AN INTEGRATED SPATIAL INFORMATION FRAMEWORK FOR INFORMAL SETTLEMENT UPGRADING

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Commission II

KEY WORDS: GIS, informal settlements, urban planning, database management, upgrading

ABSTRACT

This paper describes a new planning methodology for the comprehensive upgrading of informal settlements in-situ. This uses a variety of spatial imaging and data capture techniques to link different components of the upgrading process together, thereby providing a basis for replicability. It is based upon a system which was first developed in Brazil, but which has been substantially modified and systematized in Cape Town. The method is based upon the recognition that informal settlements are multi-functional environments. At the same time the upgrading may require that up to 30% of the families be relocated internally. The integrated spatial information system described here provides the framework to support and integrate these diverse needs. The process begins with aerial photography, generally taken by helicopter at low altitude. This provides a high resolution, visual backdrop on which the vector data and all developmental activities are superimposed. Key elements of the system comprise shack data, physical risk factors, existing access and movement routes, and a detailed social and economic survey supported by on the ground analysis. The way in which this information is linked and utilised provides the basis for a replicable in-situ upgrading methodology for informal settlements.

INTRODUCTION

Informal settlements constitute a large proportion of the housing stock of Africa s major cities, with the percentage varying from between 10-20% in South African cities to over 80% in cities such as Dar es Salaam and Luanda. These settlements are unplanned and generally unserviced. As they stand they are not amenable to formal, cadastre-based sub-division for a number of reasons. In many cases there are insufficient financial resources. Then, at least in a South African context, there is a constant movement of shacks, which makes paper-based improvements difficult to implement. At the same time these areas are often situated on marginal land which requires that certain areas will need to be cleared of dwellings. If these areas are to be developed new ways of doing this will have to be found. This cannot follow the formal township development route applicable to vacant land, which enables a development to be fully planned and designed spatially prior to construction. The very fact that sites are occupied, often at very high densities, and that the existing layout is generally of a random nature, makes this virtually impossible.

Various approaches to upgrading in-situ have been used internationally but, because of the site constraints described above, none of them have been able to develop a planning methodology that is replicable.

CURRENT APPROACHES TO UPGRADING

Current approaches to upgrading fall into one of two broad categories. The more common approach in Anglophone countries is that which evolved in countries such as Sri Lanka (e. g. Pathirana & Sheng, 1992; National Housing Development Authority, 1988), India (Ableson, 1996; Asthana, 1994) and Pakistan (Environment and Urbanisation, 1995; Hasan & Vaidya, 1986). These focus very much on upgrading and tend to operate on a sectoral basis. That is, they seek to address a specific need (e.g. water supply or housing) and do not seek to map out a long-term plan for the settlement. This approach works reasonably well in very poor areas, where there is little chance of achieving more than the provision

of basic needs and where there is little or no relocation of existing dwellings. In this approach, the spatial relationship between the dwellings is kept unchanged. This approach may result in slum improvement, but it does not really change the status of the informal settlement. The second approach is quite different. This second approach was pioneered in Belo Horizonte in Brazil, and is now the dominant approach in Latin America. This approach is based more upon the principle of formalizing the settlement than upon sectoral improvement. As this requires modifying the spatial layout of the settlement, it means that government has to be more directly involved, as greater resources and government support are both pre-requisites. In order for this approach to work, it is necessary to have flexible and adaptable tools that can map changes to the settlement quickly. Hence the Belo Horizonte project pioneered the use of GIS as a planning tool (AVSI, 1995).

The Belo Horizonte project sought to combine two elements of planning. The first was an understanding of community needs, which provided the social basis for development within a settlement. The second was the adaptation of a new mapping tool, then recently developed by UNCHS Habitat for the rapid assessment of refugee who set up large camps after disasters, to provide a fast analysis of approximate numbers. These were combined into an integrated urban planning system, which was known as Visual Settlement Planning (ViSP). In essence, ViSP created a masterplan for the development of an informal settlement based upon the principle of minimum relocation. The project worked well and became a model for settlement planning in a number of countries in Latin America. Again though it had a number of limitations. It required work on all facets of settlement planning to take place simultaneously. This was extremely expensive and not really sustainable. It was also particularly well suited to the housing configuration used in Brazil, which revolves around grouped dwelling units and footpaths. This serves to minimize relocation. In addition, where relocation is necessary, there is state compensation. And finally, the system uses a strong social support system of community social and development workers to liaise between government and community.

