

**Exploring the Concept of a GIS-based Decision Support System
for the Upgrading of Informal Settlements
in South Africa's North West Province**

Submitted by:

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Introduction

With its first democratic elections held in 1994, The Republic of South Africa underwent a profound change. The newly elected regime faced a starkly polarized geographic and social landscape. On one hand were affluent suburbs and prosperous urban centers offering promising opportunities, while on the other were overcrowded, impoverished informal settlements on the urban peripheries. Underpinning this for many years was a system of racially biased planning that emphasized separate social, economic and physical development among black and non-black racial groups - a system which inscribed deep divisions into both the geography and the social memory of the country and its people (Turok, 2001).

Unfortunately, the negative economic and social forces set in place under apartheid did not cease with the arrival of South African democracy. While some improvements have been cited with regard to housing provision and extension of services into previously neglected peripheral townships, the scale and character of investment from one locality to another varies markedly, implying broad continuity of past practice rather than progressive transformation (Turok, 2001). The legacy of apartheid remains embedded in conservative institutional and social practices that persist. Additionally, as recent assessments indicate, there is growing tension between the promulgators of law at the national level and those charged with implementing law at the local and municipal levels (Huchzermeyer, 2009). These negative realities, past and present, impede the nation's advancement, overriding the positive spirit and transformative intent of the new Constitution and its associated policy implements.

Several years after heeding the UN's call for the improvement of living conditions for "slum" dwellers with the endorsement of the *Millenium Development Goals*, a substantial proportion of South Africa's population remains housed under conditions termed '*informal*.'

Further, it is estimated that the rate of informal settlement growth exceeds that of affordable housing provision (Turok, 2001). *In situ* upgrading, or upgrading in place, is internationally recognized as the best practice for addressing the plight of these fragile communities. Though the South African Constitution is clear in its commitment to this course of action, a lack of specificity and the absence of a replicable methodology for the implementation of the *in situ* upgrading process has created wide inconsistency and, often, irresponsibility in the handling of informal settlements (Huchzermeyer, 2009).

Recent technological innovations have significantly increased the capacity of urban administrators to provide timely and consistent analyses of a high quality. Satellite imagery and other remote sensing technologies have enabled monitoring of urban growth, morphology and a wide range of phenomena essential to sound future planning. These outputs as well as data from other sources can be combined in a geographical information system (GIS) for management, interpretation and modeling (Bolstad, 2005).

A GIS-based decision support system of this nature holds the potential to help South African municipal and provincial housing officials improve the quality, consistency, and effectiveness of investment through more informed planning. A GIS can be used to identify priority areas based on either urgent needs or latent potential for growth. It will also facilitate greater balance in the consideration of physical and social factors in the planning process, and provide a firm basis for decision-making. This paper will review the core objectives and structure of the National Informal Settlement Upgrading Program, and explore the concept of a provincial GIS-based decision support system to guide future upgrade projects in South Africa's Northwest Province.

Background

Adopted in 1996, South Africa's post-apartheid Constitution embraces the notion that all South Africans should have access to adequate housing. Further, it makes it incumbent upon the state to take all reasonable legislative and other measures to effect the realization of this mandate (Department of Housing, 2007a). Through a series of structured and phased national housing programs the government aims to improve the quality of both housing and housing environments, producing not only suitable housing units, but *empowered* and *integrated communities* capable of nurturing social and economic advancement for their inhabitants (Department of Housing, 2007a).

Informal settlements are now a common occurrence in nations that are undergoing rapid urbanization. The principal cities within these countries are faced with a lack of resources to adequately deal with the immense numbers of new immigrants moving in from the rural hinterlands seeking work and a better life. The UN estimates that 5 million new immigrants per month take up residence in one of these developing urban centers (UN-Habitat, 2010). With service and infrastructure provision unable to keep pace, slums and informal settlements continue to proliferate, contributing to the spread of urban poverty and the deepening of inequalities between rich and poor.

The condition of informality is a response to an immediate need for shelter (UN-Habitat, 2010). The absence of affordable options for accommodation drives an individual or group of individuals to occupy a space without formal rights of occupation, and, often, without regard to the intended legal use of the space. Aside from the unlawful invasion of property, informal settlements are of particular interest to urban managers because of the correspondence of informality with other undesirable social conditions. *Individuals living under conditions of*

informality typically face the combined effects of poverty, social exclusion and stress, constant threat of eviction from their chosen space (tenure insecurity), inadequate/substandard shelter, and lack of proper water, electrical and sanitation services (UN-Habitat, 2010). The proliferation of such areas and the explosive growth in the proportion of the world's population housed within them has prompted broad international response. In fact, slum upgrading has recently been recognized as a top international development priority. Developed and developing nations across the world have taken a proactive stance, avowing firm and sustained commitments to bettering the lives of those living in extreme poverty, and creating urban environments that extend the full benefits of citizenship to all.

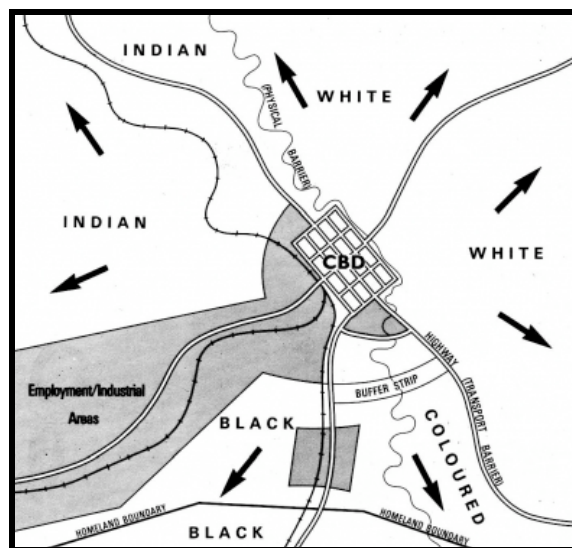
South Africa's cities have informal settlements that currently house approximately 10% to 20% of the country's population, and settlement population growth is increasing at a rate that outpaces delivery of affordable housing options (Abbott, 2002a). While in most cases the development of slums is principally tied to economic factors, specific social aspects of South Africa's history encouraged and even facilitated the development of informal settlements on the periphery of its urban centers. According to Peter Wilkinson, "from the moment it emerged as a recognizable policy arena in the early 1920s, *housing policy* was implicated in the state's efforts to establish and maintain a particular social order" (Wilkinson, 1998). Thus, he argues, informality in South Africa's case originates largely from the institutionalization of its race-based migrant labor system. By means of an extensive apparatus of controls on urban migration, the state maintained the separation of the day-to-day existence of migrant workers, confining them to designated 'native reserves' or 'Bantustans' (Wilkinson, 1998).

