DATA COLLECTION AND MANAGEMENT FOR INFORMAL SETTLEMENT UPGRADES

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INTRODUCTION

A major challenge facing African land managers is the growth of urban informal settlements. From a government perspective, management implies planning and control of the location in which these settlements spring up, improving the social and economic conditions in them, and ensuring that residents and neighbouring communities enjoy social justice. Of primary importance is the improvement of land tenure security for residents of informal settlements. Addressing all of these objectives requires current, accurate, social and spatial information. Informal settlements hold certain unique challenges in this respect due to their complexity and rapidly changing social conditions.

Informal settlements comprise 30-80 percent of a typical developing world city (UNCHS 1996). It is projected that by 2020, 63 percent of the African population will live in cities (Farvacque-Vitovic' and Godwin 1998). This is largely a result of rapid rural – urban migration. Rural areas commonly suffer from excess labour, relatively low productivity and low income levels. Consequently cities are increasingly perceived as the place of the future for millions of people (Payne 1999). It appears that the prospect of being an urban subsistence retailer or an unskilled employee holds more hope for these migrants than subsistence agriculture.

Urban growth as a result of an influx of poor people represents a serious administrative challenge. Improving the conditions of the urban poor is critical to social, economic and political stability. Farvacque-Vitovic' and Godwin predict that failure to intervene could result in urban violence and social unrest as social disparities become more acute. Moreover, it is essential that cities function in ways that contribute to the national economy, rather than burden it (Farvacque-Vitovic' and Godwin 1998). A major share of GDP is produced in cities. Cities attract international and domestic investment for manufacturing, service and commerce (Payne 1999).

The paper proceeds as follows. General social and political characteristics of informal settlements are described, upon which the need for frequent social and spatial information collection is argued. Thereafter various social and spatial data collection techniques that have been employed over the past five years as part of a number of research projects in the Department of Geomatics at the University of Cape Town are described.

INFORMAL SETTLEMENTS

Informal settlements are complex, dynamic social systems, which experience continual change. In occupying land informally, residents are often prepared to flout the law in the hope of improving their economic position. Typically, the internal social and political dynamic is characterised by both solidarity and schism. In general, conflict is inherent in the relationship between the general community and outside agencies, such as the authorities and surrounding residents, and in the relationships between different groups in the settlement itself. A community may act in solidarity when negotiating with the authorities or invading land. Solidarity may occur in dealings with the authorities, but schisms occur in the implementation of deals made with the authorities and in the day-to-day running of a settlement (Barry and Mayson 2000, Fourie 1993).

The internal political climate of a settlement tends to be characterised by tension and conflict between different factions. These factions tend to form and dissolve over time, and also grow and shrink in terms of numbers of people and sphere of influence. This phenomenon is a response to the behaviour of external agents, such as the authorities, and internal forces emanating from the actions of different individuals and groups in a community. In competing for power, land and resources, different groups and individuals strive to maximise their own interests. Internal settlement rules and agreements with outside agencies tend to be manipulated for this purpose. The result is that the tenure rules and practices change continually (Fourie 1993, Davies 1998, Barry 1999). A further characteristic is that groups comprising the leadership clique may play gatekeeper between the community and outside agents. Information is filtered before it is passed between the broader community and the authorities (Cross 1999). However, a small group outside this clique may have substantial power to influence the tenure system. A small faction can disrupt and overturn long-standing agreements with the authorities in a short time. This in turn delays processes that are designed to improve conditions in a settlement.

There are likely to be changing group and individual emphases in land tenure (Fourie 1993). For example, an individual may be permitted to sell their shack to a stranger. However, the community leadership, or a faction, may reserve the right to decide who the new occupant or owner of the shack might be. Moreover, community structures may choose to evict a person for unacceptable behaviour or, as has happened in a number of cases, for affiliation to a political party that is different to the main power groupings in a settlement (Davies and Fourie 1998, Barry 1999). Some observers view this contemporaneous existence of group and individual biases in the tenure system as an adaptation of indigenous tenure systems (e.g. Cross 1994, 1999, Byerley and McIntosh 1994). However, this behaviour has also been observed in communities in Cape Town where the residents did not have a tribal background, particularly where gangs have temporarily seized control of an area.

