

## **Peri-urban areas of South African cities: innovative technologies for sustainability**

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### **Abstract**

South African major cities have undergone, in recent times, major changes in parallel with the political turmoil of the last decade. New socio-economic policies have indirectly caused massive migrations from the countryside and peripheral townships towards the urban areas, of people in search of a better life. Job seekers and informal traders have consequently flooded Central Business Districts and traditional formal businesses have moved out to Mid-Town developments. Residential areas close to city centers have been abandoned by previous residents and re-occupied by large numbers of legal and illegal new immigrants. Because of lack of available inner-city residential space, peri-urban areas, on the outskirts of SA cities, have been populated by informal settlements, accommodating a multi-cultural population, living in sub-standard conditions. This paper describes the social, economic and political factors, which have determined such rapid changes in the last decades. New community empowerment and sustainability strategies adopted by Metropolitan Authorities are also examined, in line with new Government national guidelines. Among the new strategies adopted, this paper describes the innovative use of digital 3D Visualization and interactive Technologies, already adopted for accelerated planning and capable of bridging gaps in understanding between decision makers and the population affected by proposed urban developments.

### **Introduction**

At the heart of South Africa's remarkable recent political transformation was a constitutional settlement expressing a compromise between the major white political party (the National Party) and the major black political party (the African National Congress), with a range of other parties playing important

although secondary roles. The negotiated settlement created an interim constitution, which provided for a completely reconstituted government system at national, provincial and local level. In a global context, there seem to be no other case where national level constitutional transition has been accompanied by complex local-level transformation. This has major implications for the future sustainability of South Africa's newborn democracy. In the Greater Johannesburg sub-region, for example, a transition took place, which was subsequently adopted as model for local government elsewhere in the country, through a complex multi-layered negotiated process that successfully managed the local-level transition from urban apartheid to a non-racial and democratic system, with the establishment of a framework for managing the reconstruction and development process. Since then, the central challenge has been to ensure that urban development should be sustainable, within the equally important social, economical and environmental spheres. Key to success is the promotion and support for community participation and empowerment.

### **The apartheid city and local government challenges**

Graphic images of the apartheid city are world famous: on one side opulent white suburbia, with municipal service standards comparable to the best in the world; on the other side black townships on the periphery of cities, with unimaginative housing, poor services and ever-widening informal settlements. Although no precise figures are available because of Census logistical difficulties, South Africa's 1990 population of 38 million has increased by 50% by the year 2002. Although HIV is now savaging official estimates and statistics, 70% of the black population is now living in urban areas, because of the influx of illegal immigrants from Sub-Saharan Africa. By the year 2010 it is expected that more than 75% of the country population will be living within the major five South African metropolitan areas, centered around Johannesburg-Pretoria, Durban, Cape Town, Port Elizabeth and East London, which will generate more than 75% of the national GDP. The Gauteng province (comprising Johannesburg and Pretoria) is the primary metropolitan area in South Africa: by 2010 it is expected to reach a population of 12 million and to produce 50% of GDP. The apartheid system created a settlement pattern that can be summarized as follows:

- Concentration of people in the five metropolitan areas, characterized by inefficient land use, unrealistic commuter distances and unequal access to services. The urban poor settled in growing numbers on the urban peripheries (peri-urban areas) in both formal and semi-formal townships and informal settlements, sheltering more than 10 million people.
- Distribution of the non-metropolitan population in more than 300 undefined settlements located on unclaimed land, outside traditional homelands.
- A growing urban population, inside the former traditional homelands, in up to 300 towns, previously economically supported by the apartheid government's industrial decentralization policies.
- The proliferation of semi- and peri-urban informal settlements, located inside

homeland boundaries, but on the peripheries of metropolitan economies, from which they derive some form of income.

- The mere survival of a rural population, already greatly depleted by massive migrations to the cities, estimated to grow to 15 million by the year 2010.