"The fundamental purpose underlying the protracted and often fiercely contested efforts to segregate the African urban population into discrete residential areas, 'townships' exercised administratively as well as geographically from the social and spatial fabric of the 'white' cities and towns, was to regulate the degree of permanence with which that

population could establish itself there. It is in relation to this strategy of 'containing' African urbanization...that the evolution of South African housing policy must be understood."

Housing, employment and the transit connections between them comprise the three essential structural elements of every city. As critical resources, access to these three amenities determines, to a great extent, the quality of lifestyle available to residents. South African cities are unique in the way these sectors were controlled to promote and subordinate the interests of different racial groups. They produced distorted settlement patterns characterized by pronounced social and economic segregation and physical fragmentation (Turok, 2001).

Under apartheid, black urbanization was strictly regulated. Distally located, black townships were denied industrial, commercial and retail development, severely restricting the available tax base. Further, laws limited black entrepreneurship and ownership of property, two principal means of wealth generation and accumulation. Combined with inadequacy of infrastructure and limited land availability, these factors stood as insurmountable impediments to independent black advancement (Turok, 2001).



[http://www.pmbhistory.co.za/?showcontent&global\[_id\]=143](http://www.pmbhistory.co.za/?showcontent&global[_id]=143)

**Group areas as designated under the *Group Areas Act of 1955*
(later replaced by the *Community Development Act of 1966*).**



<http://www2.gsu.edu/~wwwher/about/southafricapictures2005/soweto.jpg>

"South African [informal] settlements in both urban and rural areas are generally inefficient, fragmented, inconvenient and massively wasteful in terms of both publicly and privately controlled resources. For many they are hostile places in which to live, offering few, offering few economic, social, cultural, environmental or recreational opportunities. In large part this is the result of the interplay between historical spatial planning policies and practices and the implementation of the ideology of apartheid"

Turok, 2001, p. 2351

One of the new government's primary objectives was to create post-apartheid cities, destroying the territorial traces of apartheid. In spite of the dramatic legal paradigm shift, however, neither the shape of South African cities nor the demographic distributions of their populations evolved as expected. It was assumed that normal urban migration patterns would resume with the abrogation of apartheid era restrictions. But, this has not necessarily been the case. Circular migration patterns remain firmly in place, with family wage-earners commuting vast distances, across multiple municipalities, to employment opportunities that are increasingly less centrally located (Todes et. al., 2010).

A proactive housing policy has been in place since 1994, and has provided suitable homes to more than two million families since its enactment (Hervé, 2009). Unfortunately, the program rapidly came to be seen as incomplete. Critics continually cite its overemphasis on delivery and lack of emphasis on much-needed physical, social, and economic integration. The limitations of the policy, in the face of an ever-growing population, perpetuated the housing crisis. The number of households without formal housing grew from 1.45 million in 1996 to 1.84 million in 2001 and then to 2.4 million in 2006 (Hervé, 2009). A lack of well located and affordable housing options forced more families to take up residence in shacks (makeshift housing in shantytowns) or in backyards, and, thus, the issue of informality became more pressing.

Breaking New Ground

National housing policy was assessed and revised ten years following its initial implementation. Policy revisions sought to address the continued marginalization of the low-income black population. While previous policies improved the quality of structures available to the poor, their new housing units still left them socially and economically disconnected from the broader urban fabric. Policy revision also addressed issues with subsidy provision, optimizing funding mechanisms to better support the new informal settlement upgrading policy. Instead of qualifying solely at the household level, the *Breaking New Ground* policies made improvement subsidies available to the community as a whole (Huchzermeyer, 2009).

The Informal Settlements Upgrading Program (ISUP) was established with the explicit objective of carrying out "structured, *in situ* upgrading of informal settlements" to achieve the goals of: **land tenure security, health and social welfare, and individual empowerment**

(Department of Housing, 2007b). The program seeks to address the challenges of informality by emphasizing the role of housing delivery in poverty alleviation. It aims to link infrastructure provision with employment creation and sustainable urban development. Further, it makes housing (top structure) subsidies available as a means to wealth accumulation and empowerment. Essentially, the program leverages housing delivery as a mechanism to spur economic growth, combat crime, and improve social cohesion and quality of life (Department of Housing, 2007b).

The program defines an informal settlement as one that may be characterized by: illegality and informality; inappropriate location; restricted public and private sector investment; and high levels of poverty and social stress. Settlements meeting the program's criteria become eligible for national ISUP funding to implement qualified upgrading projects.

Community Involvement Costs	Detailed Town Planning	Site Supervision Fees
Geotechnical Investigation	Land Surveying and Pegging	Permanent Engineering Services
Land Acquisition	Contour Survey	Project Management
Pre-Planning	Land Survey Examination Fee	Relocation & Sustenance Costs
Interim Engineering Services	Civil Engineer's Fee	Social Service Support

Department of Housing, 2007b, p. 28

Qualified Upgrading Projects and Activities

As informal settlements are usually located on contested land, *tenure security* forms the basis of the upgrading process and is prerequisite to any public investment. Funding is made available for acquisition of well-located land. Governmental entities are asked to make occupied lands in their possession available at no cost. No definition is offered for "well-located," but policy language suggests such land should further the overall objectives of social and economic integration.

In situ upgrading is preferential as it is more accommodating to the needs of impoverished and vulnerable populations. Social exclusion and disruption of delicately balanced livelihoods could result from haphazard settlement relocation (Huchzermeyer, 2009). The policy expressly states that relocation should be pursued only as a last option, and conditions this measure on community approval (Department of Housing, 2007b).

Requests for relocation are usually raised on grounds of unsuitability of the occupied land for residential use. In anticipation, the ISUP goes so far as to make funding available for land rehabilitation (sewer and drainage improvement and proper grading of slopes), significantly expanding the range of upgrade opportunities. However, this funding is conditioned upon two requirements. First, sufficient vertical planning must be undertaken by the petitioning local government. This means that project planning must be consistent with comprehensive spatial planning at the broader local level and the provincial level. The second requirement is that investment be made “only on the basis of sound financial and socio-economic indicators” (Huchzermeyer, 2006).

Finally, to advance the goal of empowerment, the program makes provision for community-level social and economic facilities. Social facilities include childhood development centers, health clinics and community centers. Local economic development will be encouraged through the inclusion of transportation hubs and community markets. Desired facilities should be determined through collaboration between residents and local implementing authorities (Huchzermeyer, 2006).