The rights of the individual and the leadership's adherence to principles of social justice varies from settlement to settlement. In some cases community leaders rely on selling land rights as a source of income. Consequently, there is competition for positions of leadership. These struggles can be violent, and in extreme cases result in murder.

Intervening in informal settlements with the objective of upgrading them or merely attempting to ensure that hygienic physical conditions and social justice prevails is an extremely difficult task for an external agent. Community leaders act as gatekeepers, relations with the authorities tend to be informal and therefore unregulated, and it is difficult for formal land administration institutions to make deals that are implementable. Agreements can be overturned on a day-to-day basis. Due to the complexity of these situations, many upgrading projects have not achieved the results desired by the authorities. In particular many observers are critical of projects that deliver individual tenure, especially allodial ownership. However, there are also problems associated with using communal forms of tenure.

Discussion of these concerns falls outside the scope of this discussion, other than the observation that there are no right answers. Informal settlements situations can at best be alleviated, but not "solved".

While recognising that such situations cannot be solved, both social and spatial information are critical to assessing a situation and to initiating appropriate strategies to address it. Moreover, the continually changing nature of informal settlements means that such information needs to be collected far more frequently than in say a middle class suburban area. For example, in a number of areas in Cape Town informal settlement residents had been adjudicated to be granted ownership of a house based on a government subsidy scheme. When the time came to deliver land parcels, largely due to informal transactions, there were inaccuracies of between 20% and 50% in the official records (Barry 1999). Resolving the resulting “disputes” over who was entitled to have registered ownership of a parcel bestowed on them was time consuming and expensive, and it delayed the delivery process. In one case the resulting frustration lead to the local administrative office housing the records being burned down.

In terms of data collection and management, what is required is an initial inventory measurement based on social and spatial information followed by frequent, cheap, rapid data collection to ensure that management information is accurate and current.

SOCIAL DATA COLLECTION TECHNIQUES

It is critical that official records of land tenure information should be held to be legitimate by all parties concerned. Otherwise these records have little value. A way of cultivating such legitimacy is to make the processes of data acquisition and information management participatory. Ideally, communities should participate in the definition of the information to be collected, in collecting the data, collating the information and disseminating it. This is only likely to happen if the process and purpose of the data collection exercise is generally accepted as legitimate. To further enhance the legitimacy of the information, it is also important that the recorded information is easily interpretable to members of affected communities.

Palm Top Computers

Census type, socio-economic data pertaining to the number of dwellings, number of people in a dwelling, income levels, employment levels and demographics of a settlement is required for an initial assessment of a settlement. What may also be required is an analysis of the system of tenure that prevails in a settlement, what tenure system is desired if it is upgraded, and if the tools to uphold the tenure system such as land registration and fixed or general boundaries are likely to be used.

Socio-economic, census surveys are conventionally collected using paper questionnaires. This is time consuming, and expensive. These surveys often require skilled data collectors and the data has to be manually input into a database. In informal settlements, such data needs to be updated frequently. Cheap, rapid collection methods that employ members of a community are ideal. Collecting data on a palm computer reduces the time to transfer data. The challenge is if residents of a settlement are able to use the technology effectively.

To develop participatory and economical data collection models, a study was initiated in the Department of Geomatics at UCT. Selected settlement residents were equipped with a palm top computer for which icons were developed to represent different data types. Linked to the computer was a GPS for position information. This approach was first tested on a land reform project in a rural settlement, and then an urban settlement that was in the process of being upgraded.

While the rural settlement had practically no history of conflict, the urban settlement had experienced substantial conflict relating to land rights over a period of 7 years. Three people in the rural settlement and eight individuals in the informal settlement collected data using the palm computer.

The icon-based data collection study was inspired by the success of the Cybertracker project (Cybertracker 1999), which developed a system whereby illiterate game trackers used palmtop computers interfaced with a palmtop GPS receiver to collect spatially referenced scientific data relating to animal behaviour in South African game parks. In the Cybertracker project, game trackers were involved in developing graphic icons that describe a specific type of animal behaviour. When a game tracker observes an animal performing a particular behaviour, the icon is accessed and the time and location of the event recorded in the palmtop computer.

The settlement studies adapted the Cybertracker data collection methods and system of hardware and software to collecting socio-economic data relating to land tenure. In contrast to animal behaviour observations, socio-economic data collection does require certain levels of literacy, as much of the data is textual. In the rural settlement the three data collectors had two to three years of high school education. In the urban settlement, the eight data collectors had an average of four years of high school education.

