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On the Cover:
A map is more than a crumpled piece of coated paper wedged into a glove box. Maps are communication devices that unify or divide cultures, tell stories, raise awareness, and help make life altering decisions on a daily basis. These visual representations of space help us understand where we are at and where we still yearn to go. Maps are collaborative. They require cultures to develop a unified symbology for interpreting them. The legend houses the symbols, patterns and shadings that give a map its importance. The legend is the secret decoder ring. It makes sense out of a confusing landscape and unlocks the mysteries of a mapmakers art. The interactive process of building a map legend lies at the heart of an article by Giacomo Rambaldi entitled "Who Owns the Map Legend?" The article looks at map making as community process where the public is trusted to keep and define geographic representation. Deciding what is "important" on a map is a collaborative event with the power to shape history.

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Who Owns the Map Legend?

Giacomo Rambaldi

Paper presented at the 7th International Conference on GIS for Developing Countries (GISDECO 2004), 10–12 May 2004, Universiti Teknologi Malaysia, Johor Malaysia.

Introduction

Maps are media in cartographic or digital formats. Communication occurs mainly by way of symbols that need to be interpreted via the map legend and its graphic vocabulary. Lacking universal standards, each map has its own visual language. This language—or enough of it—has to be "common property" in order for communication of any kind to take place.

This *ad hoc* language has become increasingly important since maps have been used in the contexts of interactive processes aimed at bridging barriers among stakeholders having different backgrounds, perspectives, and communication patterns. Intellectual ownership of such language and the *content of knowledge* that it communicates, are critical factors in determining the success of the processes to which mapping and maps are put.

Based on literature review and case studies done in developing countries in the contexts of participatory planning and territorial negotiations, this paper analyzes the roles of the legend—and the processes that lead to its composition—in determining the intellectual ownership of spatial information visualised in the form of maps.

Mapping And Participatory Processes

Historical Perspective

Mapping is a fundamental way for displaying spatial human cognition. "It is a representational medium that both has a history and is part of the practice of history." (Herrington 2003) For centuries and increasingly with the advent of Geographic Information Technologies and Systems (GIT&S), graphic representations of part or the whole of Earth in cartographic, electronic, 2- or 3-dimensional formats have been playing significant roles as media (Sui and Goodchild 2001) used to store, display, and convey information, and as a basis of analysis and decision making.

In the past, maps have been made primarily to serve precise tasks, such as describing discoveries, navigating space, defining boundaries, registering ownership, and locating resources. In the early 1990s, Monmonier (1996, 2) wrote that "*a single map is one of an indefinitely large number of graphical models of the spatial aspects of reality that might be produced for the same situation or from the same data.*"

Changes have occurred since GIT&S have increasingly become accessible to civil society and graphic representations of space have been used as channels for two-way communication purposes to support social learning, dialogue, and negotiation processes. In March 2004, more than 200 representatives from indigenous groups attended the International Forum on Indigenous Mapping in Vancouver, British Columbia, Canada, sharing the motto: "*Maps are more than pieces of paper. They are stories, conversations, lives and songs lived out in a place, and are inseparable from the political and cultural contexts in which they are used.*" (Warren 2004)

The participatory use of maps started in the late 1980s. At that time, development practitioners were inclined to adopt PRA *sketch mapping tools* (Mascarenhas 199 1) rather than venturing into more complex, demanding, and time-consuming *scale mapping*. This was because preference was given to eliciting village dynamics and to facilitating communication between insiders and outsiders (researchers), rather than to courses of action enabling communities to interact efficiently with policy makers. In addition, in many developing countries, aerial photography, satellite imagery, and official, large-scale topographic maps were under governmental control and their access restricted because of national security concerns.

The situation changed in the 1990s, with the diffusion of modern GIT&S including geographic information systems (GIS), low-cost global positioning systems (GPS), remote sensing image analysis software, open access to data via the Internet, and the steadily decreasing cost of hardware. Spatial data, previously controlled by government institutions became progressively more accessible to and mastered by non-governmental and community-based organisations, minority groups, and sectors of society traditionally disenfranchised by maps and marginalized from decision-making processes (Fox 2003). This new environment facilitated the integration of GIT&S into community-centred initiatives, particularly to deal with spatial information and communication management. Practitioners and researchers around the world have been working on different approaches making use of a variety of GIT&S, but all sharing the goals of placing ordinary people in the position to generate, analyse, manage, and exchange georeferenced data, and to integrate multiple realities and diverse forms of information to foster social learning and

broaden public participation across socio-economic contexts, locations, and sectors. This has spurred a rapid development in the management of spatial multimedia information through what is generally termed as Participatory GIS (PGIS), where maps are conceived as interactive vehicles for discussion and information exchange, are physical or virtual, are in 2- or 3-dimensional formats, and are enriched by an array of data types including sound and images (Aberley 2002).

Large-scale maps (< 1:20,000 scale) and physical or digital terrain elevation models have been used for conducting collaborative research (Hampson 2003; Tran Trong 2002; Quan 2001; Martin 2001; Tan-Kim-Yong 1994, 1992), community-based planning, monitoring change, asserting territorial claims (McCall 2004; Bersalona 2004; Rambaldi 2002a; Zingapan 1999; Poole 1998, 1995; Denniston 1995), managing territorial disputes and supporting related negotiations (Cook 2003; Chacon 2003; Carton 2002a; Rambaldi 2002b; Wood 2000; Johnson 1999; Poole 1998), preserving and revitalising indigenous cultural resources and intangible heritage (Poole 2003; Crawhall 2003, 2001), and consultative policy making (Carton 2002b). While most authors point to the effectiveness of GIT&S used in a participative mode, McCall (2004), Fox (2003), Crawhall (2003), Rambaldi (2002a), Abbot (1998), and Rundstrom (1995) call for caution because these may lead to increased conflict, resource privatization, and loss of common property.

Maps As Media

The Power of Maps

Maps are highly communicative forms of spatial representation, and as Alcorn (2000, 11) puts it: "*Maps communicate information immediately and convey a sense of authority*." Few dispute them, particularly when these are drawn as planimetric projection (in two dimensions) and at scales smaller than 1:20,000. This may be due to the difficulty encountered by individuals in relating the information displayed on small-scale maps to their real world, thus limiting their capability of critical argumentation.

The communicative power of maps has been used for both noble and questionable purposes, including among others education, awareness raising, advertisement, political propaganda, disinformation (Monmonier 1996), re-/deterritorialization, and nationalisation (Wood 2000).

"Maps produced by European explorers were an exemplar expression of cartographic power: by ignoring indigenous names, and barely alluding to the presence of local settlements, in effect they declared the land to be empty and available." (Poole 1998)

The Key to Using Maps as Media

Visual language. Mapmakers use maps to convey information mainly through a visual language made out of legend items, a combination of symbols (points, lines, polygons, and volumes), their variables (hue, orientation, shading value, shape, size, and texture), and interpretation keys. Physical terrain models offer a more efficient interpretation base in displaying the vertical dimension, which provides additional cues to memory and facilitates mental spatial knowledge processing.

The "talkative" capacity of maps rests in the selection of featured items, in the manner these are depicted, and in the capability of users to understand, interpret, and relate these to their real worlds.

Particularly when a map is used to support a dialogue, it is important that its graphic vocabulary is fully understood by all parties involved. Each displayed feature needs a key to be interpreted. As Carton (2002b) puts it, the legend items form the kernels of the mapping language.

Choosing symbols and their variables. The most expressive variables associated to symbols are colour and size. More authoritative than others, colour (or hue) serves as a powerful system of differentiation, "*burdened with cultural meaning, overwhelmed by its associations and its history. Yet colour is a code that is constantly subject to change*." (Ferrier 2002, par. 3) Nonetheless, when it comes to mapping Earth features, there are some silent conventions that have become common practice: water bodies are shown as blue and vegetation as green; more is darker and less is lighter. Other hues are associated with traditional meanings depending on the cultural traits of the participating communities: death is associated to white in India, black among Westerners, and violet amid Mangyans in the Philippines.

> "*What these various figurative uses of colour have in common is the way that they present colour as linked with perception, and as perception that is not neutral or objective, but value added that is, overlaid with cultural value*." (Ferrier 2002, par. 5)

In mapmaking, the association of a specific hue to a symbol or feature is therefore far from being a neutral act and may even become provocative in a participatory setting, like the false colour red that symbolises vegetation in remote sensing. The same applies to points, lines, areas, and volumes, the remaining sets of symbols. When used to depict real-world features, their choice and their variation correspond to selected interpretations of reality made by those who compose the map.

Defining the attribute. For mapmakers, an *attribute* is the characteristic of a geographic (physical and social) feature described by numbers, characters, images, or sounds. To be objectively interpreted, spatial characteristics depicted by the use of symbols need clearly defined attributes. This is quite straightforward with numbers and images, but it becomes relatively critical when text is the chosen medium and when the purpose for participatory mapmaking is to establish two-way communication channels. *Primary forest*, as an example, is a term that may have a different meaning for a scientist, a government official, or a farmer, or it may mean nothing at all.

Picture by Pafid

Figure 1. Indigenous People in the Philippines Featuring a Catchment by the Use of Soil

Figure 2. Villagers in Mindanao, Philippines, Preparing a Resource Distribution Sketch Map

Photo by Bruce Young, Pafid, 2003

Figure 3. 1:5,000 Scale Participatory 3D Model (Indigenous people outlining boundaries.)

Map Legends From A Practical Perspective

From Pebbles to Keyboards

The most basic mapmaking method consists of drawing maps on the ground (Figure 1). Informants use raw materials like soil, pebbles, sticks, and leaves, at the reach of their hands to reproduce the physical and cultural landscapes as they know and perceive them.

Finger-pointing, verbal interactions, and progressive additions and modifications of landmarks lead to the visualisation of the territory and issues at stake.

Hardly any legend is produced, and such ephemeral maps disappear in a matter of a wind blow. Acquired knowledge is memorised by participants and mentally recomposed when needed.

Sketch mapping is a slightly more elaborate method that makes use of large sheets of craft paper and is usually facilitated (Figure 2). Features are depicted by the use of natural materials or more frequently by coloured marker pens or chalk.

Participants are in the position to make their choices in terms of what to use and how to visualise desired items. Usually depicted features are exaggerated in size, depending on the importance participants attached to each of them. When properly facilitated, the process is documented and records are kept in terms of the keys necessary for interpreting depicted symbols. Provided a legend is produced and joint to the final output, this method ensures storage, mobility, and wider shareability of collated information. Still, the lack of a consistent scale and georeferenced data leaves ample room for subjective interpretations.

More sophisticated methods of participatory 2- or 3-dimensional *scale mapping* aim at generating georeferenced data and depend on a disciplined use of selected symbols and colours for depicting desired features (Figure 3).

These methods rely on the availability of such topographic data as contour lines, and they require substantial preparatory work.

Good facilitation ensures sufficient and varied stock of materials for depicting symbols and their variables to be placed at the disposal of mapmakers.

A legend may be "proposed," "imposed," or better "composed" during the course of the mapping exercise. In the latter case, the legend evolves dynamically through an iterative process.

GIS used in a participatory mode allow communities to display and eventually handle spatial data. Nonetheless, these are necessarily fed via a computer keyboard or other digital devices. Thus, the choice on how to visualise tangible or intangible features through digital maps rests in the sole hands of the system operator and in the graphic capacity of the software, which may

Table 1. Evolution of Legend Items during Phases of Participatory Mapmaking

On the Field		On/Off the Field
Community Consultation and/or Raw Data Collection	Data Collection & Non-digital Mapmaking	Data Analysis, Digital Editing, Manipulation, etc.
• Tentative list of features compiled • Textual description of single features drafted • Eventual customary associations between "features" and "their display" identified • Draft legend prepared	• Draft legend items revised • New items included • Selected items excluded • Sensitive features identified • Makeshift legend(s) produced (showing public and/or confidential items)	• Content matching • Polishing • Symbols and variables matched with available software graphics • Display of layers (public and restricted access) agreed on and defined • Legends prepared

or may not be in the position to reproduce features as envisioned by the participants.

Nurturing the Legend

In practical terms, the facilitation of a community-based mapping exercise involves the drafting of a list of legend items ahead of the event to kick-start the process (Table 1). Such a list is the result of preparatory consultations held with concerned stakeholders with the objective of identifying features of the physical and cultural landscapes that are relevant and known to those who will take part in mapmaking.