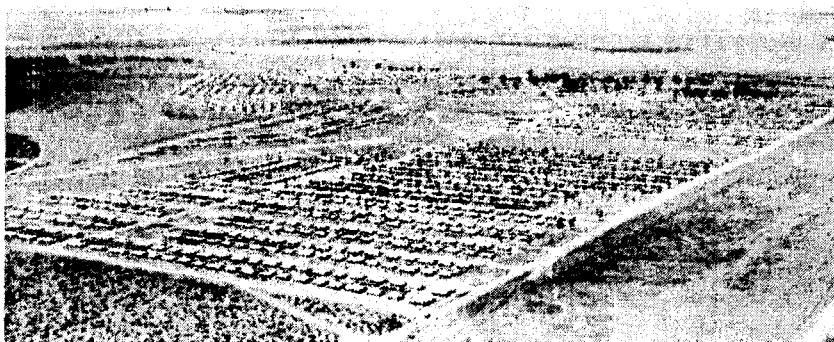
The entire structure of the apartheid city was governed by the racially based demarcation of urban space through the Group Areas Act. Passed in the 1950s, this Act empowered urban administrators to slice up the cities into four racial zones for Whites, Blacks, Coloured and Indians. Each zone was then separately governed by different planning, municipal and administrative laws. By the beginning of the transition to democracy in 1990, each area had its own unique local government system, urban planning system, housing delivery and ownership system. Underlying the division of the cities along racial grounds, there was also a racially motivated urban economic logic, that worked inevitably in favor of white residents. Within the advocated concept of 'separate development' the reality was that the economic urban relationship between the white and the "others" was quite similar to the traditional colonial relationship based on unequal exchange of benefits. This was most evident in the way the local government finance system was structured: all the major commercial and industrial areas were located in the 'white' areas and fell under the jurisdiction of the White Local Authorities. It has been calculated that up to 70% of all revenue reserved for the White Local Authorities came from the commercial and industrial areas in the form of property taxes and service charges: this was the revenue used to cross-subsidize the development of high-level services in the white suburbs. On the other hand, black townships had insignificant commercial or industrial base: they were merely residential areas for people who worked in the white areas. Revenue for the building and upkeep of their services and infrastructure came mainly from service charges and rentals paid by residents of large state-owned housing estates. The remainder came from National Government subsidies of up to 30% of running costs. Economic sustainability of the white areas was based on consumer spending mostly in white areas (due to almost total absence of commercial services in black areas). This economic base in turn created a viable tax base for the White Local Authorities, which enabled the cross-subsidization of the white suburbia. The underdevelopment of the black townships was a result of the ever-demanding transfer of resources to white areas: this was the questionable logic holding the apartheid city together as a single interdependent urban system.

South African urban infrastructure was built around three main energy intensive processes:

1. In order to keep race groups physically separate but economically integrated, a massive transport system was created that, by the late 80's, was capable of carrying millions of people, on a daily basis, across long distances. With the average time and distance of journey constantly increasing in line with urban and industrial expansion, the State was forced to subsidize rail and bus companies in parallel with an ever-growing energy consumption. The transport system soon revealed itself to be severely unproductive and of growing burden to the entire national economy.

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2. The water cycle and the waste systems were structured to suit mainly the affordability levels of white consumers. Solid and liquid waste were not recycled but instead deposited into so called 'sacrificial land' on the outskirts of cities. The entire ecological system was structured to direct needed water supplies to the central areas where large-scale urbanization and industrial development had taken place. But although a very high standard of services was provided to white suburbs, up to 70% of urban residents did not have adequate water and sanitation provision. A situation developed where large informal settlements in ecologically fragile urban areas soon began poisoning the underground water tables and rivers.
3. Legislation regarding Environmental Impact Assessments was non-existent. Urban development was therefore not planned to take into account environmental factors. The monotonous, treeless black townships linked to the white towns by a subsidized, energy-wasteful transport system is perhaps one of the world's most memorable monuments to the kind of modernist urban planning that has created unsustainable urban systems (see Fig 1).



**Figure 1: Typical township planning (KwaThema - Witbank)**

The restructuring of the apartheid urban system is still one of the primary challenges facing the new elected democratic Government. At the center of this system lies a Local Government, which only recently has been transformed into a system with unified structures and overall management responsibilities.

### **Local Forum, local governance and people empowerment**

The early 90s saw the establishment of local-level negotiation forums across the country. The parties involved represented various local government structures, business, municipal service providers, civic and residents associations, political parties and trade unions. Local forums became the training schools of the new South African democracy: this is where networks and relationships were built, where mutual learning took place and where a new culture of governance and consensus building developed. Although imperfect, tense and unstable, these local forums became the model for similar structures that emerged at provincial and eventually at national level, in the form of the Negotiating Council, that

finally created the 1994 national constitutional settlement. Local forums scope was to “transform the metropolitan regions so that the standard and quality of life of the people can be improved, and political participation ensured by the establishment of a legitimate system of local and metropolitan government based on non-racialism, democracy and a common fiscal base, and capable of promoting economic, institutional, physical and social development”. In 1995 Democratic Municipal elections took place, incorporating local government into a new three-tier system (local, provincial and national). Metropolitan Chambers (such as the Central Witwatersrand Metropolitan Chamber, first in the country and centered around Johannesburg) were established as policy-making bodies operating ‘by consensus’. Unlike similar urban reform processes in other parts of the world, the MCs faced the task of simultaneously transforming the four primary cornerstones of an Urban System, namely:

- The institutional and financial structures of urban government: such as the structures of elected political representation and their constitutional boundaries, the corresponding administrative systems responsible for policy management and service delivery, and the financial management system responsible for expenditure control and budgeting.
- The social and physical infrastructure and associated operating services: such as roads, electricity, water, sanitation, transport, town planning and housing, as well as matters such as education, sport and recreation, welfare, culture and health.
- The nature and dynamics of an urban economy; this refers to the nature of different economic sectors, institutional arrangements for boosting economic growth and linkages to the financial system.
- The environmental management system, dealing with energy inputs (fuels, water, electricity and food) and waste outputs (solid waste and air pollution).

The way ahead towards a democracy based on fully participatory and transparent government, all-inclusive in terms of issues affecting all, was now clearly plotted. All the major Metropolitan Councils in South Africa have now assumed in full the following capacities, integrated into an urban planning and implementation policy, namely:

- The life-supporting capacity, including climate, bio-diversity and the living environment.
- The resource providing capacity, including non-renewable resources, such as fossil fuel, as well as renewable resources indispensable for sustainable urban development such as water, vegetation and food.
- The waste-assimilation capacity, including the limited capacity of land and air in absorbing wastes of various kind.
- The recreational and aesthetic capacity, with particular attention to conservation, health and space for leisure.

Massive challenges were now presented to MC decision makers, such as the problem of establishing effective mechanisms to ‘bring the people on board’, eliminating barriers in understanding of processes, decision making and the meaning of executive decisions in context. Issues of language (eleven recognized official languages), education (illiteracy), culture (tribalism, the role of chiefs,

cross border migration, land ownership) etc., has created the acute need to find alternative and innovative means to bridge the gaps in understanding among all stakeholders: Information and Communication digital Technologies ( ICT) have been increasingly looked at, as possibly one of the tools to be adopted in helping in solving such problems.

### **Peri-Urban areas of South African cities: general context and current realities**

As indicated, South African major cities have undergone major changes both in their physical structure and in their administrative reorganization. Liberalization and democratization processes have indirectly caused massive migrations from the countryside and peripheral townships towards the urban areas, by people in search of a better life. Job seekers and informal traders have flooded Central Business Districts and formal businesses have moved out to new Mid-Town developments. Traditional, but of limited capacity, residential areas around city centers have been abandoned by previous residents and re-occupied by legal and illegal new immigrants. Peri-urban areas within the outskirt of South African cities have received the brunt of the 'invasion' with a rapid rising of large informal settlements, accommodating a multi-cultural variety of people living in sub-standard conditions. Such areas are large bands of land where various and difficult-to-control activities take place, such as:

- Uncontrollable rise and growth of massive informal settlements, on any type of land, including farmland and nature reserves, established by people escaping the countryside, foreign oppression or simply poverty.
- Unplanned road infrastructure created by informal users 'as needed' and not according to a city plan.
- Uncontrolled ad-hoc traffic circulation, through natural habitat, dry riverbeds, delicate wetlands and city nature reserves.
- Indiscriminate and badly located informal small enterprise developments.
- Illogically and ad-hoc distributed services, such as schools, crèches, shopping outlets, clinics etc. (located both as emergency and permanent provisions by Metropolitan Councils).
- Uneconomical and ad-hoc distribution of infrastructure (sewage, water, electricity, telephone and roads reticulation).

### **Growing needs for new technologies**

New tools for effective development, monitoring, communication and full public co-participation are therefore necessary: 3D digital and interactive Visualization Technologies, as developed at the CSIR in Pretoria, are one of the success stories of the last few years. The now mandatory government requirements for full community participation to decision making, at all levels of governance are encouraging the adoption of Information and Communication Technologies (ICT) in support to a fast growing need to fast-track info-sharing and ultimately the effective delivery of services and a better quality of life for all the people.



Town planning and integrated environmental management projects across South Africa are demanding simple to complex innovative tools, ranging from ground/aerial photography, satellite data, Geographic Information Systems, Computer Aided Design, 3D digital simulations and 3D fully interactive Virtual Reality. Their effective implementation is gathering interest and support, with particular reference to their recognized potential significance in helping the redevelopment process of South Africa and the Southern African region. The Gauteng province (centred around Johannesburg and Pretoria) in particular has shown leadership, with the adoption of such technologies in a variety of projects.