The data collectors designed icons to represent particular questions. As a back up they also stored the questions in text form in the palm computer. In the field, they were accompanied

by a researcher who observed the data collection process, recorded the responses simultaneously on a paper questionnaire, and compared results with those of the data collectors (Barodien 2001).

All but one of the eleven data collectors proved to be competent in using the palm computer after a short training period. A comparison with the hard copy questionnaire showed that responses were accurately recorded. However, the use of icons to represent a question and an associated set of answers was found to be unsuitable for collecting census type socio-economic data. In the rural settlement, all three subjects reverted to using the textual expression of the questions, and they recorded the responses in textual format. In the urban settlement, the eight subjects used a mixture of icons and text to pose questions and record the responses (Barodien 2001).

The study suggests that palmtop computers are, in principle, feasible for socio-economic data acquisition. The data collection in text form can be carried out successfully by members of the community provided they have a level of education which equips them for basic computer tasks. However, the use of icons to represent questions and answers was found to be of limited suitability. Employing literate members of a community for the collection of socio-economic and their subsequent continual update, using modern technology, makes it possible to maintain the currency of the population register in the settlement.

Photographs and Video Imagery

In the studies in Cape Town, disputes surrounding the adjudication of who should or should not be assigned land rights arose. Moreover, the official records that were meant to reflect transactions in land rights after adjudication were often inaccurate. This lead to further disputes when the time came to register land rights. In one case, Marconi Beam, even when the community kept it's own records in the informal settlement by noting transactions in a book in an administrative office in the settlement, many transactions were not recorded. Moreover, at the time that people were being moved into a formal housing estate, a faction challenged the legitimacy of this set of records and disrupted the delivery of houses (Barry 1999).

Subsequently, based on these experiences, in a similar settlement the project managers took digital photographs of every person in a household who been adjudicated to be granted ownership of a house in a nearby settlement. The photographs formed part of an adjudication certificate. Lodgers in a shack who were not part of the family unit were excluded. If a transaction in land rights took place prior to ownership being delivered, the updated certificate was displayed for public inspection on a notice board in the settlement. Minutes of meetings and agreements were also posted on the notice board. In this project, manipulation of the agreements between the landowner and the community and the rules pertaining to that agreement were reduced, arguably, as a result of the publicity and transparency.

In spite of this, there were attempts to disrupt the delivery process by a group of people who arrived in the settlement after adjudication had been completed. Most of this group were lodgers in families who were expecting to be granted a house. It was in the interests of the group of lodgers to disrupt the land delivery process in order to acquire ownership of a house themselves. However, the principle of continually making information publicly available and the use of photographs on the adjudication certificates that identified all members of a household ensured that this group was not in a position to raise a credible claim.

Another option that was developed in a rural settlement and then tested in an urban informal settlement was the use of video imagery to record information relating to land rights. Video clips were included in a relational database in which an onscreen title certificate was created which enables the user to view standard titling information. The video could be played back by clicking on the image of the person as shown in figure 1. The title certificate was linked to a GIS that was used to manage the transition to permanent land rights for the community.