Implementation of the ISUP requires extensive *intergovernmental* and *interdepartmental* cooperation. Local municipalities and provincial governments each take on designated responsibilities throughout the course of the upgrade process. Upgrade activities are further

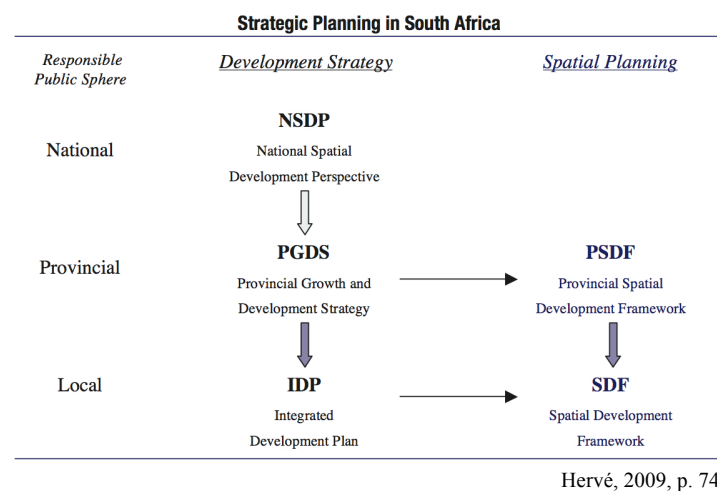
supported by the National government, which also maintains active involvement in implementation (Department of Housing, 2007b).

Principally, the municipality takes on the role of the developer. Local officials, having determined that a settlement within their jurisdiction might qualify for upgrade funding, make application to the appropriate provincial authority. If approval is attained, the provincial government and local municipality enter into a series of development agreements about the course the project will take. After completion, the municipality must take ownership of the new facilities, overseeing regular service provision and maintenance.

The provincial housing department (PHD) is the principal financier and overseer of project implementation. Provincial housing officials are charged with ensuring National program objectives are achieved through active collaboration with localities during the planning and commencement of an upgrading project. At appropriate stages of development, the provincial housing department dispenses funding necessary to carry out approved tasks.

The policy states explicitly that "PHDs must do everything in their power to assist municipalities to achieve their obligations under this program" (Department of Housing, 2007b). That is to say, PHDs are to act on behalf of the National government in ensuring that National priorities are taken into consideration and objectives met. National policies and objectives are driven by strategic planning as communicated through the National Spatial Development Prospectus (NSDP). Further, strategic planning is conducted at the provincial level in the form of a Provincial Spatial Development Framework (PSDF) (North West, 2010). Essentially, the provincial government is purposed to act as a vital link between the promulgators of law at the national level and the implementers of law at the local level. In this regard, provincial governments are to facilitate coordinated vertical activity between the different levels of

governance (Department of Housing, 2007b). To this end, local governments have recently been required to undertake strategic planning. The Integrated Development Plan (IDP) and accompanying Spatial Development Framework (SDF) were conceived to communicate local needs and priorities. While these elements combine to form a framework for strategic planning, the lack of a consistent and reliable methodology remains a major issue (Hervé, 2009; Cash & Swatuk, 2011).



The Need for a Strategic Planning Methodology

The weakness of the overarching strategic framework addressing urban development is an obvious handicap to coordinated and consistent local actions. This accounts for the diversity of measures taken by the provinces and municipalities in carrying out national housing objectives. Even with the advent of mandatory IDPs, the concept is still relatively new and many municipalities are facing capacity-related difficulties. These new strategic planning tools have been imposed, but it remains difficult at this stage for municipal planners to truly reap the benefits of the strategic planning model. "Indeed, most communes call on private consultants to

produce their IDPs. In this way, the municipalities fulfill their legal obligations but do not take advantage of this mode of strategic management" (Hervé, 2009, p. 81-2).

South Africa is not the only developing country without a mandated methodology in place for addressing informal settlements. Despite the prevalence of experience and extensive body of literature available on *slum upgrading*, researchers and practitioners have yet to formulate a standardized or replicable approach. This is due in large part to the wide variability between settlements. Indeed, these communities, each one with its own unique challenges, must be handled in a very different manner than traditional greenfield developments (Abbott, 2002b).

The upgrading of informal settlements is a process. Thus it is important to think of it not from a development perspective, but more in terms of urban renewal. The intent is to transform the settlement under conditions of minimum relocation...The issue is not just one of poverty, but a much wider issue of vulnerability linked to social exclusion. What is being sought therefore is social integration, and the way in which this is done is through settlement transformation, which is something much more encompassing than simply physical upgrading, which constitutes just one element of the broader process...An approach to upgrading that is constructed around method seeks to use physical change constructively to aid the broader social transformation of the settlement.

(Abbott, 2002b, p. 330-31)

Having written extensively on South African informal settlement upgrading, researcher John Abbott differentiates previous attempts at method formulation into three theoretically-oriented 'thematic' categories: (1) incremental provision of physical infrastructure; (2) community-level microplanning; and (3) 'holistic' planning.

The 'progressive improvement model,' which advocates settlement upgrading through the incremental provision of physical infrastructure, is currently the most widely practiced method. Abbott attributes its predominance to policies adopted by the World Bank in the 1960s and 70s which placed emphasis on infrastructure and the physical environment as central to settlement improvement. This practice took hold likely for predictability of implementation and for measurability of outcomes. However, not only was its focus too narrow, but it incorrectly

fostered the notion that informal settlements could be treated in the same manner as greenfield developments (Abbott, 2002b).

Microplanning is a participatory, project-based methodology which places planning firmly in the hands of the community. Typically led by a sector-specific NGO, projects are divided into four phases: initiation, planning, design, implementation and maintenance. The community stakeholders are directly involved in each step of the process (Abbott, 2002b).

Finally, 'Holistic' planning is a comprehensive approach which makes extensive use of geographic information systems (GIS), remote sensing and other technological implements. It combines physical planning with social and economic data about the inhabitants of a particular area, offering planners the opportunity to tailor their interventions. Abbot asserts that the holistic approach is the only one designed to deal with settlements in their totality, however, he quickly dismisses its potential for widespread adoption on the basis of intensive resource investment (Abbott, 2002a).

Remote Sensing and Geographic Information Systems

While remote sensing technology is not new, its purposes have only recently been recognized to align with the observation of phenomena of interest to social scientists. As Rindfuss and Stern suggest, social researchers have generally been far more concerned with why things happen than where they happen. "Changing land use, road and building construction, and the like are regarded as manifestations of more important variables, such as government policies, land-tenure rules, distributions of wealth and power, market mechanisms, and social customs..." (Rindfuss & Stern, 1998, p. 2). At one time, they would argue, few social scientists had true appreciation for the spatial dimensions of the phenomena they studied.