As the mapping process enfolds, facilitators solicit the thorough revision of the proposed legend items (Figure 4), their unambiguous definition, and their association with clearly identifiable and culturally acceptable symbols in order to distinctively depict and describe physical, biological, and socio-cultural features of the territory and its people, and to facilitate their objective interpretation.

The participatory process of progressively adding features to a map has important discovery and social learning implications that frequently induce participants to identify, prioritise, and select new items to display or, in some cases, to remove previously listed ones, for example, those that are nonexistent, are considered as nonrelevant, or are insufficiently defined (Boxes 1, 2, and 3). These processes, which lead to the interactive development of the legend, depend on local knowledge, perceived priorities, and sensitiveness of data, and are based on dialogue and negotiation as documented by Hardcastle (2004), Rambaldi (2003, 2002a, 2002b), and Carton (2002b) in the contexts of community-based mapping exercises in Southeast Asia, the Pacific, and Europe.

Discussion

The three cases featured in this paper indicate that prioritising and getting a consensus among mapmakers on which items are relevant and what should be featured on a map, are the first steps in a participatory process aimed at addressing community-based issues related to the territory and its resources

The key for depicting spatial information for communication purposes is to make such visualisation objectively understandable through the development of a visual language having a clearly-defined vocabulary. Common ground and understanding need to be established, and the use of local definitions and vernacular translations helps.

In choosing symbols and their variables, good practice ensures that these are visually linked to real-world features, culturally significant and acceptable, sufficiently assorted, readily available, and consistently applied. Furthermore, good practice makes sure that their attributes are clearly and unambiguously spelled out to grant as far as possible objective understanding.

Except for community maps making use of locally available materials, such as soil, leaves, charcoal, and the like, community mapmakers have to match the features they want to depict with symbols made available by the technology in use. Participatory 3D models offer pushpins and map pins, yarns, and paint to depict points, lines, and polygons. Digital maps display results based on the available sets of symbols, which are numerous but limited to the software and available add-ons.

Questions of ownership should arise in the minds of the facilitators: Who decides on what is "important"? Who defines the attribute of single items in objectively understandable terms? Who selects the symbol and variable to depict a given feature? If made public, who decides on what to display on the map and its legend? Ultimately, who owns the pictorial language, its graphic vocabulary, and the resulting message? Who owns the map legend?

Conclusion

The full potential of GIT&S as two-way communication channels will become a reality when practitioners and facilitators realise the importance of ensuring full involvement of concerned stakehold-

Box 1

Context: Protected area management plan preparation, Pu Mat National Park, Social Forestry and Nature Conservation (SFNC) Project in Nghe An Province, Vietnam (1998–2004)

Purpose of the community mapping exercise: To improve relationships and foster reciprocating respect between National Park staff and local communities; to induce a paradigm shift on "Who knows" and "Whose knowledge counts"; and to provide stakeholders with a comprehensive, user-friendly research, planning, and management instrument.

GIT&S used: P3DM and GIS

Key informants/mapmakers: 76 Dan Lai, Thai and Kinh Hill Tribe peoples, 6 park rangers, and 10 SFNC project staff

Figure 5. Hill Tribe People Discussing Legend Items during a P3DM Exercise, Pu Mat, Vietnam

Context issue: At the beginning of the activity informants were invited to review the draft legend, suggest changes, make integrations, and improve definitions (Figure 5).

Figure 6. Final Legend of the 3D Model of Pu Mat National Park, Vietnam

By the end of the exercise, after 4 days of intensive dialogue, the initial legend had expanded from 18 features to a total of 55 features, including points, lines, and polygons.

Some items listed on the draft legend were removed, because they were nonexistent or deemed as irrelevant or too sensitive as per community perspective. These included among others the following features: (1) points: gold-mining site, abandoned village, hunter's hut, resting site for forest rangers; (2) polygons: industrial crop (changed by informants to more specific definitions, such as sugarcane and tea plantations and planted bamboo forest); and (3) lines: buffer zone boundary.

Others were added, including: (1) points (i.e., locations): like Commune's People Committee, border police station, temple, cave, docking site along river, tree nursery, cemetery, etc.; and (2) polygons: identified as natural bamboo forest, resettlement area, crops on terraces, stony areas.

Some features identifying wildlife sighting sites for tiger, bear, elephant, deer (saola), gayal, and the like were removed from the model and excluded from the final legend because they were deemed sensitive and at risk of exposing endangered species to increased pressure from poachers.

In addition to revising the listing of the legend items (Figure 6), the villagers in collaboration with government officials improved their textual definitions and ensured the translations of the various features to ensure an objective understanding across stakeholders (Rambaldi 2003).

Box 2

Context: Collaborative Protected Area Management Planning, Mount Malindang Natural Park, Misamis Occidental, Mindanao, Philippines. National Integrated Protected Area Programme (NIPAP), Philippines (1996–2001).

Purpose of the community mapping exercise: To contribute to the development of a protected area management plan based on a blend of indigenous technical knowledge (ITK) and scientific knowledge.

GIT&S used: P3DM and GIS

Figure 7. Villager Inputting Data on a 3D Model by the Use of Colour-coded Paint

Key informants/mapmakers: 98 community members including representatives from the Subanen Indigenous Communities, residents of all local administrative units (barangays), local government officials, Department of Environment and Natural Resources (DENR) and non-governmental organizations (NGO).

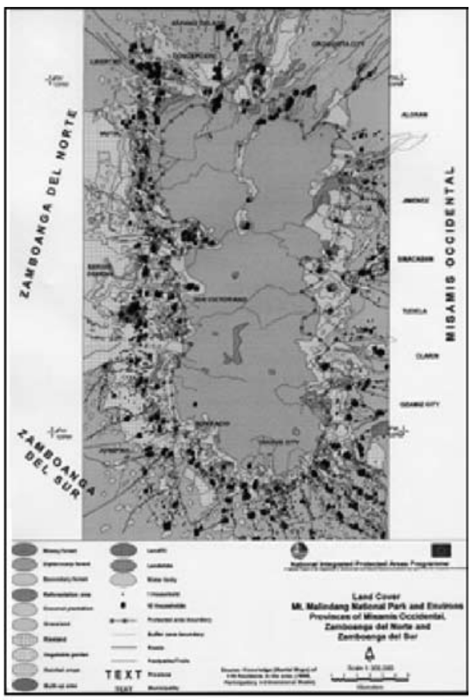

Figure 8. Map Resulting from Data Extracted from a Participatory 3D Model, Mt. Malindang National Park, Philippines, 1999

Context issue: The 1:10,000-scale exercise covered a vast area (1,176 km2) including portions of five Indigenous Peoples' Ancestral Domains. In order to assist participants in recomposing their mental maps (Figure 7), the facilitators produced base maps featuring roads in addition to contour lines, which are a standard feature for base maps used in P3DM.

When assisted in outlining the roads by transposing their coordinates from the base maps to the 3D model, participants contested the validity of the data, stating that the roads no longer existed and that these were logging roads currently overgrown by natural vegetation. The legend item was modified and what was originally indicated as "road" was redefined as "footpath" (old logging road) and depicted on the model only where applicable depending on its actual existence.

It is worth noting that the data used for the production of the base map were obtained from the National Mapping Resource and Information Agency (NAMRIA). The data turned out to date back to World War II.

In reviewing and expanding the legend, informants included such new items as "landslide" and "landfill area," and further refined specific land uses (e.g., coconut plantations, vegetable gardens, orchards, etc.) and vegetation types. In this latter case, participants listed and depicted five different types of forest that were not shown on pre-existing maps (Figure 8).

Box 3

Context: Collaborative Protected Area Management Planning, Mount Pulag National Park, Benguet, Cordillera Region, Philippines. National Integrated Protected Area Programme (NIPAP), Philippines (1996–2001).

Purpose of the community mapping exercise: The model has been used by the Protected Area Office for raising awareness on the location of the park boundaries and important natural resources. More importantly, it has been used for discussing the outlining and revision of protected area boundaries with local communities (Figure 9).

The local government unit has used the model for revising local administrative boundaries and for planning purposes.

Figure 9. Village Elders Outlining Linear Features on a 3D Model in the Cordillera Administrative Region, Philippines, 1999

GIT&S used: P3DM and GIS

Key informants/mapmakers: 75 representatives from the Ibaloi, Kalanguya, Kankana-eys, and Karaos indigenous communities, local government officials, DENR, National Power Corporation (NAPOCOR), and NGOs.

Context issue: This has been the first P3DM exercise implemented in 1998 in the framework of NIPAP.

Informants were provided with a draft legend including 15 different features, and were asked to check, update, and further expand it.

The definition and translation of each legend into vernacular required thorough discussion and levelling off among informants and facilitators.

Figure 10 . Elders Locating Sacred Areas in Mt. Pulag, Cordillera, Philippines, 1999

Proposed items were redefined, associated to clearly identifiable symbols. New items sprung up as the mapping process enfolded. These reflected deep-rooted community concerns and priorities. "Landslides" and "bare land" were singled out as important items to be depicted on the model.

The discussion and depiction of administrative and cultural boundaries turned out to be an extremely sensitive topic among neighbouring tribal communities (Figure 10), and was toned down and finally dropped from the discussion. This was an important learning from the exercise, as boundaries are most frequently leaded with latent conflicts and need special, well-prepared approaches to be dealt with, possibly after the "neutral" depiction of land use and cover, most likely in a separate exercise.

"Sacred areas" with extensive textual description took their due place among the listed legend items.

ers throughout the entire process. This means that besides putting stakeholders at the forefront in generating, collating, and analysing local knowledge, they must be prime actors in defining the map's pictorial language and its graphic vocabulary, the legend.

This also means that in an interactive process that would lead to the composition of a map as a means for social learning and negotiation, the preparation of the legend, particularly the selection of features to display, and the way they are depicted and textually defined, assumes a key role in determining its final intellectual ownership, its resulting message, and its usefulness in the process.

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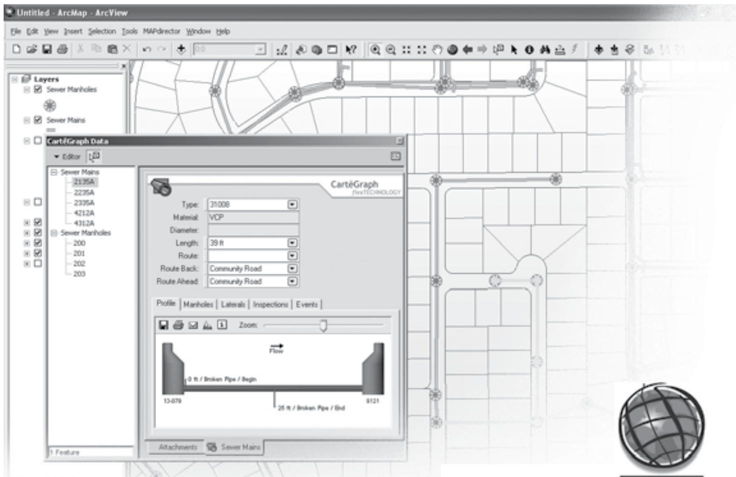