In 1996, a research project was started in Cape Town with the objective of testing the viability of the Belo Horizonte methodology in a different context. This began first as a desk study and then followed through into a pilot project in a community of 3000 families. Upgrading was not new to South Africa at that time. There were a number of different projects to draw on, particularly in the Durban region. But these had all been ad hoc, and therefore difficult to replicate. In addition, the thrust of community-based development in the country followed much more closely the Indian experience. As a result there was pressure on the project to move more in that direction, a move that was also influenced by a suspicion of technology-based solutions. The net result was that the project was carried out with a consciousness of a much more open view of what constituted upgrading, and an approach that sought to draw benefits from both sets of experiences. The result was a methodology that, while still GIS-based, followed more of a middle path between the two extremes outlined above. It is this methodology that is discussed here.

THE PROJECT AREA

Cape Town had 64 informal settlement clusters in 1998 with over 70,000 shacks (Abbott and Douglas, 1999). The majority of these settlements were grouped around two geographical areas, known collectively as Ikapa and Khayelitsha (see figure 1), which were situated in areas that had been classified as racially defined Black Local Authorities by the previous apartheid government. The first of these was situated close (15-20km) to the centre of Cape Town, and constituted the study area for this project in its earlier research phase (Abbott, et al, in press). Two specific settlements were chosen, from within this first area, to test of the methodology described here. This choice was arrived at through an extensive community consultation process (Abbott et al, 1996).

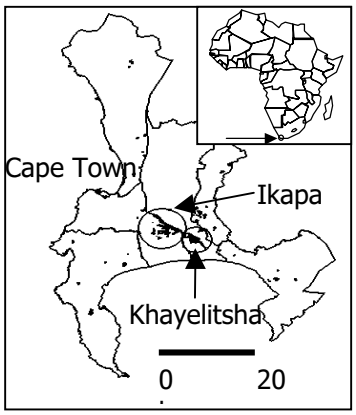

Figure 1. Location map

The two informal settlements, named New Rest and Kanana, are situated south of the N2 freeway. Although adjacent, they are separated by a major suburban feeder respectively. New Rest comprises 1,130 dwellings while Kanana has approximately 1,600 shacks. The combined population of two settlements is approximately 10,000

persons (May 1998 figures). Both sites have physical constraints. Part of Kanana is founded on an old landfill site, and is also in the path of a possible airport link road. New Rest has areas that are prone to flooding and also has a section that is founded on poor quality fill material. The two areas are being developed sequentially following the same procedure. For the sake of simplicity, therefore, this paper will focus on New Rest, which is the lead project of the two.

South African informal settlements are made up of single dwelling units that are detached, although they may be very close to one another. As mentioned elsewhere (Martinez and Abbott, 2000) densities in these settlements vary quite significantly. New Rest has a density of approximately 70 dwellings per hectare, and is therefore close to the median. This was a strong influencing factor in choosing the project area, as it meant that the figure was large enough to test the validity of the methodology, but not too big as to guarantee total rejection by the local authority (existing densities in low-income developments are 35-45 dwellings per hectare).

DEVELOPMENT OF THE METHODOLOGY

As mentioned earlier, the approach taken was one that sought to find a balance between ad-hoc development and the implementation of a master plan. Informal settlements are multi-functional environments. Hence any attempt to upgrade them in a sustainable manner has to recognise and support this multi-functionality. This means working on all facets of development. At the same time, this has to be balanced by an implementation programme that is flexible, and which caters for a range of different affordability/expenditure patterns. This use of individual project or sector development within a multi-functional strategic approach is made possible through the use of a GIS-based operating environment.

The starting point is an assembly of geo-spatial information, bearing in mind that this is now being collected to support a broad-based development. On this basis, the information gathered can be divided into three categories, as follows.

i. Base data.
ii. Demographic, social and organizational data.
iii. Spatial and physical data.