Much to the contrary, technology has significantly increased the capacity of urban administrators to provide timely and reliable analyses of a high quality. Becoming increasingly available to the public, satellite imagery and other remotely sensed observations have enabled monitoring of urban growth, land use change and a wide range of spatial processes of interest to planners. Satellites such as SPOT, IRS, and IKONOS are currently producing images that enable mapping at scales as precise as 1:10,000 (Masser, 2001). With even more powerful analysis tools in development, and their outputs increasingly more cost accessible, the application of remote sensing technology is likely to become of greater significance in the management of cities in resource-poor countries.

Another technological advance, the geographic information system, makes it possible to integrate large quantities of information collected from many different sources (Bolstad, 2005). Facilitating new methods of spatial analysis, a GIS also has the ability to integrate data across many different types of media - i.e. tabular census data and aerial images. The data can be manipulated, overlaid, and modeled in ways previously impossible, leaving the GIS user constrained only by the quality and availability of the data itself (Bolstad, 2005).

Data entry <ul style="list-style-type: none"> - manual coordinate capture - attribute capture - digital coordinate capture - data import 	Analysis <ul style="list-style-type: none"> - spatial query - attribute query - interpolation - connectivity - proximity and adjacency - buffering - terrain analyses - boundary dissolve - spatial data overlay - moving window analyses - map algebra
Editing <ul style="list-style-type: none"> - manual point, line and area feature editing - manual attribute editing - automated error detection and editing 	
Data management <ul style="list-style-type: none"> - copy, subset, merge data - versioning - data registration and projection - summarization, data reduction - documentation 	Output <ul style="list-style-type: none"> - map design and layout - hardcopy map printing - digital graphic production - export format generation - metadata output - digital map serving

Bolstad, 2005, p. 15

Common GIS Operations

The challenges facing urban managers in the coming decades are numerous, varied and immense in scale. They range from conservation of finite resources to environmental sustainability and poverty reduction, just to name a few. Taken further, the consequences of our inability to effectively manage these challenges grows more and more dire as time passes. Masterful employment of highly capable tools such as GIS will be essential to meet the pressing needs of future populations.

As previously discussed, legislation is promulgated at the National level, but dispensation of funding and project oversight is principally the task of provincial governments. Provincial governments are also responsible for facilitating municipalities in the project planning and conceptualization process (Department of Housing, 2007b). They are charged with ensuring that approved upgrade projects are in alignment with not only the local Spatial Development Framework, but the Provincial Spatial Development Framework as well. This vertical consistency is thought to ensure the maximization of limited funding.

A number of authors have identified the absence of an established and consistent methodology for ISUP implementation as one of the program's greatest shortcomings (Hervé, 2009). While flexibility has led to a wealth of experience and literature on a variety of implementation techniques, ambiguity has at times left the integrity of the process and the well being of settlement inhabitants vulnerable to the predilections and priorities of individual local government administrators (Cash & Swatuk, 2011). Without a firm basis for decision, these administrators are sometimes prone to hastily dismiss the exploration of in situ upgrading in favor of relocation to an area more conveniently suited to local needs (Huchzermeyer, 2009).

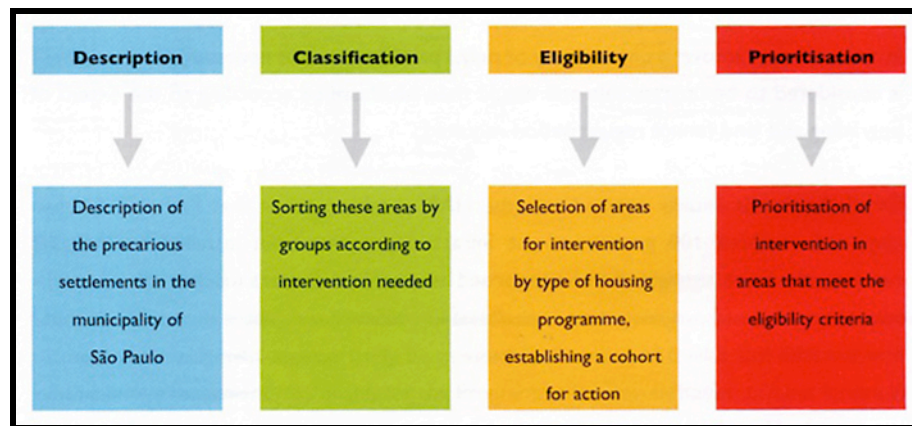
These circumstances affirm that there are a number of sound justifications for provincial investment in the development of a GIS to guide implementation of the ISUP.

Chiefly among the valuable applications of GIS as a support system are data inventory, analysis, and thematic visualization (Bolstad, 2005). At the regional level in particular exists a need to develop strategies for the best use of limited financial resources. This might include prioritizing upgrade projects in various areas identified specifically for their latent potential for long-term sustainability. Once a body of base level data has been amassed, overlay operations well within the capability of a GIS may be performed. If a set of criteria have been developed, territories can be assessed and scored on the basis of their spatial and demographic characteristics. These factors will frame the basis for characterization of a particular spatial unit as favorable or nonfavorable for improvement.

This methodology has been developed extensively in Brazil. Facing the same problems experienced by other developing metros grappling with settlement informality, housing officials in São Paulo sought a tool that would permit them to continually evaluate data, model various scenarios and adjust programmatic interventions accordingly (Cities Alliance, 2009). The result of many years of continual development is the HABISP system. This "managerial information system" houses data from a number of different municipal sectors as well as demographic data about settlement populations and aerial imagery. Permitting extensive overlay analysis, the HABISP system assists planners in prioritizing various areas based on urgency and type of intervention needed (Cities Alliance, 2009).