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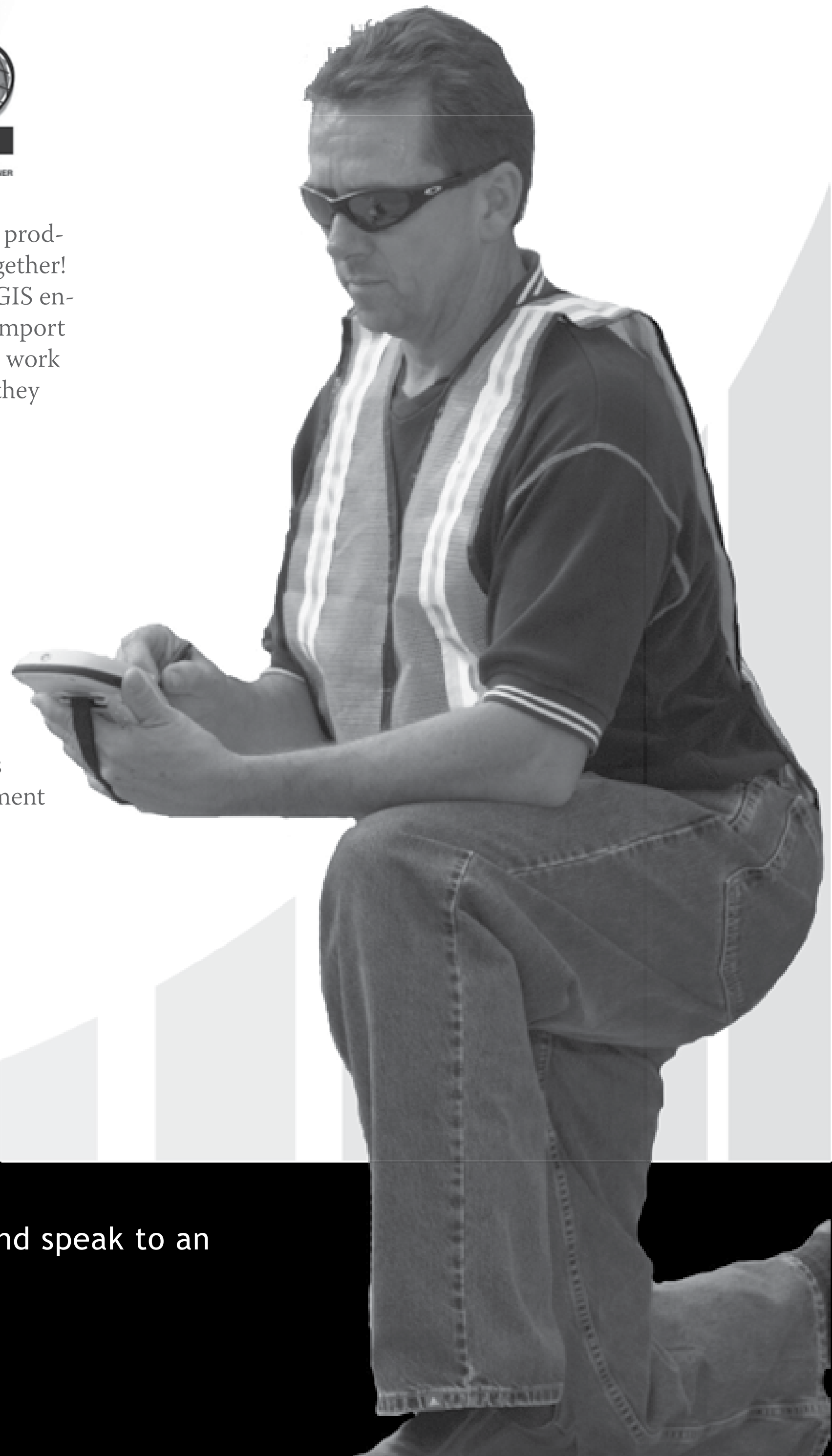

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Post-Experiment Evaluation of the Use of Geographic Information in a Public Participatory Process

Florent Joerin and Aurore Nembrini

Abstract: *This paper presents a post-experiment evaluation of a public participatory process that was conducted in a Geneva neighborhood. During the experiment, a set of geographic indicators was used to help residents express their opinions and formulate a diagnosis of the neighborhood. The evaluation is centered on a specific set of considerations that were based on observations regarding others' research using public participation and geographic information systems (PPGIS) in public participatory processes. These considerations, which provide reference points for discussion about the use of geographic information in participatory processes, focus on the following elements: access to information, level of information and decision sharing, the difference between knowledge and values, the choice and design of media and interfaces to communicate information, and the role of information. It was determined that these considerations could both facilitate a discussion of the experiment's benefits and limitations, and enable future improvements. This article demonstrates the importance of fundamental reflection on the use of geographic information in participatory processes.*

Introduction

The complexity associated with sustainable development (Ascher 1995; Hales 2000) presents a specific challenge for urban management professionals. Planners are often obliged nowadays to work with a wide variety of criteria that integrate economic, social, and environmental objectives (Healey 1997). At the same time, social demand for participation in the planning process is on the rise, and many traditional planning procedures are at a standstill because of social conflicts (Couclelis and Monmonnier 1995; Söderström and Cogato Lanza 2000).

Within this context, public participation has become a key issue in land use planning processes. Participatory approaches, which serve to open up discussion to new stakeholders with a different set of territorial issues, provide opportunities for building the consensus needed to carry out urban projects (Dente *et al.* 1998).

Several tools and methods have been developed to provide information and encourage public participation in decision-making processes (Howard 1998; Al-Kodmany 1999; Kingston and Carver 2000, Söderström and Cogato Lanza 2000; World Bank 1996). These include the use of geographic information systems (GIS), which have—by virtue of their geographic information collection, storage, analysis, and dissemination capabilities—served to introduce new perspectives. Given stakeholders' increasing need for information, applications linking public participation and GIS (PPGIS) are becoming more and more widespread (Craig et al. 2002).

Based on these findings, the Swiss "CITYCOOP" project, a contributor to the European COST-C9 "Processes to reach urban quality" Action, has spearheaded a research study on the use of GIS and "cartographic indicators" (defined as "cartographic representations of specific socio-economic indicators") in participatory processes. In order to bolster reflection and facilitate tool development through the use of actual public participation, the CITYCOOP research team decided to conduct an experiment involving residents in a specific district of Geneva. This experiment has been described in detail in other publications (Nembrini *et al.* 2005; Joerin *et al.* 2005). Despite the strong impression of success overall at the conclusion of the trial, we were left wondering how this research could be adequately evaluated: What were the experiment's specific successes and failures? What improvements would be required when conducting other, similar experiments?

Essentially, this paper describes the evaluation process as it was carried out. The first component consists of a review of the literature dealing with PPGIS applications, focussing specifically on the discussion of their respective evaluations. Based on this literature review, we developed our own set of considerations, which are in turn used to evaluate and discuss our application in detail. The application itself is described briefly.

Public Participation And Geographic Information Systems

A large number of GIS based tools and methods have been developed for supporting participatory decision-making processes (Shiffer 1992; Klosterman 1999; Kingston and Carver 2000; Talen 2000; Jankowski and Nyerges 2001a, b; Craig *et al.* 2002; D'Aquino 2002). These tools have been used with different types of stakeholders and in a wide variety of social and political contexts. The result has been an equally wide-ranging diversity of approaches (Nembrini and Joerin 2002). This section summarizes the main trends (and, in some cases, illustrates them

through the use of examples) on the basis of three factors: 1) the tool's contribution to the participatory process, 2) its users, and 3) associated communication methods. We believe that these three aspects represent the main characteristics of PPGIS applications available for use in identifying similarities and differences.

Contribution to the Participatory Process

PPGIS research has led to a multiplicity of diverse uses of GIS and to numerous interpretations of its contribution to the participatory process. *Information availability* is generally the main concern. In this case, the purpose of the tool is to centralize information at a single source and to subsequently distribute it to various locations within the city or community in question. The Internet is being used more and more frequently to improve information availability (Kingston and Carver 2000). Local governments (e.g., Amherst , Poitou , and Quebec City) have set up tools that residents can use to retrieve information about their particular neighborhood or region. Other PPGIS applications focus on *interaction with participants*, which can be undertaken in one of two ways. Some research projects focus on cooperative mapping, which involves working with the participants to develop maps (Talen 2000), while others collect and integrate opinions and preferences expressed by users. Examples of this latter approach are the pilot site developed by the University of Leeds for the village of Slaithwaite (Kingston and Carver 1998) and the *Argumap* concept (Rinner 1999), which establishes interactive links between arguments and map objects.

Users

PPGIS is, by definition, designed to be used directly by the general public, especially in the case of Internet based applications. The system's tools, however, are generally too complicated to be used in group sessions without the help of an expert, sometimes also referred to as a facilitator (Talen 2000; Jankowski and Nyerges 2001b). In these cases, although the information is intended for use by the general public (who then becomes the "information user"), the tools are actually designed for use by experts who must act as mediators between the tool and the participant, and who also help interpret the information thus accessed.

Visualization and Communication

Territory visualization is a key element of participation. Consequently, some tools focus on methods of communicating information about a territory. Developers try to improve spatial perception for the user by creating improved visualization technologies. These technologies can also include video, virtual reality, or 3D (Batty 1999; CommunityViz™)—features that serve to understand territory and provide users with a better understanding of the issues concerning landscape insertion in particular. Virtual reality, video, or 3D could be applied in order to improve spatial perception capabilities. Some tools have multiple technologies working through the same interface. For instance, Shiffer (1992) proposes *a collaborative planning system* that enables the integration of analytical tools, access to information, and collective perception by incorporating graphic interfaces in various formats (images, maps, video, documents). A very different approach is presented by Al-Kodmany (1999), who proposes translating individuals' intuitions into a usable idea, working in tandem with GIS and an artist who captures and expresses the ideas, discussions, and perceptions by utilizing realistic sketches on an electronic board.

Evaluating The Use Of Geographic Information In Participatory Processes

Although the introduction of PPGIS into real planning practice is a challenge that has not been undertaken to date (Carver 2001), the use of this tool to support public participation experiments is frequently described in the current literature. Unfortunately, evaluations of these applications are rare and only a few studies deal with PPGIS capabilities. Research in this field still focusses on the tool itself, and it places emphasis on the technological aspects rather than the conceptual framework (Onsrud and Craglia 2003).

Discussions about the contribution to the participatory process are rare. Many tools are designed to provide information to the user in a unilateral manner; however, they rarely serve to canvass stakeholders for their opinions and preferences and are even less frequently used for information sharing.

As pointed out by Jankowski and Nyerges (2001b), discussions on the role and the place of spatial information in decision-making processes are generally not included. Tools are designed to do "almost everything" or "as much as possible"; in other words, they are expected to play a key role in the decision-making process and in particular to control all information exchanges between stakeholders. In reality, however, some questions remain unanswered: How would stakeholders react to this implicit hypothesis? Do they really wish to interact through the use of a computer?

One possible alternative would be to design particular tools or create functionalities that would be specifically adapted to the various phases of the decision-making process (Jankowski and Nyerges 2001a, 2003). We believe that information plays a different role in each of the two main parts of the decision-making process: 1) the problem identification component (which includes diagnosis) and 2) the actual resolution of problems (in which different scenarios are compared and sorted through [see "Role of Information in the Decision-Making Process" in the next section]). However, most of the applications focus on problem solving, in order to support the design and analysis of various alternatives, without actually placing the problem in context (Söderström and Cogato Lanza 2000).

These observations illustrate the need for improved interaction between technological means, such as GIS or PPGIS, and research on the participatory processes involved in land use planning (Forester 1994; Innes 1996; Hanna 2000). We believe this interaction should attempt, in particular, to define or specify the role of tools in decision-making processes.

Indicators for the Evaluation of PPGIS Applications

Jankowski and Nyerges (2003) have shown that applications of PPGIS are difficult to compare and evaluate, due to their diverse approaches and contexts. A specific approach may be effective in a particular situation, but may not be so in another context. Furthermore, the lack of post-experiment evaluation makes it impossible to create a learning process that could establish rules linking, for example, context and approach characteristics.

Laituri (2003) proposes a set of indicators for evaluating case studies in GIS application. These indicators place emphasis on the issue of access to information and effectively characterize an application's context. Similarly, Jankowski and Nyerges (2003) outline 25 possible "aspects," grouped under 8 "constructs," that cover the social and technical dimensions as well as the tool's characteristics and the process itself. This proposal allows for a more general definition of both context and approach. However, it focusses more on defining the research axes, identified in the interdependence of these aspects, than on proposing an application evaluation grid.

In other words, a grid has not yet been established for evaluating and making real comparisons of the applications of participatory processes, based on the use of geographic information. We believe, however, that proposing a universal grid could be too simplistic and have therefore chosen to set some considerations or design principles that would facilitate an evaluation or discussion of our application. These considerations are formulated in a relatively general manner, leading us to believe that they could be applied to other contexts.

The following considerations regarding the use of geographic information in public participatory processes were developed from the above PPGIS overview. They do not deal with the technical aspects of PPGIS, which are already extensively covered by other researchers. Instead, they focus on the role played by geographic information and tools such as GIS in the decision-making process. The next section also discusses the potential or required contributions of the tool to stakeholder interactions. The first four considerations focus on the role of information and the communication thereof, and the final one examines the role of the tool in the decision-making processes.