Each of these is discussed briefly below.

THE BASE DATA[1]

The collection of the base data represents the first change in thinking away from a conventional housing development approach. Here the focus shifts from the site (parcel) as the basic spatial unit (BSU) to the shack (dwelling). This is what exists and it is this unit that will have information attached to it. This means that the cadastre is no longer central to the development process, a major change from current thinking.

There are three components to the base data. The (fixed) cadastre is no longer the basis for development. Hence the development strategy will need to be based upon transient data. Similarly, because the BSU is now a physical feature, the data source will need to be spatial in type. This data source is a photographic image of the site. There are three image types available: satellite, aerial (controlled flight path) and helicopter. In the initial stages it is not necessary to have high levels of accuracy in the positioning of the shacks. In the Cape Town project a helicopter was used and the images were warped into position using an affining process, with the reference points being taken from a 1996 1 in 20,000 aerial photograph (see figure 2). This was adequate for the first phase of the work, which was concerned with capturing demographic data. This type of image generation is cheap and rapid, which means that any shack movement can be monitored and integrated. The use of more expensive aerial photography, on the other hand would not be cost or time effective. In the later stages of the project, where a freezing of shack movement is required, then this is the point at which an accurate aerial survey can be flown. With the new

[1] All data and graphical information reproduced in this paper is drawn from the work by Abbott et al which is currently under review by the Water Research Commission of South Africa.

1m resolution satellite imagery, it is possible that this could take the place of helicopter-based photographs.

The large-scale images serve a number of distinct functions. Firstly they provide the basis for all community discussion and negotiation. Our experience is that communities relate well to photography, recognizing their shacks and gaining a good understanding of the inter-relationship between the shacks and their area. This in turn provides the foundation for community decision-making. Secondly, the image provides the basis for a spatially referenced housing typology database. This is extremely important. Fire is a major hazard in the informal settlements in Cape Town. To address this problem it is imperative that housing improvements take place in parallel with the settlement upgrading. Thirdly, the image is used to generate an accurate vector map of the area. This in turn will provide the basis for ongoing design of services and infrastructure and for land regularization and registration.