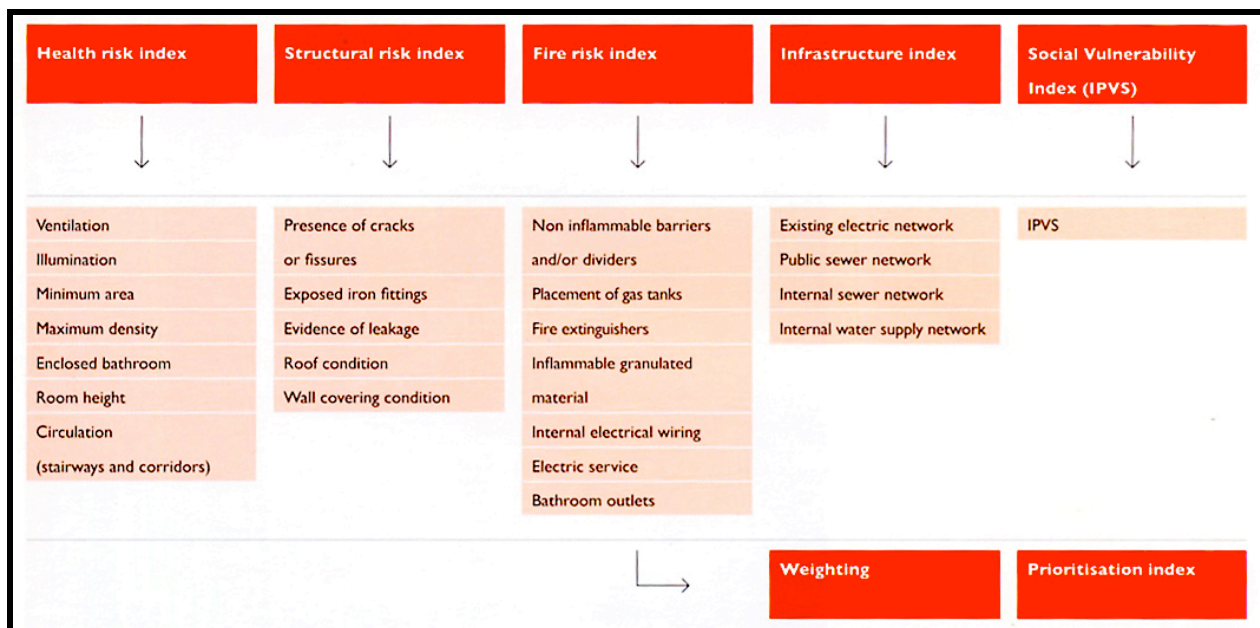
The system consists of four steps: *description, classification, eligibility and prioritization*. During the description phase, basic characteristics of the area are determined. A site is then classified as upgradable or non-upgradable on the basis of the associated characteristics. If

upgradable, a site is evaluated to determine its eligibility for the most appropriate housing program. Finally, it is prioritized on the basis of available resources (Cities Alliance, 2009).



Cities Alliance, 2009, p. 53

Prioritization is based on a score determined by a site's risk level across a number of essential indicators. The five indicators are health risk, structural risk, fire risk, infrastructure risk, and social vulnerability risk. Each indicator is operationalized by associated measurable factors. The risk index for each factor is weighted, and ultimately a prioritization index is calculated (Cities Alliance, 2009).