Considerations For The Use Of Geographic Information In Public Participatory Processes

Access to Information

Public participation in decision-making processes is gradually being recognized as a necessary condition for consensus building and as a means to reduce conflicts (Couclelis and Monmonnier 1995; Söderström and Cogato Lanza 2000; Joerin *et al.* 2001). However, the role of information in participatory processes remains largely unexamined.

Participatory decision-making processes often involve a number of negotiation phases. A stakeholder who controls access to information during a negotiation phase can wield considerable power. For this reason, we should not ignore the possibility that various stakeholders who are involved in participatory processes might try to maintain control of some of the information in order to decide whether or not it should be used in negotiations. Notwithstanding this factor, restriction of stakeholder access to information is much less frequent today. First, most stakeholders in participatory decision-making processes are sooner or later provided with access to all types of information, even of a scientific or technological nature (Joerin *et al.* 2001). For example, most citizen groups will include an individual with the appropriate occupational skills who can help grassroots stakeholders obtain and use information that might even be very specific in nature (Dente *et al.* 1998). Furthermore, the fundamental goal of public participatory processes should be to ensure the local stakeholders take ownership of the project and accept the final decision. A project will not achieve this goal if some of the stakeholders do not possess all of the information required or do not receive it in a timely fashion. It may be unrealistic to hope that every stakeholder will put all of their information on the table at the beginning of a "real" public participatory process; however, each party should at least have access to all essential information.

Access to information must be considered not only at the administrative or legal level, but also—and perhaps particularly—at the cognitive level. Keeping in mind the link between information and power, the use of very specific terminology or of technical maps and diagrams could serve as a means for a specific group of stakeholders (e.g., engineers or architects) to maintain control of the decision-making processes.

It is therefore logical to assume that public participation and empowerment are conditioned by information-sharing processes that allow all members of the general public—whatever their backgrounds—to understand the knowledge and apply it to the decision-making process. In this regard, we believe that information tools such as PPGIS must support this appropriation of information, because the use of this knowledge is intended to support a collective learning process.

Information and Decision Sharing

Various levels of public participation can be identified (Arnstein 1969; Kingston and Carver 1998; Schlossberg and Shuford 2003). On the ladder proposed by Kingston and Carver (1998), statutory procedures for public consultation are considered *low-level* participation, while defining the agenda and taking part in final decision making through partnerships or empowerment would represent the *highest level* of public participation.

Similarly, various levels of information sharing exist; for example, situations in which the public must collect data on its own, or is simply advised of policy decisions, are characterized as low level, whereas providing opportunities for all stakeholders to *add information* are considered high level. These various levels of information sharing have to be taken into consideration, and PPGIS project design should include opportunities for deciding on the level of participation. Another aspect of the process that

should be considered is the fact that public participation can take other forms besides the communication of information. An example would be eliciting information from local stakeholders regarding specifics such as the individual and social reference points of public space users.

Knowledge and Values

Both knowledge and values are an integral part of the decision-making process. "Knowledge" refers to facts and can be considered as more objective, whereas "values" refers to opinions and thus can be considered subjective in nature. The level of noise due to traffic in a particular district, for instance, is a fact and is measurable. For the same level of noise, experts or planners might consider the district to be quiet in comparison to other districts, but its residents might consider this level of noise to be intrusive. In this case, living in a "quiet area" is likely to be greatly valued by residents.

All stakeholders should have an opportunity to bring their knowledge and values to the process. However, integrating their points of view and values into GIS applications that serve to support participatory processes is a fairly recent development, and it remains relatively unused in practice (Jankowski 1995; Joerin *et al.* 2001).

Many research projects or participatory processes revolve around collecting residents' knowledge of or values regarding the decision's urban context (Weiner and Harris 1999; Kingston and Carver 2000; Després *et al.* 2003; Repetti and Prélaz-Droux 2003). An important part of the decision-making process would therefore be to establish which stakeholders should be invited to contribute their knowledge and values, and when. Furthermore, the database supporting the process should be designed to permit a clear distinction between these two types of information. Ideally, it should keep a record of the information sources for both types of data. These sources can be stakeholders (e.g., residents) or institutions (e.g., a land use planning agency).

Stakeholders, Choice of Media, and Type of Interface

The medium and the interface must be chosen keeping in mind the decision-making process they are supporting, the role of information in this process, and the users of this information, who can be different segments of the population (GIS experts, urban planners, politicians, or residents).

The media used to disseminate and exchange information can include paper, public meetings, the Internet, etc. If information is obtained through street interviews, a simple hard-copy questionnaire is often easier to use. On the other hand, the use of a computer can make some meetings more attractive and dynamic. It should be recalled, though, that computers may not always support—and in fact can restrict—discussion between stakeholders. In all cases, high technology takes up space (in the room) and time (in the process). Therefore, special attention must be paid to ensuring they bring real, tangible benefits. Furthermore, the media used for information gathering can be adapted to a greater or lesser degree to the type of stakeholder being consulted. These methods should therefore be diversified in order to obtain an adequate representative sampling.

The issue of interface is closely related to that of computerized information communication. Similarly to the media chosen, the interface has to be adapted to the type of user. In the case of PPGIS, a clear distinction should be made between the GIS user (or mapmaker) and the information user (or map reader). When maps are used to communicate information, the user must possess some knowledge regarding both computer use and map reading and interpretation, the latter of which requires an understanding of the mapmaking process (Barkowsky and Freska 1997). Because maps are the product of a generalization process involving selection and classification, they can never be considered independently of their cultural background or the cartographer's point of view (Monmonier 1991). Although map readability is a key concern, there is some risk involved in oversimplifying information, due to interface design constraints, for representation on a map.

PPGIS and, consequently, its interface would play different roles in processes depending on the size of the stakeholder groups. A public participatory process with a large group will obviously have to face a great diversity of skills and needs relating to information communication. If the group is not too big, training can be proposed in order to provide all participants with a common basic skill level (Weiner and Harris 1999; D'Aquino 2002; Repetti and Prélaz-Droux 2003).

Role of Information in the Decision-Making Process

Tools such as GIS, along with more comprehensive decision support systems, are all designed to offer a specific set of functionalities. The basic components include information capture (i.e., measurements or questionnaire), information storage (i.e., database management systems), and information transformation and synthesis (i.e., statistical or multicriteria analysis). Research on tool design is too often based on the following—exaggerated—hypothesis: "The more functionalities a tool contains, the more useful it will be." We believe, however, that these tools could better contribute to decision-making processes if they were instead designed while considering the following questions: Which functionalities should or could be used? By whom? When? And for what purpose within the decision-making process? It would therefore be important to ensure the role assigned to the tool and its functionalities are a match. This role is, in our opinion, defined on the basis of the role played by information in the decision-making processes.

In order to assign the role of information in the decision-making process, reference can be made to the four phases described by Simon (1960). The first is the intelligence phase, during which stakeholders become aware of a problem (i.e., something needs to be changed or improved). During this initial phase, also called the *problem setting* phase, stakeholders express and build their motivations for change. The following phases relate to *problem solving* (Fareri 2000): a) various alternatives are devised and evaluated based on a set of criteria (design) and b) stakeholders compare and choose the best alternative available (choice). The

final phase involves detailed assessment, implementation, and post evaluation.

This linear process is the one most likely to be applied by a rational decision maker, whose focus is almost exclusively on the information available about various alternatives. Other researchers have adapted this model, attaching more importance to the psychological and cognitive aspects of decision-making processes (Festinger and Peterson 1957; March and Simon 1957; Janis and Mann 1977). Nonetheless, this breakdown into four phases is useful in considering the role of information during the process. An information tool can be developed for use during the entire decision-making process or for a particular phase. Depending on the phase to which it is assigned, it can utilize, analyze, and synthesize different types of information in a variety of ways.

Using Information In A Participatory Process: Application At The Neighborhood Level

This experiment was conducted with resident participation in the St-Jean neighborhood, in the city of Geneva. St-Jean represents a diversified urban context in terms of residence types and population. It also features a highly active participatory dynamic, one concrete illustration of which would be the civic forums open to all residents, held almost every month, for the purpose of encouraging discussions of political questions regarding the neighborhood.

The primary objective consisted of designing and implementing a process that would enable residents to develop an overview of their neighborhood, and thereafter to develop a participatory diagnosis. This concept (participatory diagnosis) is based on the hypothesis that wider participation at the diagnostic phase of the decision-making process—considered to be the problem identification phase—fosters the emergence of consensus on any decisions about the neighborhood. It complements diagnoses produced by various experts or public servants on issues such as traffic, pollution, health, and education. Residents involved in the process are given access to this information regarding their neighborhood. They can correlate it with their own knowledge and concerns about the neighborhood, in order to determine priorities. The diagnosis should help them on one hand to provide feedback on future projects regarding their territory, and on the other hand, to propose new actions for a district improvement.

With this experimental approach, our purpose was essentially to learn more about the following aspects:

- The purpose for which geographic information should be used.
- How information should be used in the different phases of the decision-making process (and which type of information).
- How participants' knowledge and values can be integrated into the process.
- How all available information, whether received from official sources or provided by residents, can be combined together.

A Four-Step Process

The experiment ran from September to December of 2002, and ended with the presentation of the results at a public forum. It consisted of supporting the activities of a working group, comprised of a dozen residents, that was formed spontaneously at a public forum (in June 2002). This working group, called the Diagnosis Group, took part in the four steps of the process. Each step involved two stages. The first was a working session with the Diagnosis Group. During the second stage, a segment of the population was asked to express its opinion on the results of the working session. Following is a description of the four steps.

Step 1: Collecting concerns. The first step consisted of collecting concerns about the neighborhood's situation and its evolution. Approximately 30 concerns were expressed by the Diagnosis Group at the first working session. A questionnaire was then prepared so that residents could validate and add to these concerns. A total of 190 concerns were collected from residents encountered in cafés, the public library, or shopping centers. Most of the concerns are geographically positioned and can be located on a map.

Step 2: Defining the issues. The Diagnosis Group then defined a set of issues corresponding to all concerns in the neighborhood. Each issue synthesized several concerns relating to the same problem, and as such represented a desired state of the neighborhood and was expressed as a trend. For example, all concerns relating to the lack of parking spaces were reformulated by the *Improve parking space management* issue. The Diagnosis Group defined 16 issues.

Step 3: Assessing the issues. During this stage, our research team created cartographic indicators that could be used to support an assessment of the importance of these issues. These indicators were presented on maps using GIS running on laptop computers. Individuals consulting the cartographic indicators were able to correlate these representations, built from administrative data, with their own representations of the territory. Indicators were dedicated to spatial comparisons. They were assessed on an ordinal qualitative scale and presented in three varying geographic scales (Figure 1). Residents could evaluate the situation in their own street by comparing it with the neighborhood overall (or with the city as a whole) and thus correlate the facts—or rather, the representation thereof—with their own perceptions.

The interviews, which lasted approximately one hour each, were held at diverse meeting points in the district. Some 30 individuals were consulted. After reviewing these maps, the respondents answered a series of questions that were intended to help determine the level of priority for each issue (Figure 2).