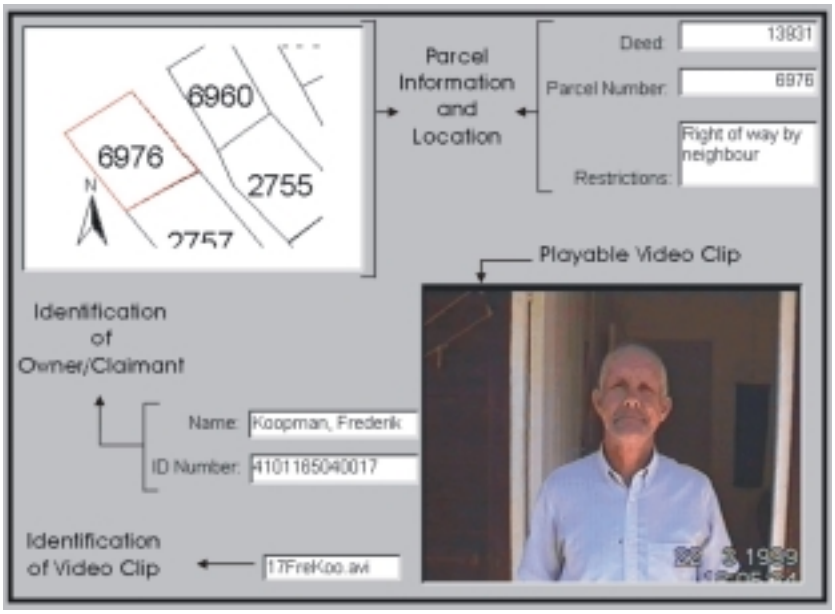

Figure 1 On Screen Title Certificate

In the initial development and testing of the video imagery system in the rural case study, people claiming rights in land were recorded on video while they read an affidavit in front of the house that they occupied. The contents of this affidavit were determined by the people themselves. This proved to be unsatisfactory as people were unsure what should be included in such an affidavit. Firstly, some affidavits included superfluous information with the result that they were too long and used up a large amount of disk storage space. Secondly, a number of people did not prepare the affidavit (Roux and Barry 2001).

The system was later tested in an informal settlement where a researcher conducted structured interviews with residents in the community. This proved to be a workable method in that interviews could be kept to a reasonable length of time, thus reducing disk storage space requirements (Roux and Barry 2001).

The system has as yet not been used for actual land rights delivery. However, it is the view of the authors that a video based registration system has potential in situations where there is conflict over land rights, provided the use of video itself is regarded as legitimate by the community. An adjudication record that comprises video clips should be more easily understood by community members than a record based wholly on written documents and diagrams. The information can be retrieved and played back in an easily understood format in cases of conflict, or in cases where there may be uncertainty over the definition and allocation of certain rights and interests. Moreover, videos tend to attract onlookers and family members, and there is a great deal of publicity when the filming takes place, thus generating a 'population of witnesses' to the transaction (Roux and Barry 2001).

Land Tenure, Boundaries and Registration

Further issues that may be explored are the desired system of tenure, and predictions of whether boundaries and registration are to be used or not. Tenure questions relate to the nature of the land tenure system that prevails in a settlement and the system of tenure desired if and when a settlement is upgraded. Questions relating to land registration should explore if registration is likely to be used to record transactions in a secondary land market or when dealing with deceased estates Boundary questions should explore if a particular boundary type, such as fixed or general, is likely to be adhered to.

These questions are best addressed through interviews with agents outside of a settlement (e.g. officials), influential people in the settlement and with people who will make decisions about their land rights in households in the settlement. These can be augmented by studies of similar cases where land has been registered based on a particular type of boundary.

In studying the tenure system with the general populace in a settlement, it is important to establish beliefs underlying the land tenure system. However beliefs are a poor predictor of actual behaviour. Behaviour in this instance refers to how people will use the infrastructure delivered in the upgrade, which includes registration and boundaries. If people have sufficient volitional control over their actions, what should be measured is their intention to perform or not perform a particular action. If these cannot be established, then it is best to attempt to measure attitudes to perform a particular action (Ajzen 1991). For example, in Cape Town, respondents in a number of informal settlements displayed a strongly negative attitude to the possibility of a neighbour encroaching over their legal boundary. Moreover they expressed an intention to evict the encroacher (Barry 1999).

In collecting this type of data, it was found that questionnaire based interviews with residents were not useful. The situations were far too complex for a simple question and answer interview. Each question had to be explained in detail and often the question itself

was framed too narrowly to obtain useful data. What was found to be useful was a system of group discussions held in the streets and public areas (see figure 2). People were drawn from various areas of a settlement and public group discussions were held. Often passers by would join in. Models of houses, shacks, and boundary systems were used in posing questions and generating scenarios. Questions were posed to establish beliefs about the tenure system. Scenarios were created to elicit statements of intention to perform or not perform particular actions. For example, groups were asked what they would do if a stranger claimed that he or she owned the house that each of the group members were to be granted. What action did they intend to take in such a case? In this way a variety of responses were obtained relating to intentions to use title deeds, attorneys, the courts or community based conflict resolution mechanisms.

The accuracy of any prediction based on beliefs, attitudes and intentions from verbal responses need to be checked against measurements of actual usage of registration and boundary systems. This is best done by studying cases of communities that had previously lived in informal settlements and had been moved into formal housing.