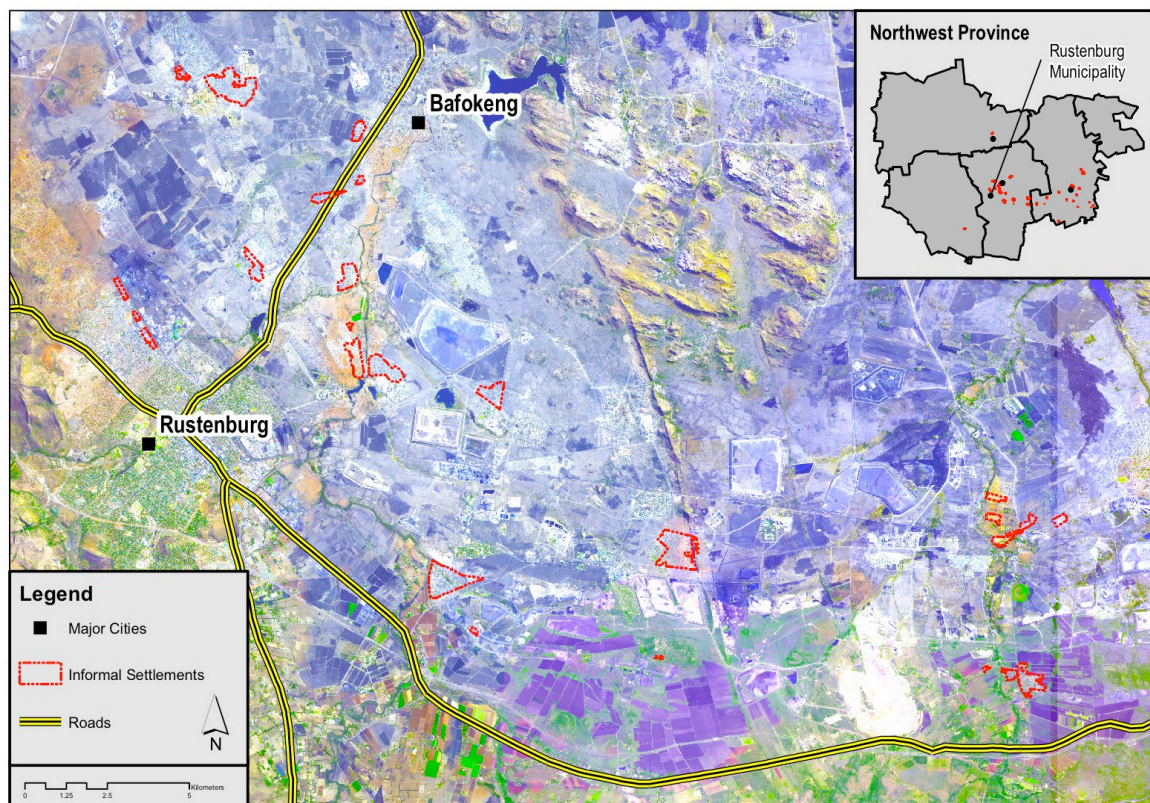


Cities Alliance, 2009, p. 57

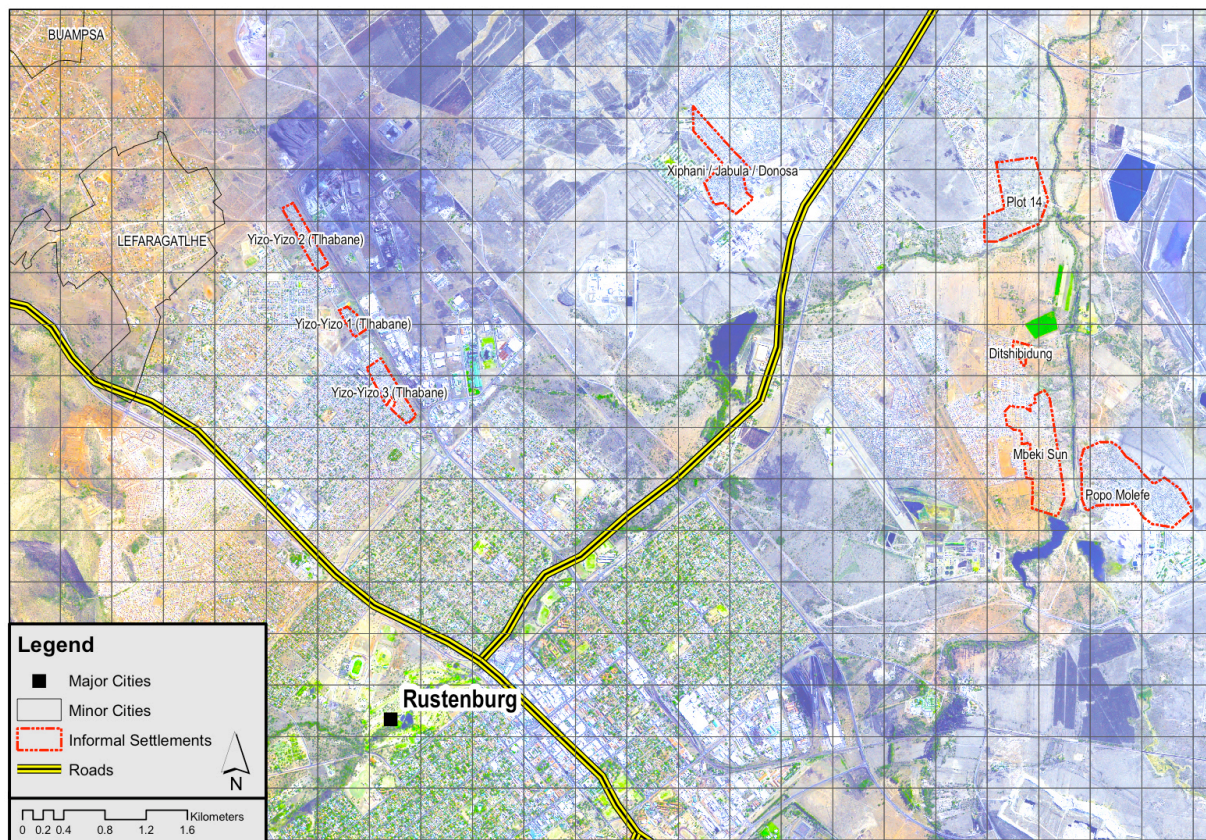
The HABISP system has been highly effective in assisting Brazil's urban managers in taming its informal housing crisis. The program has achieved high remarks from the international development community and is being replicated across Latin America (Cities Alliance, 2009).

A GIS-based Decision Support System for the North West Province

In line with the National Informal Settlement Upgrading Program, South Africa's Northwest Provincial Department of Human Settlements has embarked upon a provincial mission to upgrade its informal settlements. To improve all qualifying settlements within the province by 2014 is the Department's key objective. It is actively seeking a structured, programmatic approach to settlement upgrading that could facilitate rapid planning and project execution.



Informal settlements of the Rustenburg/Bafokeng Region



The municipality of Rustenburg shown with nearby informal settlements

To this end, the Department has recently undertaken the development of a body of base data on informal settlements. It is the first province in South Africa to make such an effort. According to Ilan Guest of SatPlan, a consultant involved in the collection and analysis of the data, the multiyear database of locational statistics and growth patterns dates back to 1994. It provides a common reference point for provincial and local governments as they engage collaboratively in the upgrade process. Currently in its fourth year, the five year project will gain intimate familiarity with each of the qualifying informal settlements within the province, collecting data at the level of the individual dwelling. The process has yielded significant returns for the province, offering a clear picture of the demographic composition of the settlements

through household surveys, and a broader look at the impact of national housing delivery through comparison of aerial imagery taken over the course of several years.

Moving forward into the development of a methodological planning framework first requires the enumeration of essential factors to be considered. These factors should be driven by legislation and policy objectives. The Informal Settlement Upgrading Program seeks tenure security, health and social welfare, and empowerment for those living under conditions of informality.

Policy priorities are as follows:

- *In Situ* upgrading with relocation only as a last resort;
- The production of socially and economically integrated communities capable of self-sustenance;
- Reaching the greatest number of households possible;
- Maximize limited funds through effective feasibility planning and mindfulness of the; 'cost vs. upgradability potential' continuum; and
- Prioritization of investment where there is most urgent need and potential for greatest social impact.

Department of Housing, 2007b

Essential factors and their associated measurable indicators might include:

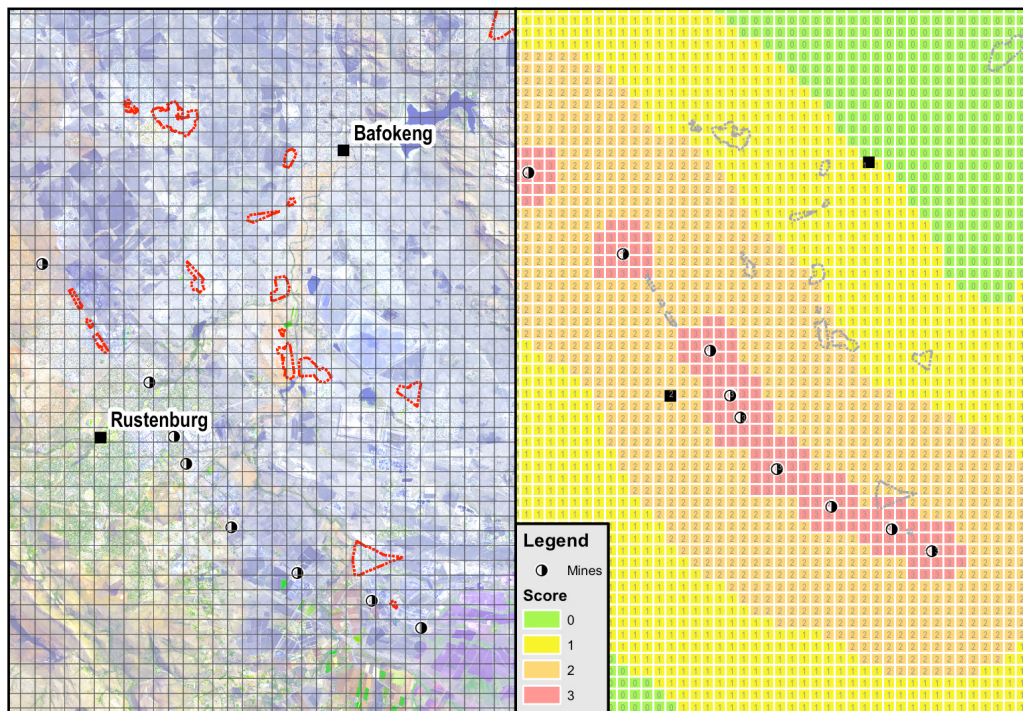
<i>Land Tenure</i> <ul style="list-style-type: none">- Private- Public- Tribal- Parastatal	<i>Geotechnical Conditions</i> <ul style="list-style-type: none">- Contours- Dolomitic Soil- Undermining- Flooding
<i>Proximity</i> <ul style="list-style-type: none">- Existing Urban Centers- Bulk Services<ul style="list-style-type: none">- Electricity- Sewer- Mining/Industrial Activity- Hazardous Facilities or Activities	<i>Socio-Economic Indicators</i> <ul style="list-style-type: none">- Physical Area- Number of Dwellings- Population Characteristics- Employment/Occupation Data

For this hypothetical exercise, six factors were operationalized using data available from the Northwest Province.