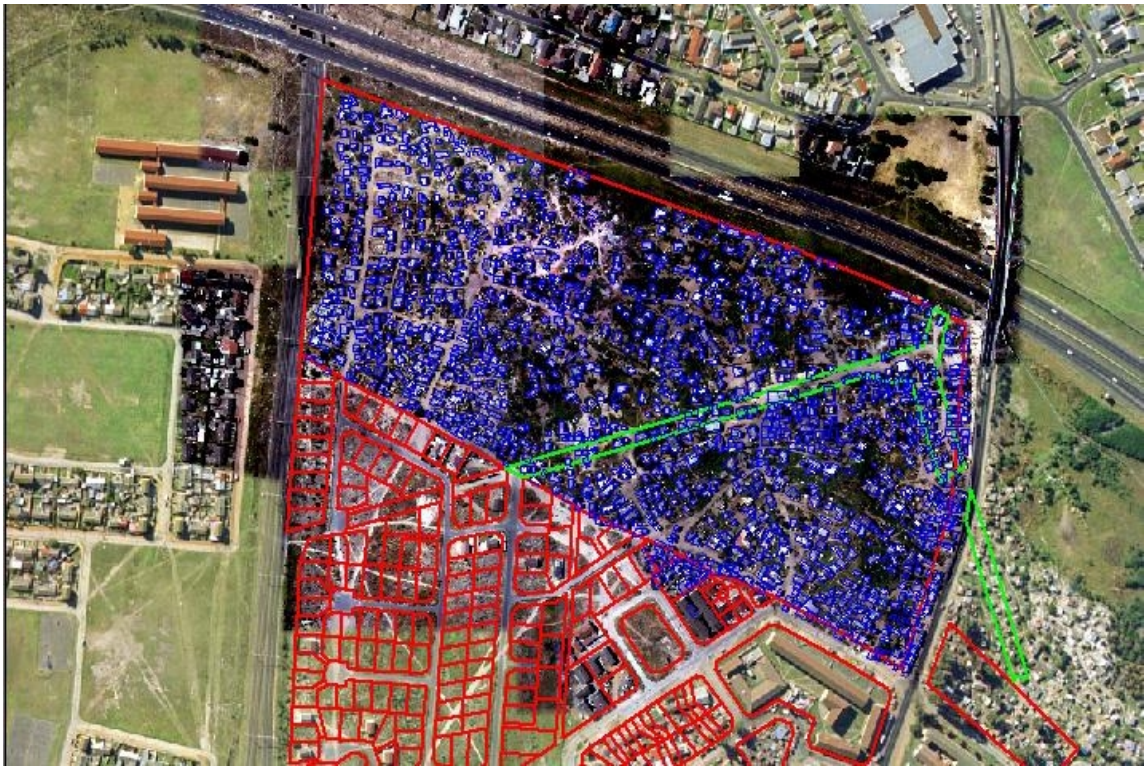

Figure 2. Aerial photo-mosaic of New Rest

Creating a vector overlay for the shacks is straightforward. The critical issue is the numbering of the shacks (figure 3). This can, of course, be done automatically as part of the attribute creation process. However, this does not mean that these numbers will be accepted. The way forward at this point is for the community to create the numbering system and to physically allocate these numbers to the shacks. This serves two purposes. The first is that it establishes community support for the project, without which the project is unlikely to succeed. The second purpose is to involve the community in the GIS-based process from the beginning. Hence the shack numbering provides the basis for community partnership in decision-making around the upgrading.