Fig 2 Group Discussions in an Informal Settlement

There are a number of reasons why these predictions may prove to be inaccurate. Firstly, people may choose to provide a response to a question that they know does not accord with their actual beliefs, attitudes or intentions. Wilkins observes that direct verbal statements of sampled members of the public may not provide a reasonable guide to their likely future action (Wilkins 1986). Secondly, the research itself may influence the results. As researchers become part of the groups that they investigate, part of the behaviour observed will be in response to the presence of the researcher (Shipman 1972). Consequently, as people learn about the subject matter of the research, they may be inclined to give the

"right" answers in an interview or group discussion. Thirdly, land tenure systems, particularly in volatile situations such as in informal settlements, are not static. Lévy-Leboyer notes that people's behaviour changes over time as they learn and interact with others, including the researcher (Lévy-Leboyer 1986). Therefore, a response that a person gives to a question at a particular time in the process of land being delivered may be different to the response that they might give at a later date. An interview or group session provides a snapshot of a situation. Fourthly, what Ajzen (1991) refers to as control factors may prevent people from carrying out their intentions. Control factors fall into two different categories. Firstly, lack of resources may prohibit a person from performing an intended action. For example, people may say that they intend to use registration to transfer land, but at the time that a transaction takes place, they may find that registration is unaffordable. Consequently they may transfer the land informally and the transaction may not be legally recognised. Secondly, power factors, such as the actions of a gang or a warlord, may prevent the performance of an intended action.

Spatial information and GIS provide the means to measure some of the anomalies between predicted behaviour and actual behaviour. Spatial information is critical for making informed decisions. GIS can be used to integrate the different information types for administration and analysis.

SPATIAL DATA

The collection and processing of spatial data for informal settlement management can be rudimentary. For example photographs captured with an amateur camera and measurements with hand held GPS receivers can be used to count, record and locate the number of shacks in a settlement. However, when monitoring change in occupation patterns in a settlement, then more sophisticated techniques are desirable.

The rationale for more sophisticated techniques is best illustrated by an example. In a settlement in Cape Town, the authorities reached an agreement with the community leadership to move the residents to a new development. Based on a census survey, 750 households would be moved and the shacks demolished. Within a few months of this agreement being struck, a further 600 shacks had been built in the settlement. However, the landowner was unaware of this development and project managers in the housing development completed their project based on the original figure of 750 households. In the political climate at the time, the landowner was forced to find accommodation for the additional 600 households.

In this case an initial survey had been carried out using stereo aerial photography at a photo scale of 1:10 000. Subsequent surveys were performed using aerial imagery captured with a non-metric digital camera and rectified using polynomial rubber sheeting and overlaid on the original survey using GIS software. However, the frequent changes in the settlement meant that control points were often destroyed or moved and the distortions that remained in the rectified images were unsuitable for meaningful overlay analysis. Increasing the density of control points fixed in the field, using recognisable features from previous surveys as control points, and tiling the single images improved the quality of rectification

(Barry and Mason 1997). However, the tasks of identifying shacks by on-screen inspection and manually delineating individual shacks in an on-screen digitising process proved to be laborious and uneconomical. Attempts were thus made to develop algorithms for fully- or semi- automated feature/shack extraction.

Automated Feature Extraction

The automated extraction of man-made structures such as buildings and roads from digital imagery has been a focal point of photogrammetric and image processing research for the past twenty years (Nicolin and Gambler 1987, Huertas and Nevatia 1988, Liow and Pavklidis 1990, Haala and Hahn 1995, Henricsson and Baltsavias 1997 and Seresht and Aziz, 2000). Approaches to building extraction vary widely and so do the degrees of automation and the detection rates. Most systems that have been developed are based on generic building models comprising simple regular shapes, structured settlement plans and/or homogeneous roof materials. Typically, informal settlements are not built in structured patterns, shacks are irregular in shape and height, and roof materials vary in structure and colour.

In the context of research on informal settlements, a method for the extraction of shacks based on a sequential hybrid image processing/digital photogrammetry approach was developed by Martine, Rüther and Mtalo (2001). In this method, off-the-shelf software is combined with code developed for the specific application.

Two test cases, one in the informal settlement of Marconi Beam, Cape Town, and one in Manzene, Dar-es-Salaam, were investigated. The Manzene images were scanned off conventional aerial photographs of relatively low photographic quality and had to be enhanced using the image pre-processing algorithm known as Wallis filter (ERDAS IMAGINE 8:3:1). The Marconi Beam images were captured with the digital KODAK DCS camera and required no pre-processing.