Five questions were asked, and the information obtained was coded using the French Abaque de Régnier method

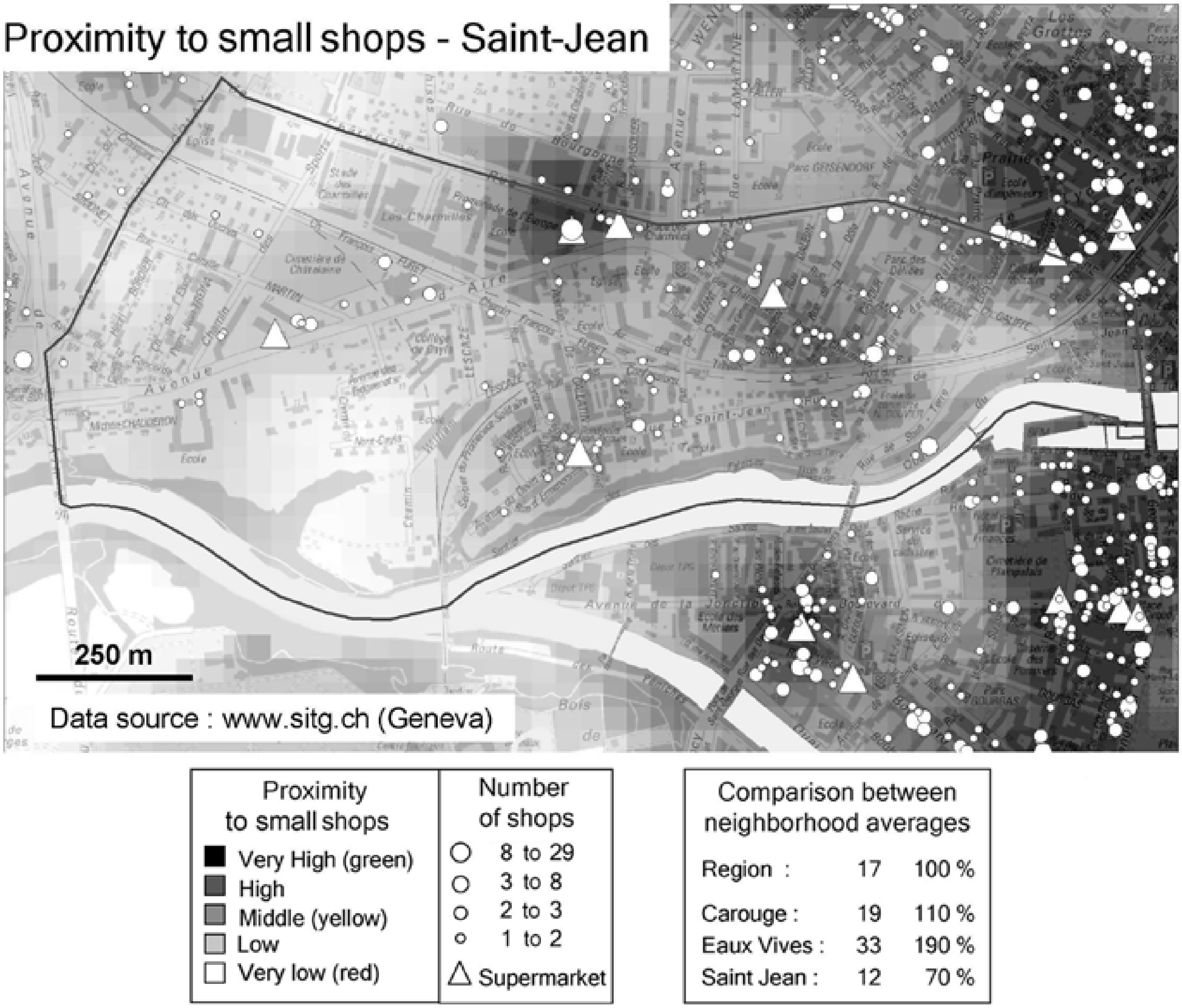

Figure 1. Cartographic Indicator: Proximity to Small Shops. This map depicts the St-Jean neighborhood (in the city of Geneva).

(Godet 2001). This process entails matching each answer (favorable or not) with a specific color in order to obtain a "mosaic" of opinions (Figure 3). This "opinion mosaic," or "opinion landscape," can then be used to perform a synthetic analysis of all the answers by simultaneously depicting all positions regarding a specific problem. Although the information is perceived from a global perspective, the "mosaic" depiction shows each individual viewpoint while eliminating the dilution resulting from statistical averages.

Step 4: Developing the diagnosis. In this final step, the Diagnosis Group prioritized the issues on the basis of these assessments. Two working sessions were required in order to synthesize the opinions expressed during interviews. The Diagnosis Group prioritized the issues according to criteria such as *issues given highest priority, issues of concern to a majority, number of consulted indicators*, etc. This process served to establish the diagnosis, which was comprised of four high priority issues and three medium priority issues; the remaining issues were assigned no priority.

Analysis And Discussion Of The Application

In this section, the experiment is analyzed and discussed in light of the considerations highlighted in the section "Considerations

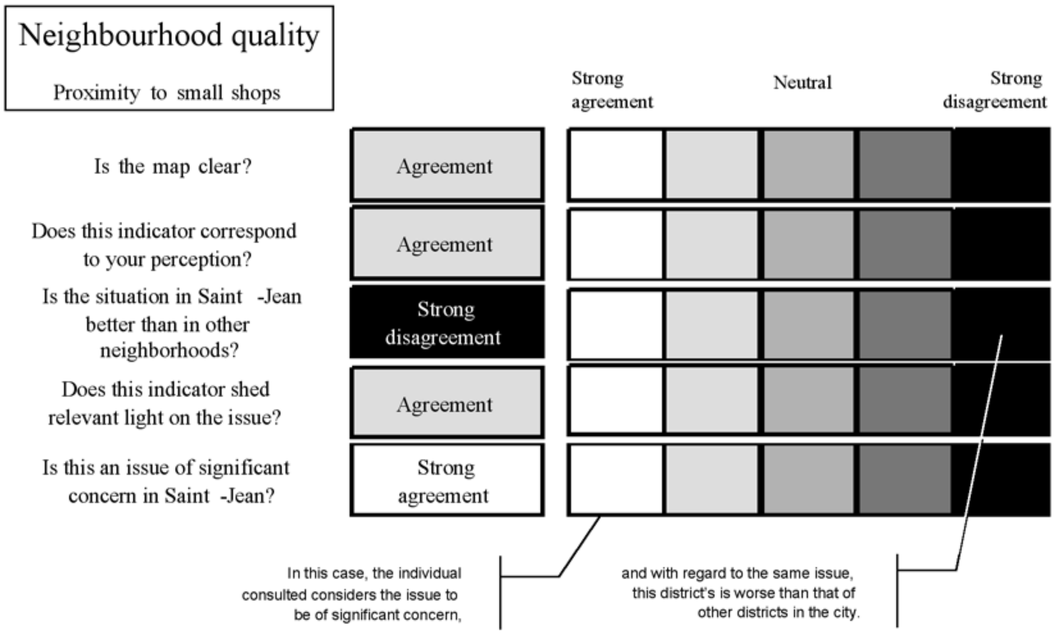

Figure 2. Question Set. Set of questions asked after review of each cartographic indicator, with interface used to collect answers.

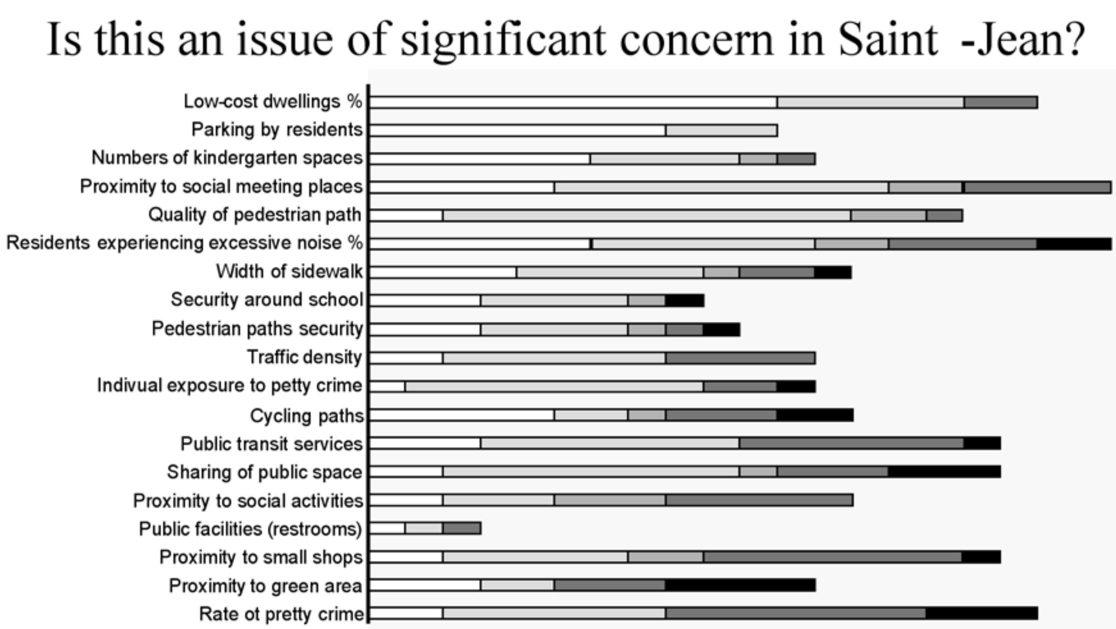

Figure 3. Opinion Mosaic. Opinion mosaic showing all answers collected for the fifth and final question (see Figure 1). Transition from white to black reflects gradations of reaction to the issue in question: white = extremely concerned, black = not at all concerned.

for the Use of Geographic Information in Public Participatory Processes."

Access to Information

The cartographic indicators should serve as reference points during the interviews for establishing correlations between the representations built from administrative data and those created by users for the territory. For the purposes of this experiment, indicators were limited to spatial comparisons. Thus, they were assessed on a qualitative scale and presented at varying geographic scales (Figure 1).

Several questions can be asked about the significant amount of information presented using maps: Was the presentation of information in this form appropriate? Did it contribute in any real fashion to the appropriation of information? Did local stakeholders really understand these maps? Can cartographic information actually be used in the cognitive process, which should be leading to a decision?

Based on the answers to Question #1 (Is the map clear? [Figure 2]), we were able to conclude that most of the individuals consulted had no difficulty reading the maps. We also observed that the use of geographic information served to support and mediate the dialog between the different stakeholders. It also helped at times to objectify the representations of the local stakeholders and to simultaneously promote the discussion of administrative representations. Thus, we believe cartographic indicators contributed to the collective construction of a common frame of reference.

During the interview, we took care to clarify the influence of geographic information, especially maps, so that local stakeholders would be fully aware of how this information might have changed their opinions. In attempting to achieve this goal during the interviews, we attempted to point out that the maps presented were not fully objective. In particular, color choices or category definitions have resulted from a partly subjective interpretation. Despite our efforts, however, it was noted that this point was often not really understood and maps were generally perceived as an objective representation of the "reality."

Information and Decision Sharing

Information sharing was one of the main goals of the experiment. Two major sources of information were combined: 1) the residents' perceptions, which were expressed in the form of specific concerns and issues, and the priority level assigned by residents to each issue; and 2) the official data provided by the administrative authorities (census data, traffic and noise measurements, etc.), which were used to produce the indicators. These two sources of information were pooled together through a series of comprehensive interviews, during which the individuals consulted were asked to observe the geographic indicators before assigning a level of priority to each issue.

For the purposes of decision sharing and determining levels of participation, the research group maintained an ongoing open discussion about the process with the Diagnosis Group. Our aim was to support each step of the process through the use of information tools, while at the same time minimizing its influence on opinion formation and on the content of the representative diagnosis in order to allow appropriation of the process and its result (the diagnosis) by the participants.

As mentioned above, however, this objective was not fully achieved. First, the indicators were defined and depicted (represented) on maps without the Diagnosis Group's involvement. In fact, although we asked the Diagnosis Group to take part in the map development process, its members refused, mainly due to a lack of time. Second, we also assumed the role of both expert (mapmaker) and mediator during the interviews, and although we were careful to take a neutral position when presenting the maps, we did inevitably influence the interpretation and appropriation of information. We noted, for example, that when asked if the map was clear, some interviewees felt that a negative answer would imply a criticism of our map development skills.

Knowledge and Values

Some interesting findings resulted when we correlated considerations on knowledge and values with information sharing. For the purposes of our experiment, information obtained from residents was comprised mostly of values and opinions. The range of concerns that formed the starting point of the process (Step 1) was essentially subjective information. The answers given by the individuals who consulted the cartographic indicators (Step 3: Assessing the issues) also expressed values.

At the opposite, information obtained from administrative sources was mainly knowledge-based (data and measurement). For this reason, the participatory diagnosis was not a full collaborative process between the residents and the authorities. In order to be termed "collaborative," both types of information—knowledge-based and values-based—would have been required from each of the two categories of stakeholders.

Stakeholders, Media Used, and Interface

Two groups of stakeholders were involved in two ways. On the one hand, we had the dozen residents who made up the Diagnosis Group and who stayed with us through the entire process. On the other hand, a group of residents was consulted on the positions taken by the Diagnosis Group. The media and interface used to communicate information to these two different groups have been adapted to their characteristics.