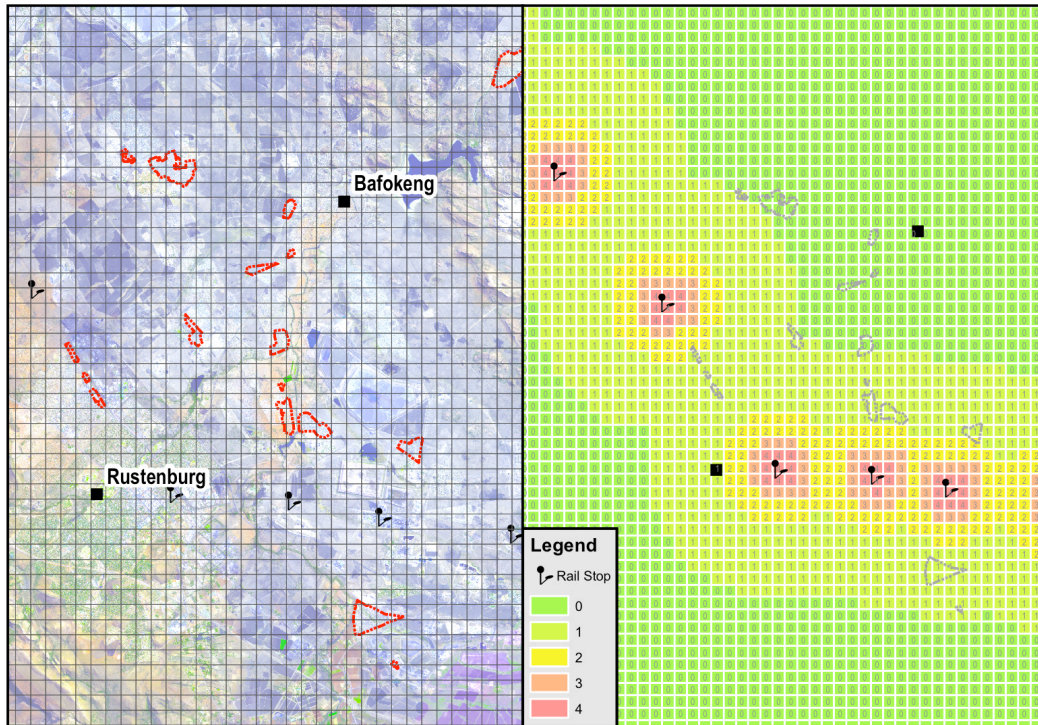
Factor	Operationalized As	Data Format	Intervals and Scoring
Employment	Mines (<i>Proximity</i>)	Point	<= 1k (3); <= 5k (2); <= 10k (1)
Transit Accessibility	Major Roadways (<i>Proximity</i>)	Line	<= 1k (3); <= 5k (2); <= 10k (1)
	Rail Stations (<i>Proximity</i>)	Point	<= .5k (4); <= 1k (3); <= 5k (2); <= 10k (1)
Sustainable Growth	Major Cities (<i>Proximity</i>)	Point	<= 1k (3); <= 5k (2); <= 10k (1)
	Small Cities (<i>Proximity</i>)	Polygon	<= .5k (3); <= 1k (2); <= 5k (1); <= 10k (.5)
	Small Towns (<i>Proximity</i>)	Polygon	<= .5k (1)
Tenure Security	Land Ownership (<i>Intersect</i>)	Polygon	'State Ownership' (2)
Infrastructure	Powerlines (<i>Proximity</i>)	Line	<= 1/2k (2)
Geotechnical	Slope (<i>Intersect</i>)	Polygon	'Above 9%' (-5)

Single or Multiple ring buffers were applied to each shapefile at the specified intervals.

Additionally, a grid of one-half kilometer² cells was then spatially joined to each of the above shapefiles. Each grid cell represents a specific geographic unit of space that can be attributed a 'score' based on its intersection with a buffer ring.