In the next stage, Digital Surface Models (DSM) (figure 3) and ortho-images were generated using the digital photogrammetry station SocetSet from LH-Systems. The DSM, as opposed to a Digital Terrain Model (DTM), represents a combined surface of roofs and terrain, with the shacks appearing as ‘blobs’ raised above the terrain (see figure 4). This stage is followed by generating a DTM in which the ground surface is modelled from a grid of ground surface points visible between shacks. A raised structure hypothesis is then implemented which segments the image into shack/ground sections by global height thresholding of the DSM supported by the DTM (Fig. 4). Threshold height values are above the ground surface and below the rooftop heights.

Approximate coordinates of building centres are then derived from the segmented DSM image. These serve as focus-of-attention areas for subsequent building extraction in the orthoimages. Initial windows for building extraction are provided by projecting the elevation blobs’ centre points into the orthoimage. Approximate building contours are subsequently established by using regions growing from blobs’ centre points constrained by edges. Approximate building contours are then formulated into SNAKES. In this

context, a SNAKE is a dynamic, heuristic process for creating a final estimate of the outline of a complex object (figure 5). In the SNAKES approach building contour nodes can change positions, thereby enabling the contours to slither. During slithering, optimal delineation of buildings as defined by contours is attained.

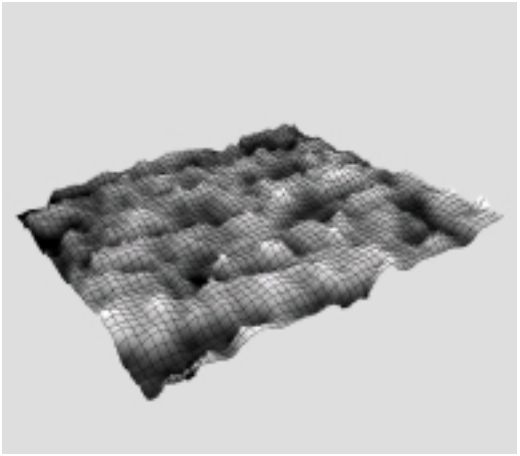

Fig. 3 DSM of Marconi Beam with shack blobs

Fig. 4 Intermediate processing stage showing detected blob edges

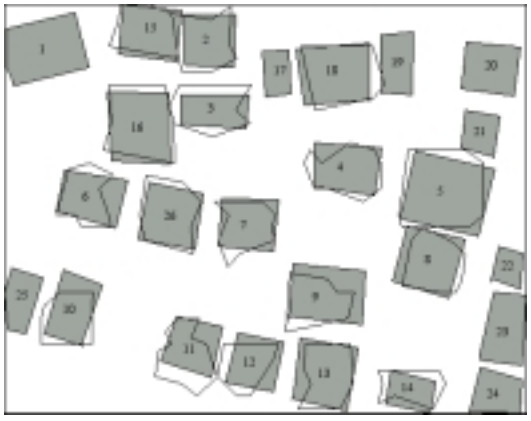

Fig. 5 Intermediate and final shack outlines

In the Marconi Beam and Manzene studies, this process resulted in detection success rates of between 60 to 70%. Although not entirely satisfactory for practical purposes, the method does yield significant time savings and merits further development.

CONCLUDING REMARKS

In conclusion, we have presented a number of data collection techniques that can be used in the management of informal settlements. What is necessary is that the information should be collated and used to develop intervention strategies in conjunction with the

community. Both social and spatial data should form part of an information system for management of this process.

What is critical is that an accurate initial information system is created. For this initial system, social data can be collected using methods such as group discussions, video imagery and a census. The spatial database should be created using suitable photogrammetric techniques that ensure that features are accurately georeferenced. The various research projects described above indicate that a number of techniques can be used to update the database. These include the use of a palm computer, simple photographs and automated feature extraction. Such information is critical to effective planning and management of situations in which informal settlements occur.

REFERENCES

Ajzen I 1991. *The Theory of Planned Behaviour*, Organizational Behaviour and Human Decision Processes 50:179-211

Barodien G 2001. MSc(Applied Science) thesis *in litt*. Department of Geomatics, University of Cape Town.