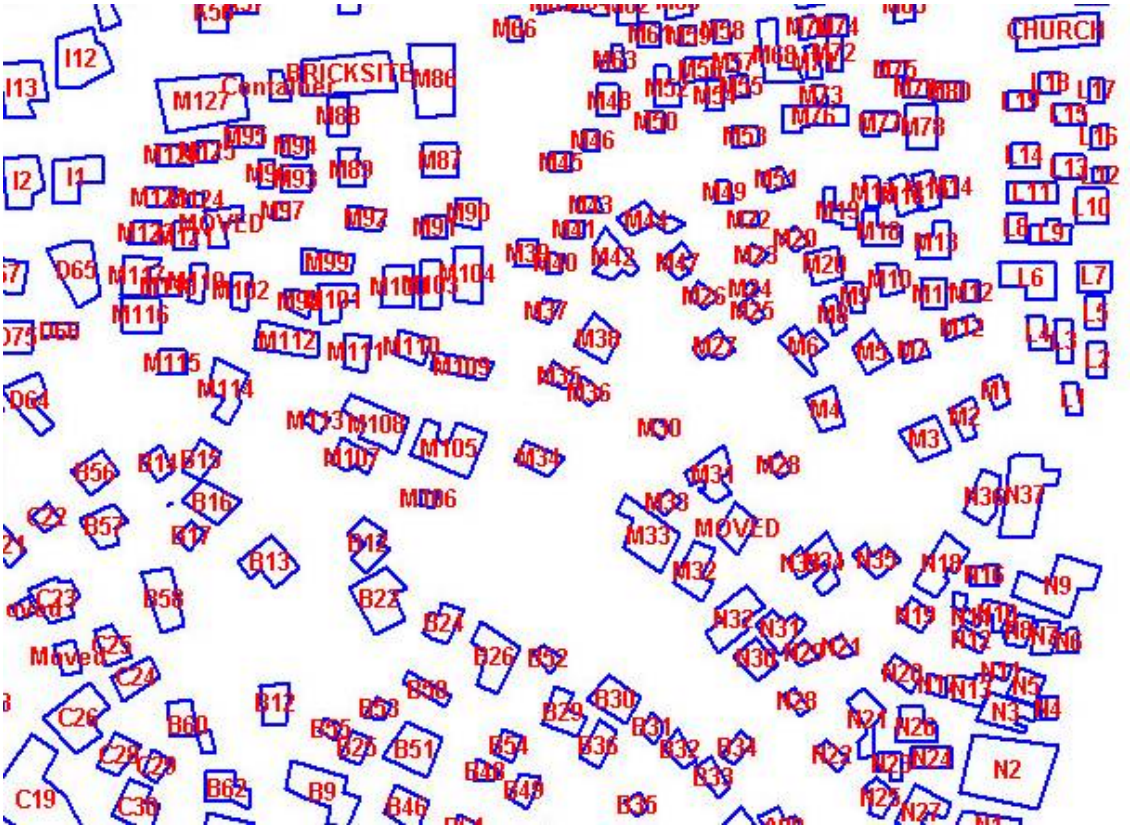

Figure 3. Detail of the shack numbering

DEMOGRAPHIC, SOCIAL AND ORGANISATIONAL DATA

The previous section illustrated the first major difference between in situ upgrading and greenfield site housing development as being the switch in emphasis from the parcel to the dwelling. This section reflects the second major difference, which is, if anything, even more fundamental. It was pointed out earlier in the paper that in situ upgrading covers all facets of development. The only common denominator running through all facets of the upgrading is the community. Hence the second shift reflects a change in focus from the physical site to the people who are living on the site. From this it follows that an understanding of the community is central to the process. Such an understanding comes from information judiciously interpreted. And this in turn is derived from a combination data and intuitive analysis guided by experience. Effective integration of the two can only be achieved through spatial referencing of the data.

In addition, once it is constructed in this way, the social database provides the framework for an inter-active education process, between community and professionals, which operates in two directions. Because each family is interviewed, this presents an opportunity for everyone to be informed of the project and to discuss it. This is a process that has immense value in deepening the community participation process and has been shown to work in South Africa as well as Brazil (Abbott et al., 1997). At the same time it allows the professionals to get to know the community on the ground and to obtain an understanding of the problems to be dealt with at first hand. Again this has immense value, particularly when it comes to defining infrastructure needs and the relationship between people and levels of service (see Abbott, 1994 for a discussion of some of these issues).

The database is organized into a number of categories, which cover the head of household, the spouse, children, and other residents of the shack. The information covers a basic profile of the individual, his/her residence in the area, linkages to other geographical areas, education, employment and skills. The information is linked to the shack number, and this forms the linkage with the base data. The output from

this second set of data then takes the form of a series of thematic maps, which portray the information spatially.

Figures 4 provides one example of this output. It shows the gender distribution of the head of household, which indicates that 40% are single parent households headed by women (yellow shacks). Such a finding clearly has a major impact on the planning process. A second distribution (not shown) provides a breakdown of employment in New Rest. In this analysis employment has been divided into four categories: formal employment, informal employment inside New Rest, informal employment outside New Rest and no recognized form of employment. In this case formal employment was found to be higher than expected, at 58.6%. 12.6% of heads of households worked in the informal sector within New Rest (thereby providing the potential for the creation of a future economic development strategy for the area) while 10.0% were occupied in this sector outside of area. 18.8% had no recognized form of employment.

It can be seen from this brief description that the survey represents a distinct shift away from the information gathering exercise associated with random interviews. Even so, it is important to recognize that this is only the base. The success of the project lies in the detail; in the ongoing involvement of community workers coupled with extensive and ongoing interaction; and most importantly in the extent to which the process empowers the community to take control of the wider upgrading process. This aspect is covered later in the paper.