Participants in the Diagnosis Group generally had a relatively high level of education, and most were familiar with computers. Nevertheless, the use of GIS was significantly restricted during the working sessions. Our preferred method was to show a set of maps in hard-copy format or displayed using an LCD projector. Priority was placed on the discussions and social interactions. The GIS system was actually a type of "backstage" tool that was used to store, manage, and synthesize information.

The second group, the interviewees, was much less homogeneous and generally with a lesser level of education. Furthermore, its composition was different at each step. For this reason, we preferred to use a hard-copy questionnaire to record residents' concerns.

When prioritizing the issues, a laptop computer was nonetheless used for presenting the cartographic indicators. However, the interviewees did not have to handle the laptop and no real interactivity was possible. (In fact, the maps were presented with a *PowerPoint* slideshow organized with hyperlinks enabling navigation from one indicator to another). The main reason for using a computer was practical, that is, to conduct interviews as quickly as possible, but its use was also often attractive for the residents.

Role of Information in the Decision-Making Process

In conducting this experiment, we chose to work exclusively on the first phase of the decision-making process (intelligence or identification of problems). Study cases on high-conflict decision-making processes concerning land planning in Geneva (Joerin *et al.* 2002) have demonstrated the influence of this phase on conflict intensity. Our decision to work exclusively on this step would likely have strongly influenced the way information was collected, analyzed, and communicated.

As mentioned above, the main reason for using geographic information was to stimulate a cognitive process, thereby allowing for the integration of opinion building into the diagnosis. Unfortunately, the experimental setup does not allow study of this cognitive process; therefore, this point has to be discussed on the basis of our own impressions.

Our observations are different for the two groups of stakeholders, the Diagnosis Group and the interviewees. The first group had much more time for information appropriation. So when a cartographic indicator proved surprising to them, group members had time for discussions and could ask to consult the map many times during the same working session, or in different ones. We believe, in this case, geographic information actually contributed to the cognitive process. This statement is based on the fact that these particular indicators (e.g., public transport accessibility) have been chosen for inclusion in the set of high-priority issues, and some specific actions, such as a petition, have then been undertaken in order to obtain improvement.

Our impressions concerning the second group (interviewees) are almost the opposite. Although the interviews were quite long (more than one hour in duration), we generally had the feeling that the cartographic indicators did not have a real influence on the issues' prioritization. When a cartographic indicator proved surprising, the interviewee could sometimes dispute the map representation ("This map is wrong."). We also observed some interviewees who did not change their opinions, even if they recognized a contradiction between information received and accepted from the cartographic indicator. We suppose more time is needed for a cognitive process that would lead to an opinion change.

Conclusion

Our paper deals with the use of information in public participatory decision-making processes. Five considerations are presented, which focus on the following aspects: access to information, level of information and decision sharing, difference between knowledge and values, selection and design of media and interfaces for the communication of information, and applications of the information developed. We have used these considerations to discuss our own real-life experiment, which consisted of a participatory process that led to the establishment of a neighborhood-based diagnosis. Our analysis highlights the potential and limitations of the experiment, which was based essentially on the use of indicators that combine knowledge and values.

The experiment shows the feasibility of a participatory diagnosis at the very beginning of the decision-making process, for example, when the object of change has not yet been identified (problem setting). One challenge of this experiment was to convince a group of residents, already involved in their own diverse but very real conflicts, of the usefulness of a diagnostic process. Their active participation in the Diagnosis Group—on a voluntary basis—indicates to us that they were in agreement regarding its usefulness. However, the real usefulness of this local diagnosis will be seen only when residents demonstrate their complete appropriation of information, either by using it in existing groups to make progress on current issues or by creating new groups to continue the decision-making process and propose methods for taking action on the priorities they have identified. To date, two groups have been created: one to solve the parking problems and the other to improve the bus schedule (frequency). The latter group launched a petition that collected more than 1,000 signatures. Some actions have therefore been initiated, but additional time is required to assess whether this diagnosis would actually have a positive impact on efforts to resolve current conflicts with authorities.

With regard to the potential for using information, the experiment shows that geographic information can support participants' efforts to build opinions about the situation in their district and to compare it to other districts in the city.

The limitations of this experiment are related primarily to the level of influence exerted by experts and the participants' level of appropriation or involvement: Who chooses the indicators? Who builds them? Is this part of the expert's mandate or does it fall within the purview of the local population? By participating in the development of cartographic indicators, will local stakeholders arrive at a better understanding of the underlying principles, the limitations, and their possible uses? Does this participation constitute a form of empowerment that would lead to the appropriation of information? These are some of the questions that still need to be investigated.

We subscribe to the view that public participatory processes should not be based on the hypothesis that all stakeholders are experts who possess the same level of ability. Our preference is to conceive of processes that recognize different levels of ability

among stakeholders and experts, in order to assign an adequate role to each of them. This opinion is partly based on our participants' clear refusal to be involved in the map development process. On the one hand, they felt this to be too onerous, and on the other hand, they believed this responsibility should be left to the experts (ourselves). One simple rule of thumb that could be followed when splitting tasks between the expert and the stakeholders could be that complicated tasks (analysis and design, for example) would be the experts' responsibility, whereas complex questions linked to values and subjectivity would be part of the stakeholders' mandate. However, this exercise in establishing "who does what" bypasses an important question: How would experts and stakeholders work together? And more precisely: Are experts and stakeholders able to understand each other?

An interesting approach to investigate could be the introduction of mediators into public participation processes using PPGIS. This new player would have to "translate" the geographic information and convey it to the local stakeholders. Conversely, he or she would "translate" the stakeholders' comments or opinions into a structured format as required by GIS. In fact, certain types of mediators are currently quite frequently involved in public participatory processes. Their objective is to facilitate interactions between the stakeholders and public administrators (i.e., the bureaucracy). A possible new angle resulting from the use of PPGIS would be the need for these mediators to combine competency at both the technical and social levels.

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Evaluating the Effect of Proximity to Hog Farms on Residential Property Values: A GIS-Based Hedonic Price Model Approach

Katherine Milla, Michael H. Thomas and Winsbert Ansine

Abstract: *The decline of small-scale farms and the dramatic increase in the size of corporate animal operations in recent years has sparked controversy over the impacts of confined animal feeding operations on surrounding residential communities. This study examines the applicability of geographic information systems (GIS)-based hedonic price modeling for evaluating impacts to residential property values from feeding operations, particularly hog operations. Residential property attributes were derived and compiled in a GIS. These attributes were used to construct a hedonic model to examine the relationship between distance to hog farms and property sales prices. Results indicate a negative and significant impact on property value from hog operations. A comparison of the results from this study with those of several other GIS-based hedonic models indicates that GIS-based hedonic price modeling is a promising method for assessing property value damages associated with animal operations, for evaluating potential impacts when siting new operations, and for developing setback guidelines.*

Introduction

The corporatization of livestock production during the 1990s has led to rapid growth of large-scale confined-animal feeding operations (CAFOs), especially in the pork industry. The result has been a decrease in the total number of hog farms in the United States and a tremendous increase in the size of individual operations. This trend has sparked a controversy about the relative benefits and costs of large-scale industrial hog farms.

A major concern for local communities is the impact of nearby CAFOs on surrounding residents. These impacts might include offensive odors (Swine Odor Task Force 1995; Chapin et al. 1998; Tyndall and Colletti 2000), physical and mental health problems (Schiffman *et al.* 1995; Thu *et al.* 1997; Wing and Wolf 1999), and degraded water quality (Hallberg *et al.* 1992; Hallberg 1996; Jackson 1996). The costs of such negative impacts on surrounding communities are not reflected in market prices for pork. One possible approach to account for externalities associated with CAFOs is through evaluation of property values of residential parcels surrounding the operations.

In this paper we describe the use of GIS techniques to derive additional parcel attribute data for constructing a hedonic price model of the impact of proximity to hog farms on residential property values. We include a brief discussion of model construction and potential applications. A more detailed discussion of the econometric techniques and analysis can be found in Ansine (2000).

Hedonic Price Models

The goal of this study was to evaluate the influence of proximity to swine facilities on the selling price of residential properties. Previous studies have used the hedonic pricing method (HPM) to approach the impact of CAFOs on property values (Abeles-Allison and Connor 1990; Taff *et al.* 1996; Palmquist *et al.* 1997; Mubarak *et al.* 1999; Bruton 2001; Herriges *et al.* 2003). A hedonic model attempts to explain the selling price of a house in terms of its physical attributes and its surrounding environment. If successful, it can reveal whether an environmental characteristic (such as proximity to a CAFO) has a significant effect on price, and how much the house's value is affected by a marginal increase or decrease in this environmental attribute.

The hedonic price model can be expressed as

$$P = f\ (C, E) \tag{1}$$

where P is the selling price of the house, *C* is a set of physical attributes that contribute to the price of a house (e.g., number of bedrooms, square footage, lot size), and *E* is a set of environmental attributes that can include factors that surround or define the house's physical location, such as its proximity to schools, parks, shopping, and livestock farms (Goodman 1978).

Hedonic price models are commonly estimated by the method of ordinary least squares (OLS). In this method, a multiple linear regression equation is constructed of the form

$$\hat{y} = b_0 + b_1x_1 + \dots + b_px_p \tag{2}$$

For this study, _ represents the price of a residential property, $x_1 \dots x_p$ are attributes or characteristics of the property (e.g., number of bedrooms, number of bathrooms, lot size), $b_1 \dots b_p$ are regression coefficients, and p is the number of attributes or predictors. The regression coefficients represent the contributions of the attributes to the price of the property. Thus, using

the HPM, individual attributes of a residential property can be evaluated for their influence on the selling price.

Previous hedonic price studies of housing indicate that variables such as the number of bathrooms, the age of the structure, heated living space, and the lot area are consistently significant in explaining sales prices (Palmquist *et al.* 1997). Thus, construction of a hedonic model to evaluate the effects of swine operations on nearby property values requires access to physical characteristics of the property that contribute to selling price, as well as an ability to calculate distances to swine facilities and to other features (e.g., schools and parks) that affect the desirability, and thus the selling price, of the property.

The increasing availability of various residential property attributes and georegistered locations in GIS format via county tax roll databases presents an opportunity to construct and analyze much more detailed and extensive hedonic price models than is possible without this technology. For example, without the aid of GIS technology, Abeles-Allison and Connor (1990) collected data on 300 residences, Taff *et al.* (1996) collected data on 292 residential properties, and Palmquist *et al.* (1997) collected data on 237 home sales. In contrast, using GIS, Herriges et al. (2003) collected and analyzed attribute data on 1,145 house sales in proximity to 550 livestock facilities in 5 counties in Iowa, and Ready and Abdalla (2003) used data from 8,090 residential properties in Berks County, Pennsylvania.

In this study, we developed a hedonic price model relating residential sales prices to a number of property attributes. GIS was employed to compile and analyze attribute data, as well as to derive new attribute data using centroid and distance calculation functions.

Study Area And Data Collection

We chose North Carolina for our study site because a rapid increase in the number of hog operations in recent years has created concerns among residents and sparked controversy between citizens' groups and facility operators. Between 1989 and 1997, the number of hogs in North Carolina nearly quadrupled, from approximately 2.5 million to 9.6 million (National Agricultural Statistics Service) (Figure 1). Production of feces and urine from this number of animals has been estimated at more than 20,000 tons per day, or nearly 20 million tons a year (Ansine 2002).

The North Carolina Department of Environment and Natural Resources collects data on active animal operations in North Carolina that require a permit from the Division of Water Quality. These data include location in latitude/longitude coordinates; type of facility; design capacity; and dates of registration, certification, and permit. In order to select a county for study, ArcView GIS software was used to create a point theme of swine facility locations, which was superimposed on a county base map of North Carolina (Figure 2).