### **3D Visualisation Technologies in context**

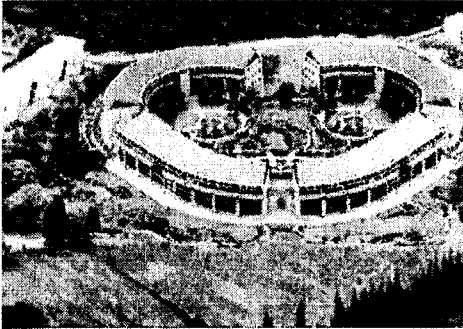
Spatial planning (urban, rural and environmental) in developing Countries, is traditionally related to the use of a variety of tools centred around Computer Aided Design (CAD), which operates almost entirely onto 2-dimensional planes, and Geographic Information Systems (GIS), which also depict spatially-distributed data on two-dimensional surfaces. However, humans located in an actual landscape view features much differently: the land surface is undulated, the landscape is three-dimensional and has characteristic features, objects appear smaller in the distance and so on. Consequently, many people (and particularly so in a developing country) find it difficult to visualize the data represented by a CAD or GIS system. In addition, one of the main difficulties often encountered during attempts at establishing a line of communication and understanding between planners (environmental, town and infrastructure) and the communities affected by such planning, is the problem represented by cultural, technical and educational communication barriers. It is in fact often extremely difficult to establish a bridge of understanding with people who do not speak the same language and have little or no formal education, particularly so when attempting to communicate complex spatial concepts related to integrated environmental and urban planning and sustainable developmental strategies. 3D Visualisation Technologies, in the form of graphics, animations (2D & 3D) and interactive visual simulations (Virtual Reality) have demonstrated to have the capability of making good to such shortcomings. So what are the possible applications, in an African context, in terms of Urban Planning, Integrated Environmental Management and Rural development? The following represent a focused look at the subject.

### **3D Visualisation Technologies and Virtual Reality Simulations in decision-making**

In simple terms, 3D Visualisation and 'Virtual Reality' means the artificial creation of real-worlds, natural and man-made environments, executed digitally with the use of computers. Rather than representing 2D flat images, as conventionally done in a CAD or GIS environment, 3D digital graphics with composite attributes are instead assembled to represent, as realistically as possible, a 3D world (see Figures 2&2a).



**Figure 3:** A digitally created, proposed urban development in Pretoria east.

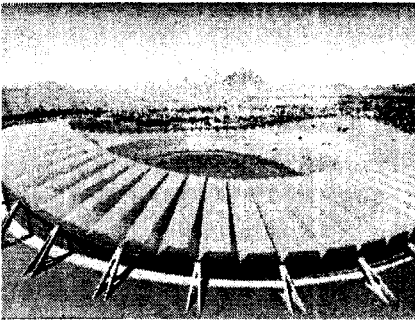


**Figure 3a: Detail**

in that it also allows to interact, in real-time, with the simulated environment. The technology in-fact allows one to 'enter' a particular area and walk through an artificial environment, where volumes and perspectives realistically match the real world. The viewer becomes a visitor, totally 'immersed' and able to look, move around and interact almost as if really being 'there'.

The digital representations thus created represent a 3D world which will be built and assembled, which will surround us and within which we will live and operate: a world complete with mountains, rivers, buildings, infrastructure, towns, people, sounds and dynamic interaction amongst all these components (see Figures 3, 3a , 4). Interactive Visual Simulation

(VR), has also a proven role to play



**Figure 4:** Proposed city stadium (Cape Town)



**Figure 5:** Use of HMD for town planning

A further capability of Virtual Reality is the ability to move and manipulate objects: 3D objects such as buildings, roads and trees can be added, re-scaled, removed or changed in position, by the simple click of a mouse or through the use of a Head Mounted Display (HMD) system (see Figure 5).



This capability allows one to view and to show the proposed environmental changes immediately, exploring 'what-if' scenarios and communicating graphically and, above all, interactively to an audience, the proposed changes. Feedback would be therefore immediate, allowing consensus to be reached on important issues such as urban and township planning, infrastructure development and, above all, environmental preservation and planning. Virtual Reality therefore will play an important role as a communication, education and planning technology, absolutely relevant in the African context, in terms of knowledgeable and full community participation in decision-making processes.