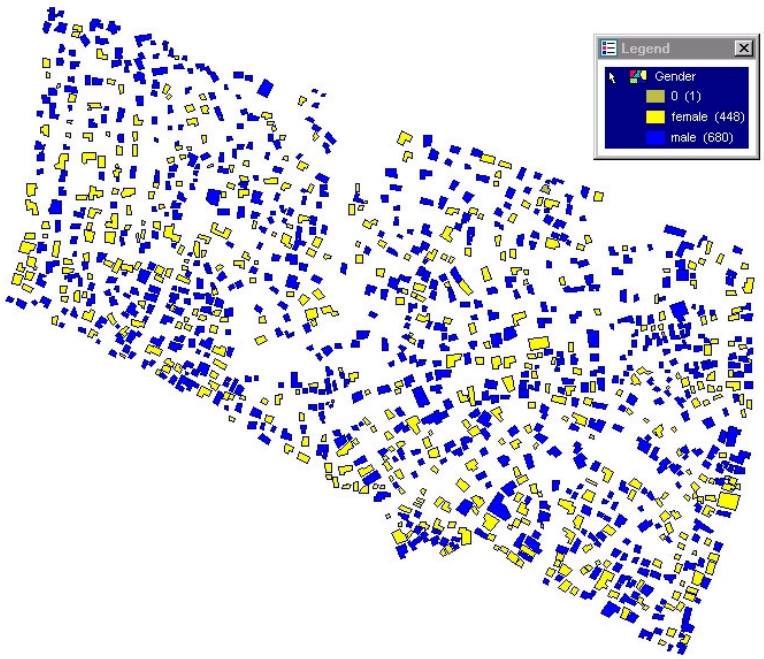

Figure 4. Head of household broken down by gender

SPATIAL AND PHYSICAL DATA

The third area of spatial interpretation/analysis relates to spatial and physical data. The order of prioritizing this list is deliberate and reflects the reality of upgrading. It is recognized that most informal settlements are sited on marginal land, and that this will have a major impact of the upgrading. However, successful upgrading is impossible without community support. If the community is integrated into the process, then the constraints imposed by the physical environment can be accommodated.

The impact of the physical environment is twofold. First comes the impact on individual families, i.e. which will have to be relocated (either internally or externally) due to the physical constraints imposed by the site? Second, what is going to be the impact of installing collective services?

There are a number of factors that might require dwellings to be relocated. These are as follows.

- Bad ground (this could be an unstable slope, a flood prone area or a fault in the underlying ground).
- Existing servitudes or rights of way.
- Competing claims for ownership.
- The need for public or social services.
- The provision of access routes.
- Changes in the house clustering pattern.
- Physical risk factors (e.g. flood-prone areas or geologically unstable sites), as well as cadastral constraints, requiring the relocation of individual shacks, are linked to the site and shack data.