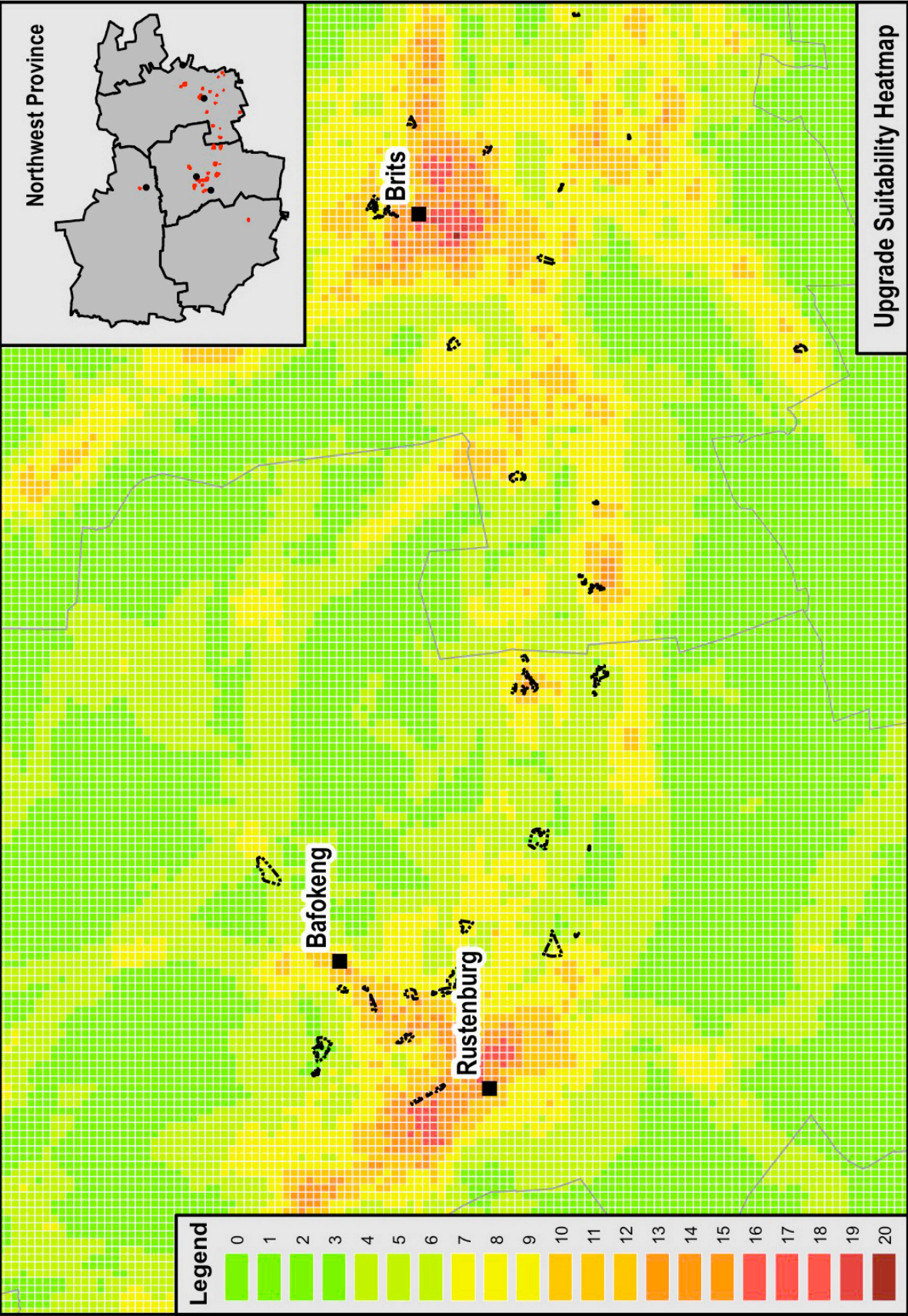


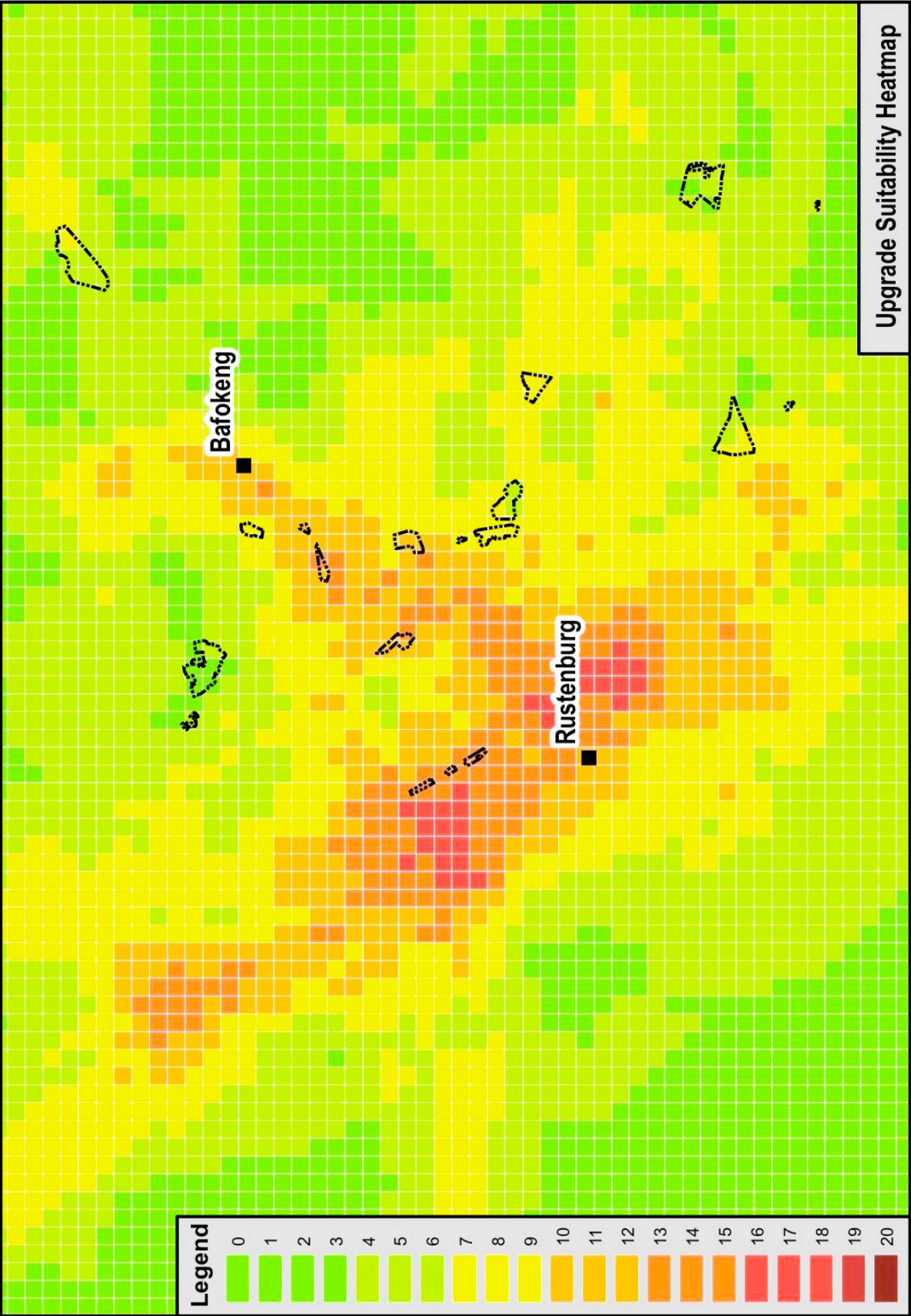
Proximity of informal settlements to mines (employment centers)



Proximity of informal settlements to rail stops (transit accessibility)

The attribute tables were joined based on the 'Feature ID' of each shapefile and the scores from each individual shapefile were added into a single point total to develop a *heat map*. Low-scoring cells appear green while high-scoring cells appear red. Essentially, the more red a cell appears, the more favorable the geographic area it represents will be for sustainable development if and when public investment is made.





The examination of critical factors for consideration and the process of operationalizing those factors as quantifiable phenomena is an important one for planners and officials charged with determining how to best devote limited upgrade funding. Additionally, it should underscore the significance of data collection to sound planning, leading planners to think about the types of data that are not yet available to them and how this data might be obtained to better understand local dynamics. Through the use of GIS-based suitability analyses, planners in the Northwest Province can more effectively target funding to meet National objectives and advance municipal development.

The Northwest Province's effort to assemble base data represents a positive first step toward a replicable, more effective framework for informal settlement upgrading. Development of a provincial GIS-based decision support system along with mandated consultations throughout the upgrading process will improve strategic planning at the local level and relieve capacity-related burden. Also, it holds the potential to help the NWISUP come closer to not only reaching its mandated delivery quotas, but to exerting the greatest social impact on those who need it most.

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