

The spread sheet developed for the GPC (a section of which is depicted in Fig. 6), is a decision support tool for analysing the consolidated 50 priority wards and individual indicators. All 508 wards are ranked in the spread sheet, with the 50 priority wards highlighted in red. The first page of the spreadsheet contains a "weighting" box, where the default weighting of 1 for each indicator can be altered. An indicator's weighting can be doubled or tripled etc., to increase the weight applied in the subsequent calculation, or alternatively set to 0, thereby excluding it from the consolidated index calculation. This provides the user with the option to change weightings for specific indicators that are perhaps more relevant to their area of interest. For example, the spread sheet can be used by different departments, ward councillors or interested sectors of society, such as social development, housing, education, planning or health, to identify single or combinations of indicators and develop an index based on their specific weighting. A new set of 50 priority wards is reflected on the top of the list, once the weighting is changed by the user.

The detailed information for each indicator, i.e. the percentage or numeric variable value and the rank of each ward, is also available per ward on the second page of the spread sheet. This finer grain of information allows decision makers to access the raw data, used to generate the indicators, for specific wards, or view data for all 508 wards. The power point presentation with the static maps and interactive spread sheet is publically available for download on the GCRO 50 priority wards project page.

Fig. 6: 50 priority wards interactive spread sheet.

50 priority wards interactive Web GIS theme

From its inception, GCRO has undertaken to promote g-government, which relates to the use of GIS maps and the Internet (and more recently Web 2.0 internet technologies) to promote more effective government service delivery through Web GIS applications [20, 21]. GCRO's main Web GIS application [22] was launched in September 2010 and its usage has grown steadily. The 50 priority wards project presented an ideal opportunity to expand the current themes on this website and a dedicated theme was developed to provide the results of the project in the form of an interactive table and dynamic maps [23].

The theme opens with the 50 priority wards highlighted in the map and attribute table (Fig. 7). Each of the individual indicator headings (e.g. percentage adults receiving social grants) can be selected to activate the selected indicator and redraw the map to reflect the priority wards related to the selected indicator. The number of priority wards depicted on the map is not limited to 50 and can be changed by the user, for example to display the top 12 or 100 wards. The weighting of indicators may be altered (similar to the spread sheet tool described earlier in this paper) by using the "change indicators and weights" tool, with the consolidated map of priority wards immediately redrawn after the weights have been altered. The maps and data for the consolidated index or individual indicators may also be printed, or the data downloaded in a.csvtext format. As the theme is incorporated into the main GCRO GIS viewer, the user has access to all of the base maps and GCRO themes, which can be switched on and overlaid on the 50 priority ward maps.

The theme has been well received since its launch in March 2012 and, of all the themes on the GCRO Web GIS application, scored the highest number of hits from March – August 2012.A number of maps were also included in the GPC's G2055 discussion document on the long-term development plan for the Gauteng City-Region [24].
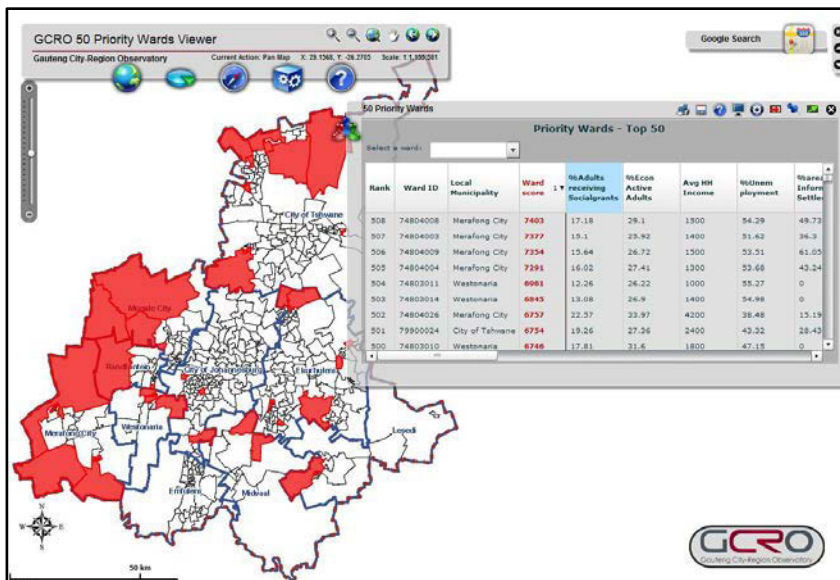

Fig. 7: GCRO 50 priority wards Web GIS theme.

Conclusion

It is recognised that in terms of human settlement planning, ward-based development is not an ideal spatial unit for planning, as it does not take rural vs. urban entities or the location of nodes and transport corridors into account. However, from a political perspective, it provides ward councillors and ward committees with the opportunity to understand their constituents better in order to negotiate elements of development that are particularly relevant to their designated ward community.

To assist with monitoring the impact of the government ward-based development programmes, GCRO's 50 priority wards project has supplied government with a set of scientifically derived baseline data and indicators for all 508 wards in Gauteng. Following an investigation into new data sources that could address the problem of outdated Census 2001 data, the majority of indicators were selected based on the availability of accessible high quality data. The data investigation concluded that proprietary datasets can offer the latest estimates of demographic variables at detailed scales such as enumerator area-level, thereby providing a valuable resource until the Census 2011 data is released. The willingness of provincial government departments and public companies such as Eskom to distribute and make datasets available for research purposes, also made the calculation of a number of key indicators possible.

The indicators were combined to create a consolidated index that identifies priority wards as possible areas for intervention and development. In contrast to the 50 poorest wards selected by the GPC in the primarily urban areas of Gauteng, the 50 priority wards were spread across the province. They occur on both the rural fringes and central urban areas of the province, where they mainly concentrated in the formerly black townships.

GIS played an important role by providing the tools to complete the spatial analysis required to generate some of the indicators and visualise the results. The use of Web GIS as a decision making and g-government tool was also clearly illustrated through the development of the online 50 priority wards theme within the GCRO Web GIS application that provides an interactive mapping facility where the weights applied to the indicators and the number of priority wards to be mapped, can changed by the user.

The research has therefore, not only supplied government with a set of scientifically derived baseline data and indicators, but empowered them with a set of interactive tools that can assist political decision makers at provincial and local government level, NGOs, academia and the general public, to independently analyse and critique where development and resources should be prioritised.

Further research could be initiated to track the detailed usage of the 50 priority wards project outputs and Web GIS application. This would involve questionnaires and interviews with government department users to establish the impact of the project and identify improvements for future iterations of the project–possibly with the next re-demarcation of

ward boundaries in preparation for the 2016 local elections. The new Census 2011 data, when released, also represents an opportunity to refine the indicators and recalculate a consolidated index using a new range of comprehensive and up-to-date ward-level data.

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