Craven County was selected for study because the county maintains an extensive tax assessor's property parcel GIS database, and the number and distribution of swine operations is sufficient for analysis, though not so dense as to complicate the statistical

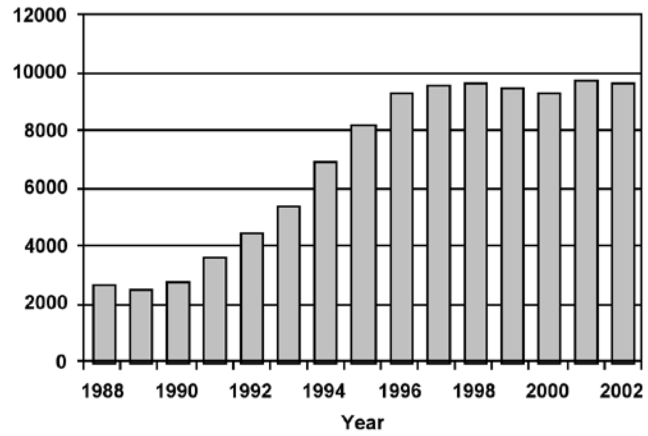

Figure 1. Total Annual Number of Market Hogs in North Carolina, 1988 to 2002
(Data from USDA National Agricultural Statistics Service)

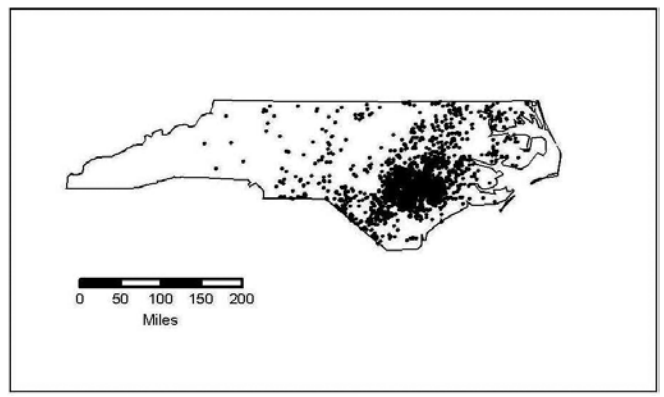

Figure 2. All Hog Operations Permitted by the State of North Carolina as of 2001

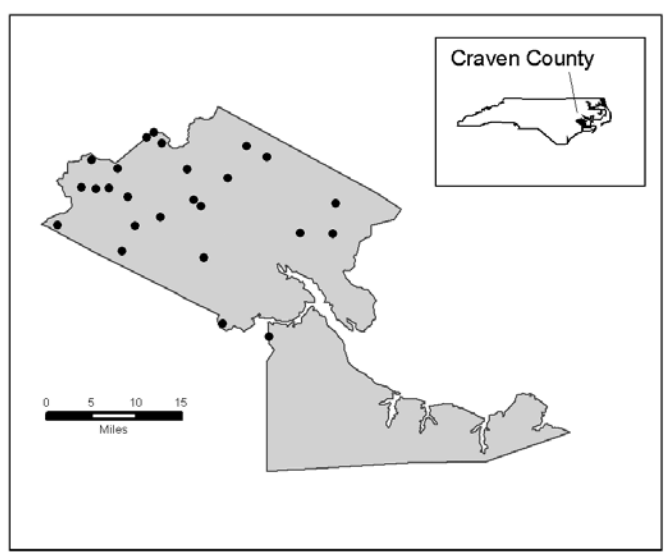

Figure 3. Hog Farm Locations in Craven County, North Carolina

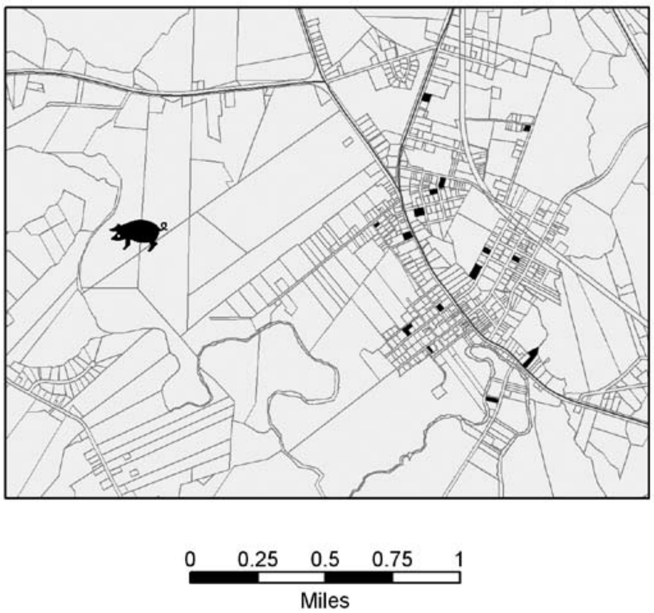

Figure 4. Example of Residential Property Parcels Near a Hog Farm

analysis (Figure 3). The data set consists of 26 hog operations ranging in design capacity from 720 to 7,680 hogs (data from North Carolina Department of Environment and Natural Resources Division of Water Quality).

Parcel data were selected for house sales transactions that occurred between January 2000 and July 2001. After removing parcels with missing data, apparent data entry errors, or very large lot sizes (suggesting homes sold in conjunction with farm or timber tracts), the final data set consisted of 810 parcels (Figure 4).

Parcels in black represent those screened from home sales data for hedonic modeling.

Additional parcel attributes were generated from the selected parcels and swine facility data by applying geometric and distance functions in ArcView. Separate polygon themes were created from the parcels data for a number of different land uses, including schools, parks, highways, police and fire departments, hospitals, and gas stations. Using ArcView's ReturnCenter function, center point themes were created for residential parcel polygons and for parcel polygons in each land use theme. Using ArcView's Distance function, distances were calculated from each swine operation and from each point in each land use layer to each residential parcel center point. Thus, distance from each land use type was added as an attribute of each parcel used in the analysis.

Method

Many aspects of a property can affect the selling price. Among the variables tested were physical characteristics of the property (number of bedrooms, number of bathrooms, size of lot, living area, and whether the home was a mobile home). Other aspects of the property considered were year of sale (2000, 2001) and time of sale (spring, summer, autumn, winter). In addition to proximity to hog farms, the effects of distances to other features were considered. These included schools, vacant lots, highways, sewage treatment, veterinary clinics, gas and oil storage, police and fire protection, banks, restaurants, golf courses, hospitals, retail food stores, lumberyards, trucking terminals, service gas stations, night clubs, marinas, mining and quarrying, manufacturing and processing, and agricultural fields. Different functional forms of the model were tested including linear, log-linear, log-log, and quadratic.

Model Results

It was determined that a log-log functional form with 7 variables produced the best results (R2 = 0.789):

$$lnSLSPR = 3.582 + 0.02717\ lnLOTSIZE + 1.109\ lnSQFTLA - 0.02425\ lnAGEOFHO + 0.349\ lnBTHRM_t - 0.485\ lnMH - 0.02790\ lnPKD - 0.03113\ lnD/D \quad (3)$$

Where:

SLSPR is the sales price of the house.
LOTSIZE is acres of land.
SQFTLA is living area (sq. ft.).
AGEOFHO is age of house (years).
BTHRM is number of bathrooms.
MH is mobile home (YES = 1 or NO = 0).
PKD is distance to nearest park (feet).
D/D is hog density/distance, the number of hogs in the nearest hog farm[1] divided by linear distance from the house measured in feet (swine/linear ft.).

While not used in previously published research, the variable D/D is particularly appealing because it captures the impact of both hog farm size (number of hogs) and proximity to the property in one variable. The D/D variable should exhibit a negative relationship with house sales price. This presumes that homeowners prefer to live farther away from hog farms and that proximity to farms with more animals is less desirable than proximity to farms with fewer animals.

The coefficient for D/D, -0.03113, represents the elasticity of D/D. This means that an increase in the D/D variable of 1% results in a -0.03113% change in the property value. An increase in D/D could result from either an increase in the number of hogs on a farm at a fixed distance from a property, or a decrease in the distance to a farm of fixed size. Thus, D/D can be used to evaluate the effect of either increasing farm size or decreasing distance to a farm. As an example, for a home valued at $114,000 (the median house price) at a distance of 1 mile from a farm with 5,000 animals, the marginal impact of adding an additional hog to the farm is a decrease in value of $0.71. Assuming the marginal impact is an average impact per hog, the value of the home would suffer a one-time loss of $3,550, or 3.1%.

[1]The number of hogs on each farm was calculated from the permitted steady state live weight (SSLW). SSLW is associated with the type of animals it processes (e.g., farrow to wean, feeder to finish). For this study, the number of hogs was calculated as the live weight divided by 135, the average live weight for feeder to finish hogs (SB1217 guidance document).

Comparison With Results From Other Studies

We could identify only three other studies in the literature exploring the use of GIS-based hedonic price models to examine impacts on property values from surrounding animal operations. Although these studies involved a diversity of models employing different sets of attributes, different functional forms, and different geographic locations, all of them demonstrated a similar measurable and significant negative impact to property values from nearby livestock facilities.

Kim (2004) performed a more complex hedonic analysis of hog farm impact to residential properties in Craven County. Kim's study, which included more environmental attribute variables, used a linear Box-Cox functional form and a stratified area sampling of assessed property values. Using concentric distance bands and accounting for spatial effects, this study demonstrated a decline in assessed property values by $0.47/hog at 0.75 mile from farms, $0.52 at 1 mile, and 0.42 at 1.25 miles. This equates to an impact of -$5,210, or 8%, on a median house value ($63,520) at 1 mile from a 10,000-head swine facility. Kim's results are in general agreement with the findings of this study, which modeled a decline of $0.71/hog at 1 mile.

Herriges et al. (2003) constructed a hedonic model using 550 livestock operations (> 90% were hog facilities) and 1,145 property sales distributed throughout five counties in Iowa. Five different model functional forms were tested. From the results of their study, the authors concluded that there may be an approximate 10% reduction in property value if a new livestock facility is located upwind and near a residence. Ready and Abdalla (2003) analyzed the impact of surrounding land uses and potential local disamenities on residential property values in Berks County, Pennsylvania. Using sales and attribute data for 8,090 single-family houses and 71 large-scale animal production operations, they concluded that the impact of a large-scale animal operation located at 800 meters was 4.1%, and that the impact did not vary significantly by type of operation (poultry, swine, beef/dairy).

Discussion: GIS And Hedonic Price Models

A Potential Method for Establishing Setbacks and Managing Buffer Zones

As the structure of the livestock industry has trended toward concentration of more animals in fewer operations, state and local governments have acknowledged the problems associated with large operations by enacting legislation imposing stricter regulations on CAFOs and increasing separation distances (Herriges et al. 2003). In North Carolina the following mandatory setbacks are imposed on new or expanded farms with 250 or more hogs: 1,500 feet from occupied residences, 500 feet from any residential property boundary to swine houses and lagoons, and 75 feet from any residential property boundary to sprayfield boundaries.

Based on the results of studies discussed here, it is quite apparent that significant externalities are associated with animal feeding operations, and that the relationship between externalities, farm characteristics, and community attributes can be quite complex. To be realistic, setback models must go beyond merely fixing set distances, but must incorporate a broad range of variables and considerations.

This study demonstrates that GIS-based hedonic price modeling may be a viable approach to establishing setbacks for animal production facilities. Hedonic models incorporating distance variables can be constructed without the need to devise objective measures of inherently subjective perceptions of negative qualities, such as odor or aesthetics. Peoples' willingness to pay, as indicated by property sales prices, reflects the full range of negative perceptions.

Negative impacts of animal facilities as reflected in lowered property values can extend far beyond established setbacks. For example, based on the results of this study and those of Kim (2004), to significantly avoid the negative impact of swine production, a setback or buffer of 1.75 to 2.5 miles would be recommended. Results of the studies of Ready and Abdalla (2003) and Herriges et al. (2003) would imply setbacks up to 1 mile and at least 1.5 miles, respectively.

A Potential Method for Assessing Damages

Establishing buffer zones large enough to avoid impact to property values is probably unrealistic, especially in regions with high property values. Even if such separation distances were feasible, such a policy could not remedy impacts that have already occurred. A growing number of nuisance lawsuits reflect the increasing and often hostile conflict between livestock production farmers and surrounding residential neighbors. Without a systematic method for determining loss, damages for reductions in property values are often awarded based on personal testimony and appraisals by the owners (Vansickle 2003). Compensatory and punitive damages awarded in lawsuits can be enormous (Lee 2004).