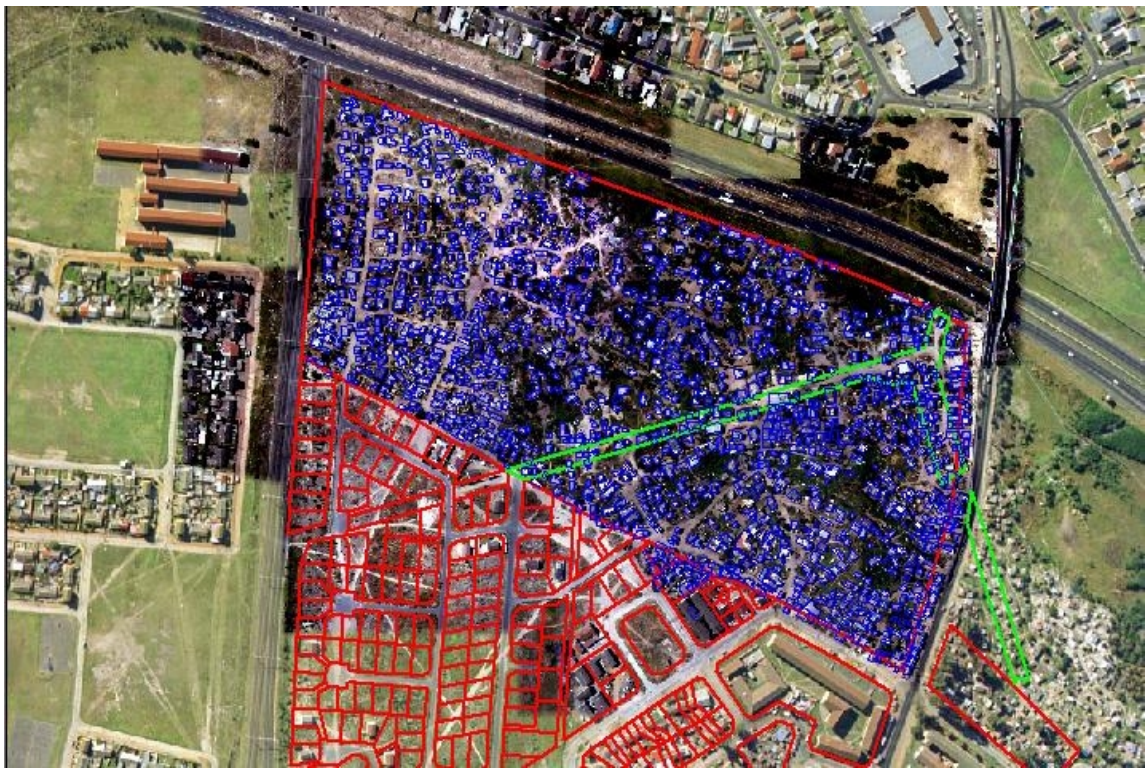

Figure 5. Impact of existing site boundary and servitudes

Figure 5 provides an example of the physical constraints identified for New Rest. In this case the constraint derives from existing cadastral boundaries. The figure shows the impact of the existing site boundary (red lines) on shacks and also the impact of current servitudes (rights of way) (green lines). The data which quantifies the different parameters set out in the list above be collected in a number of different ways (e.g. CAD, proprietary GIS, text readout). GeoMedia Professional®, the GIS software used in this project, reads all of these directly and creates linkages to the base data, so that the impact of these physical constraints can be linked to individual shacks.

INTEGRATING THE DATA TO CREATE A DEVELOPMENT FRAMEWORK

This section deals with the integration of the different data sets described above. It does not use new data. It uses GIS analysis techniques of queries and buffers to arrive at key indicators. In its approach it represents the third shift from a traditional planning approach. For while the traditional approach creates a development from a blank sheet of paper, this approach uses elements that already exist, and whose details

are gathered in the phases outlined above. As a result, the planning process is more analogous to a jigsaw puzzle, where the pieces already exist, and the solution lies in moving them around and integrating them to form a new picture. As with a jigsaw, none of the original pieces (in this case the shacks) should be discarded.

This sounds relatively straightforward. However, it is complicated by the fact that the exercise is not just a physical one. This is a complication that is not applicable to the traditional approach, and as a result its impact is not fully appreciated by development professionals. If the project is to be sustainable, then the area to be developed has to have a defined social and economic framework within which to operate. If the puzzle is to be assembled correctly, then these factors have to be taken into account.

The success of this process lies in the correct analysis and interpretation of the data already collected, and a determination of its implications. Here, three sets of issues have to be dealt with. The first relates to the potential relocation of shacks. The physical characteristics identified earlier represent potential constraints. Each poses a risk to a shack. The extent of that risk needs to be defined. Hence simply superimposing the physical constraints on the existing shacks highlights the areas of potential risk and which dwellings will be affected by it. Two illustrations of this are provided for illustrative purposes. The first is the impact of flooding. A combination of a flood analysis survey, geo-technical survey and questionnaire provides full details of all the areas that are flooded during heavy rains, and the shacks that are affected. A similar exercise can be carried out for infrastructure provision, and is particularly relevant for access routes. The difference is that, in this case, the impact is determined using buffering techniques, with the buffers being created around different road centreline options. This then highlights the shacks that are affected by a particular choice of road reserve width.

The third type of impact on shack relocation derives from what, if any, social and amenity services will be incorporated into the area. Again similar analysis techniques are applied. All of these lead to planning choices having to be made. Thus the first choice is on between relocation or adding fill to raise the ground level, and is essentially financial. The second choice is that of road reserve width, and is partly economic and partly an issue of user convenience. The third relates to the perceived importance of social services and reflects social priorities. All are equally important. Choices such as this can only be made in a partnership situation between the local authority and the community, with the professionals facilitating the process, rather than determining the product.

LOCAL LEVEL PLANNING

The first outcome of the process outlined above is the identification of all shacks that have to be relocated. From the spatial perspective, the result is a skeletal area plan, which defines major roads, areas of physical risk and public service areas, all of which need free of dwellings, together with cadastral boundaries. Clearly though, given the underlying principle of minimum relocation, the area allocated to this open space will be much smaller, as a percentage of total site area, than would be the case in a conventional development.