### **3D Visualisation, GIS and Virtual Reality: a case for a technology merger**

Currently GIS users mainly manipulate, query and display spatial data objects (points, lines and areas) in a 2D format on the computer monitor, and normally output from sophisticated color plotters or similar devices. But although it is possible to model and display a multi-option land-use plan within a GIS fusing together a 2D map of colored areas onto a 3D topographic relief (see Fig. 6),



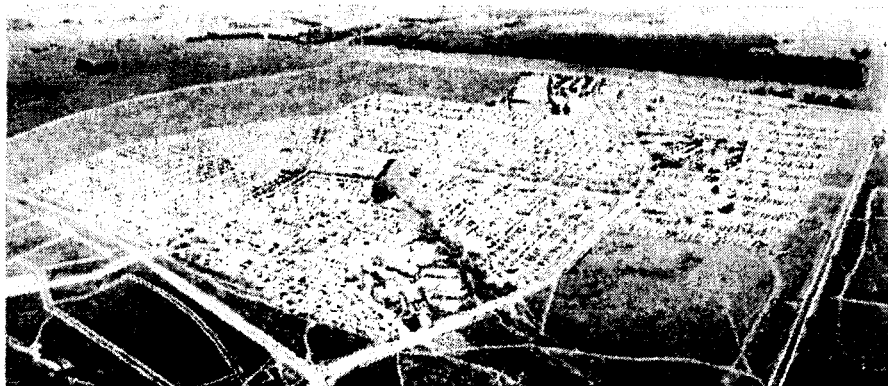
**Figure 6: Virtual GIS (Drakensberg)**

of creating close-to-reality virtual worlds. Virtual worlds have also the potential to use GIS data and technology and placing it in a 3D environment. The capabilities of current GIS and Visualisation technologies are in fact already quite close to the capability of transferring real data into a 'virtual' 3 Dimensional world. South Africa is pursuing such merger, showing imagination, courage and proven leadership in the developing world.

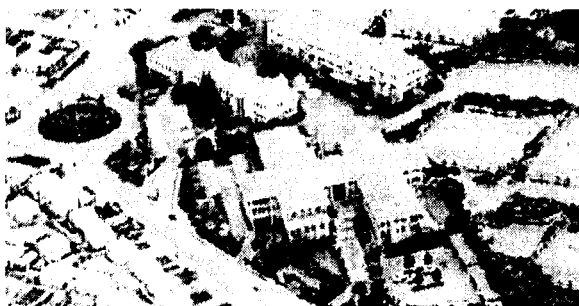
final results are always short of representing reality as it is, therefore maintaining that gap in communication between planners, decision makers and the community at large, which only sophisticated 3D Visualisation tools or true Virtual Reality interactive simulation can bridge. The merger of 3D Visualization tools, Virtual Reality and GIS technology has the capability

### **Virtual Reality in development and environmental projects**

3D Visualisation Technologies in general and Virtual Reality in particular, can aid physical planning and realistic budgeting for a development project by visualising a project's problems before committing funds. Communities in several parts of South Africa have been made able to understand and accept proposed changes to land and urban development projects, before work commenced, by viewing 3D virtual mock-ups of the development in question and the proposed land-use alterations. Traditionally this has been done using 2D maps, 3D artist hand-sketches, and scaled miniature physical models.



**Figure 7: Proposed housing and infrastructure development in Pretoria (Centurion)**



**Figure 8: Detail**

The use of realistic 3D digital views of sites, 3D perspectives and representations, linear animations and real-time interaction (VR) have been found to be an extremely powerful alternative medium to 2D maps or plans (see Figures 7&8). Major SA

Metros have already used, via the CSIR in Pretoria, 'virtual' tools to present re-development plans to communities often living in informal settlements residing mostly in peri-urban areas: success of such initiatives is extremely encouraging. These visualization tools will soon become sophisticated enough to allow real-time manipulations: at demonstration time with the communities, the land-use model would become changeable in front of peoples' eyes, with visualization of environmental impact of proposed changes. Strong community interaction with proposed planning options, through real-time interactive virtual changes, would allow a higher degree of understanding and optimal developmental planning. Advantages in using a digitally created 3D environment over the more traditional methods are: quicker 3D composite-model development, capability of 'real-time' manipulation, usage of real data for virtual model creation and close-to-reality representation of the environment and full and knowledgeable audience participation. Given also the great effort and advances by software developers in bringing ever closer to each other 3D Visualisation technologies, VR, and GIS data, there is no doubt that 3D Interactive Simulations will soon be adopted by environmental and urban planners in the developing world, to accelerate, optimise and 'popularise' complex data and spatial processes, in the interest of political transparency and integrated environmental significance. South Africa leadership in that respect should be acknowledged and possibly followed, in the interest of all.