Barry M B 1999. *Evaluating Cadastral systems in Periods of Uncertainty: A Study of Cape Town's Xhosa-speaking Communities*. PhD thesis, University of Natal, Durban.

Barry M and Mayson D 2000. Informal Settlement Characteristics in a Rural Land Restitution Case: Elandskloof, South Africa. *Sociological Research On-Line*. 5(2) August 2000:70:2. http://www.socresonline.org.uk/5/2/barry.html

Barry M and Mason S 1997. *Analysing Spatial Components of Land Tenure Systems in Urban Settlements*. Proceedings iKusasa/CONSAS '97, Durban.

Byerley M and McIntosh A 1994. *Administration of Informal Settlements*, in Hindson H and McCarthy J (eds), Here to Stay: Informal Settlements in KwaZulu Natal, Indicator, Durban. 167-176.

Cross C R 1999. *Land and Security or the Urban Poor? South African Tenure Policy under Pressure*, Proceedings of Tenure Security Policies in South African, Brazilian, Indian and Sub-Saharan African Cities: A comparative Analysis, Centre for Applied Legal Studies, University of Witwatersrand, 27-29 July 1999.

Cross, C R. 1994 *Shack Tenure in Durban* in Hindson and McCarthy (eds.) Here to Stay Informal Settlements in KwaZulu-Natal, Indicator Press University of Natal.

Cybertracker 1999. *The Art of Tracking.* http://www.cybertracker.co.za/tracking.htm

Davies C J 1998. *Land Management of an Informal Settlement in East London*. Unpublished MSc thesis, Department of Surveying and Mapping, University of Natal, Durban.

Farvacque-Vitovic' C and Godwin L 1998. *The Future of African Cities, Challenges and Priorities for Urban Development*. International Bank for Reconstruction and Development, The World Bank, Washington.

Fourie C D 1993. *A New Approach to the Zulu land Tenure System: An Historical Anthropological Explanation of the Development of an Informal Settlement.* Unpublished PhD thesis, Rhodes University, Grahamstown, South Africa.

Haala N and Hahn M 1995. *Data fusion for the detection and reconstruction of buildings. In Automatic extraction of man made objects from aerial and space images* Birkhauser Verlag, Berlin, pp 211-221.

Hagai M. Martine, Rüther H and Mtalo E G 2001. *Application of Snakes and dynamic processing optimisation techniques in modelling of buildings in informal settlement areas.* Submitted for publication to the ISPRS Journal of Photogrammetry & Remote Sensing.

Heller F (ed) 1986. *The Use and Abuse of Social Science*. Sage, London.

Henricsson O and Baltsavias E (1997), *3D building reconstruction with ARUBA: A qualitative and quantitative evaluation, in Automatic extraction of man made objects from aerial and space images* 11, Birkhauser Verlag, Berlin, pp.65-76.

Huertas A and Nevatia R 1988. *Detecting buildings in aerial images Computer Vision Graphics and Image Processing* 41, pp.131-152

Lévy-Leboyer M 1986. *Applying Psychology or Applied Psychology* in F Heller (ed) *The Use and Abuse of Social Science*. Sage, London.

Loiw, Y and Pavlidis T 1990. *Use of shadows for extracting buildings in aerial images.* Computer Vision Graphics and Image Processing 49, pp 242-277.

Nicolin B and Gabler 1987. *Knowledge based system for the analysis of aerial images*, IEE Trans, Geoscience-Remote Sensing GE-25, pp. 317-329.

Payne G (ed.) 1999, *Making Common Ground: Public-private partnerships in land for housing*, Intermediate Technology Publications Ltd, London.

Roux L and Barry M 2001. *Using Video Imagery in Land Tenure Information Systems: A Study o fa Communal Property Association in the village of Algeria, South Africa* . Geomatica 55(1), 47-55.

Seresht M S and Aziz A 2000. *Automatic building reconstruction from digital aerial images, international Archives of Photogrammetry and Remote Sensing*, Vol.XXX111, part B3, pp 792-798.

United Nations Centre for Human Settlement (UNCHS) 1996. *New Delhi Declaration*, Global conference on access to land and security of tenure as a condition for sustainable shelter and urban development. New Delhi, 17-19 January, 1996. Preparation document for Habitat II, Istanbul.

Wilkins L T 1986. *Three Projects involving Prediction*. in Heller F (ed) *The Use and Abuse of Social Science*. Sage, London.

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