The second outcome is the initiation of a planning process at this local level that is much more directly related to, and driven by, the community. It has provided a framework for the use of action planning type programmes that would not have been possible at the larger scale. This then becomes the point at which the survey data becomes central to the planning process. Unlike a conventional social survey, the spatial linkage of the survey data enables multiple queries to be made about households. This makes it possible to deepen the knowledge about families in the community significantly. Thus for example, it is possible to look at households at risk and to identify all their circumstances. Or, alternatively, it allows for the identification of families out of work to be given preference in the construction phase.

Coupled with this is the use of the survey data to identify economic opportunities. One factor that has emerged from the wider research programme associated with this project is the need to have a core economic activity, as well as building support for the home-based enterprises and other informal sector activities that already exist. Merging these social and economic issues, planning is taken to a second, local level of activity. However, instead of being built primarily on spatial considerations (layout) the

planning is built around the retention of social cohesion, the retention of the social capital base, an the maximizing of economic opportunities.

The siting of roads, cadastral boundaries and amenity areas divides the area naturally into blocks. The social survey data, integrated into a participatory decision-making process, ensures that the factors described above are taken into account fully in planning the relocations. Once relocation has been agreed then the physical planning at a local level can begin. Here again, however, the process is very different to a conventional one.

Planning at the level of the cell deals with the following components:

- Site planning and cadastral boundaries.
- Social services.
- Economic development.
- Infrastructure provision.
- Housing development.
- Improvement of the environment.

This is achieved through a GIS-based management system. Accommodating these diverse needs requires that there be inter-connectivity between different activities and the GIS platform. All activity (e.g. spatial planning, infrastructure planning and design, housing and building development) therefore takes place within the same GIS environment. At the same time, it is important that the community plays a key role in decision-making, and this requires that the same GIS system be capable of providing a degree of inter-active planning with members of the community.

CONCLUSIONS

This paper has proposed that geo-spatial information management is the key element in establishing a new planning paradigm appropriate to the development of informal settlements, as well as for a replicable methodology for upgrading such settlements. Such a methodology has, as its objective, the creation of formalized and sustainable settlements. To this end the spatially referenced management system is used to integrate the different components of the upgrading process, provide a key management tool for development, and empower the local communities to make all key decisions.

The way in which the information is structured and spatially referenced is central to the success of the methodology. The core data set is that constructed around the existing dwellings, and it is kept as simple as possible. Linkages within the GIS environment are then used to integrate all other data with this data set. From this point data collection falls into two categories, one dealing with physical and spatial data and the other with social and economic data. These three data sets together then form the basis for all decision making.

The planning process that emerging from this approach differs significantly from that used to plan new site developments. Firstly the basic spatial unit for referencing is the dwelling rather than the parcel. This represents a fundamental shift in thinking. Secondly, the whole emphasis moves from one where the site (the piece of land to be developed) dominates the process, to one where people and their needs dominate. The remodeling of the site is subservient to the needs of the community. Finally there is the issue of servicing the site. In the conventional approach services move out form the individual parcel, which is seen as the point of delivery. In this method a hierarchical approach is adopted, whereby people are grouped through a re-location exercise into smaller spatially defined sub-areas. The initial planning of infrastructure seeks to operate at a communal level to service these sub-areas, with the individual servicing of parcels coming later and being dependent upon a different set of affordability criteria.

ACKNOWLEDGEMENTS

This project has been supported from its inception by Intergraph Corporation and by Intergraph Systems Southern Africa, and its success owes much to the continued support provided by these companies. The early desk-study work was funded by the Water Research Commission of South Africa, while financial

support for the testing and implementation of the methodology was funded by Cordaid of the Netherlands as part of a community capacity building and economic development project. I would also like to thank my research students, Iuma Martinez and David Douglas, for their input into aspects of this project, the project social worker, Vuyiswa Mokwoena, the community s project coordinator, Morrison Mvumvu, and the residents of New Rest. Acknowledgement is also given to UNCHS (Habitat) and AVSI who provided links with the Belo Horizonte project and openly shared information and experiences in GIS with my research group.

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