GIS-based hedonic price modeling could provide a means for equitable damage assessment, as well as for mutually agreeable negotiations between property owners and facility operators prior to establishing a facility. Modeling results suggest that, provided operators followed practical and reasonable siting rules, the magnitude of compensatory payments made to property owners could be modest relative to the cost of establishing a new operation (Herriges et al. 2003).

Summary And Conclusions

GIS technology has enabled applications of spatial analysis techniques that were previously impractical or not possible due to the great amount of data involved. The increasing use of GIS in county parcel database management has created an opportunity to assess the impacts of land use activities on surrounding property values. In particular, attribute data derived from a GIS parcel management system can be used for hedonic modeling of damages to property values associated with proximity to livestock production facilities. The results of this study indicate that GIS-

based hedonic price modeling may be a promising technique for establishing setback guidelines, for assessing property value damages resulting from animal operations, and for evaluating potential property value impacts to surrounding properties when siting a new CAFO.

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Developing a City Skyline for Hong Kong Using GIS and Urban Design Guidelines

Ann Shuk-Han Mak, Ernest Kin-Man Yip, and Poh-Chin Lai

Abstract: *Hong Kong is a metropolis with a dense population. The need to cope with rapid population growth under the constraint of limited amounts of developable lands has resulted in a concentrated development of high-rises. Enterprising developers have clearly exploited such behaviors in the urban development of Hong Kong. Buildings have been constructed to maximum heights whenever a height restriction was not specified in the authorization to build, or stretched to their limits sideways if given a height restriction. Both of these situations have given rise to either repetitive and monotonous roofscapes or walls of regimental building flanking the harbor front. The objective of this research is to evaluate and redesign the city skyline of Hong Kong based on Urban Design Guidelines established by the Planning Department. The study makes use of the Geographic Information System (GIS) technology and its 3-dimensional (3D) modeling functions to construct, assess, and analyze the city skyline.*

Introduction

The term "city skyline" refers to a profile of buildings that forms the cityscape in daytime and the silhouette at night (Lim and Heath 1993). It comprises a group of tall buildings against the undulating backdrop of mountains enwrapping in a natural setting. City skyline registers unique characteristics of a city's landscape shaped by planning controls, topographical conditions, commercial considerations, building design parameters, and environmental concerns. The cities of New York, San Francisco, Sydney, Shanghai, and Toronto are among major metropolitan cities in the world with uniquely identifiable skylines.

Cities today are much more concerned about their images because a good impression is key to tourist attraction. Local governments of major cities have tried various means to enhance the visual quality of their city skylines by exerting more control over building heights and design parameters, as well as by constructing more green corridors (Council of the City Vancouver 1997; Lower Manhattan Development Corporation 2002; United Kingdom Parliament 2003). The question is whether there are any standards to form judgment in our assessment of a city skyline. What criteria or factors are used to form an opinion about a city skyline? Are there objective methodologies to define these criteria?

Aesthetic value has emerged as an important criterion for evaluating the quality of a city skyline (Delafons 1990; Habe 1989; Preiser and Rohane 1988). A great deal of focus in aesthetic interests concerns the height or the design quality of a building. Some writers have attempted to quantify the design quality of buildings with associated preferences. Stamps (1991) investigated the influence of height, complexity, and style on the preference of individual buildings, and concluded that relative complexity is a predictor of preference for individual high-rise buildings. Heath, Smith, and Lim (2000) investigated the effects of the silhouette and façade complexity of tall buildings on visual preferences of skylines. They found that a higher level of preference, arousal, and pleasure usually is associated with a higher silhouette complexity and façade intricacy.

There is general agreement that buildings should not be considered in isolation but in reference to their unique topographical and landscape setting (Planning Department HKSAR 2001; Yu 2000; Bishop and Karadaglis 1997). Both man-made (including cultural and socioeconomic aspects) and natural (embracing mountains and waterbodies) contexts should exist coherently and in harmony with each another (Planning Department 2001). For instance, the skyline should preserve some view corridors or breezeways to mountain backdrops or natural landscapes. Open spaces or green corridors between buildings should be protected to yield a cityscape of characteristic traits and visual aesthetics.

This article outlines the criteria for skyline development and assessment in Hong Kong. It illustrates the use of 3D and viewshed analytical techniques of a GIS to visualize and practice Urban Design Guidelines. The study also proposes further recommendations to enhance the skyline of the Victoria Harbor along the waterfronts of the Hong Kong Island.

The Skyline of Hong Kong

Hong Kong is blessed with a picturesque image along high hills overlooking the Victoria Harbor. This stretch of urban landscape is characterized with interestingly shaped high-rises set against a mountainous backdrop. Such a unique urban montage has become the image and identity of Hong Kong. Unfortunately, this beautiful vista has gradually been breached by uncontrolled high-rise developments along the harbor front (Figure 1). Many concerned citizens have protested that exceptionally tall buildings have blocked views of inland sceneries and landscapes. Planners have criticized that views from the harbor to the ridgeline and the Peak have not been duly protected (Yu 1999; Tam and Hai 2001). Buildings in districts where height controls are enforced exhibit a uniform but monotonous roofscape, reflecting the widespread practice in urban construction that observes the maxi-

Figure 1. The Two IFC (International Finance Centre) Building

The Two IFC is an immensely tall tower standing at the waterfront, overpowers the surrounding townscape. Its presence conflicts not only with the character and scale of the surrounding structures but also the height limitation of city skyline given its frontage position.

mum height as the literal cutoff. Tsim Sha Tsui East (Figure 2) serves as a regrettable example that should be avoided at all cost. Sideward expansion of buildings in these areas to compensate for reduced profits due to lower heights is extensive. This inclination has resulted in walls of building forming unattractive "canyons" flanking the waterfront.

While vertical development is unavoidable in Hong Kong, it has been agreed generally that ridgelines are valuable tourist and visual assets, and their preservation should be given special consideration in the process of urban development. Moreover, one of many recommendations is to encourage height variation within the same area such that buildings along the coastlines should get progressively higher inland to produce a more interesting cityscape (Tam and Hai 2001). The terrace-like profile often produces magnificent skyline effect (Tam and Hai 2001). The Manhattan skyline in New York, for example, is regulated from two scenic viewpoints, located respectively at the Brooklyn Heights Promenade and the Victory Boulevard on the Staten Island, where buildings are arranged in stepped-like profiles with taller developments located inland and lower structures along the waterfront. Another example is Shanghai, where buildings alongside the Huangpu River have undulating building heights that get progressively taller from the river. These city skylines exemplify that diversity in building heights adds variety and visual stimulus for the viewers. Serious consideration should be given to designating coastal sites for low-density developments. Sadly and contrary to sensible practices, the coastal strips of Hong Kong are packed with mega-towers obstructing the views of lower buildings located inland and behind them.

Figure 2. Buildings in Tsim Sha Tsui East

Height controls that were strictly enforced at one time exhibit a uniform but monotonous roofscape. Sideward expansion of buildings to maximize floor space in compensation for reduced profit margins due to lower heights is evident in this area.

Urban Design Guidelines

Barnett (1982, p. 12) defined urban design as "*the process of giving physical design direction to urban growth, conservation and change. It sits at the interface between architecture and planning, and its emphasis on physical attributes usually restricts its scale of operation to arrangements of streets, buildings, and landscapes*." Urban Design Guidelines have been articulated at both regional and local levels and published documents have extended the main ideas on city skyline and predominant built characters (Planning Committee 2002). In the United States, Hamilton County and City of Cincinnati collaborated to develop an overall urban design framework for the central riverfront (Urban Design Associates 2000). The guidelines regulated heights of buildings to preserve views from the downtown to the river and vice versa. Specifically, buildings were seen stepping down from Fort Washington Way to Mehring Way, with stadiums pushing as far eastward or westward as possible. This approach has guaranteed that existing and future developments can enjoy the most prestigious positions along the riverfront. Similar guidelines were applied in Lower Manhattan to embrace a diversity of mass, building heights and configuration, and a variety of architectural styles (Lower Manhattan Development Corporation 2002). New buildings were carefully planned in consideration of view corridors and access to the waterfront (Bell et al. 2002). In the United Kingdom, city development guidelines for London were adopted as a framework to ensure that tall buildings are designed as part of a coherent whole informed by clear visions as opposed to ad hoc, piecemeal, and reactive measures (Evans 2002). Tall buildings deemed detracting to the views, skyline, and townscape were encouraged to move and would be replaced by lower rise and contextual development compatible with the wider areas.

The Planning Department initiated a study on "Urban Design Guidelines for Hong Kong" with the first round of public consultation to collect opinions in February and March 2000. A second public consultation was arranged in 2002 to present

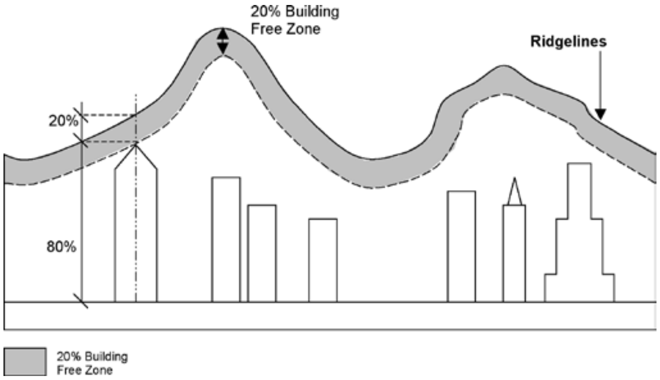


Figure 3. Ridgeline Protection (Adapted from Planning Department HKSAR, 2002)

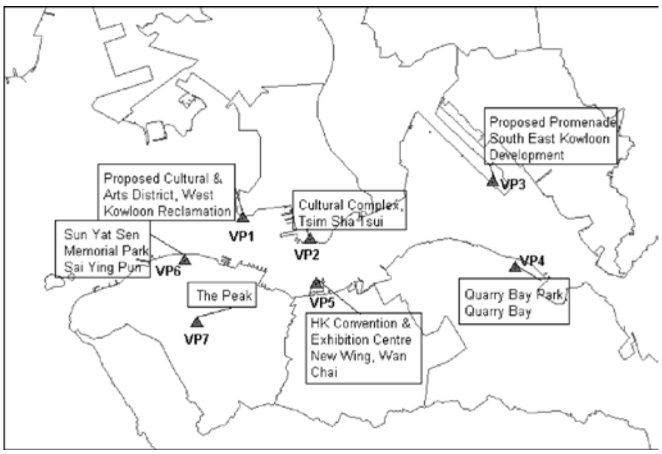


Figure 4. Proposed Vantage Points for Preserving View Corridors to Ridgelines (Adapted from Planning Department HKSAR, 2002)

Viewing from Kowloon toward ridgelines on the Hong Kong side:

VP1 Proposed Cultural and Art District, West Kowloon Reclamation
VP2 Cultural Complex, Tsim Sha Tsui
VP3 Proposed Promenade, South East Kowloon Development

Viewing from Hong Kong toward ridgelines on the Kowloon side:

VP4 Quarry Bay Park, Quarry Bay
VP5 Hong Kong Convention and Exhibition Centre New Wing, Wan Chai
VP6 Sun Yat Sen Memorial Park, Sai Ying Pun

Preservation of views of the Victoria Harbor:

VP7 Lion Pavilion, The Peak

the consultants' findings and to seek public views on the recommendations (Planning Department HKSAR 2002). Clearly-defined guidelines would help promote public awareness on design considerations besides providing a broad framework for urban design assessments. The study has provided many ideas on how to structure or improve the city skyline. It suggests that a good city skyline should exhibit the following qualities:

- Considers the relationships amongst buildings and between buildings and open space
- Takes into account the overall design of a city as a whole and its harmony with surrounding natural features such as ridgelines and peaks
- Enhances townscapes and local environments of quality character and interest
- Preserves the centrality of some buildings as the city's landmarks

The proposed guidelines also outline criteria and parameters deemed essential in augmenting the visual quality of a city's skyline. These include ridgeline protection, vantage positions, landmarks at strategic locations, and variation in building heights as discussed below.

Ridgeline Protection

Urban Design Guidelines of Hong Kong recommend that at least 20% of building free zone must be sustained against the backdrop of ridgelines from various viewing points (Figure 3). In effect, the contour of maximum building heights can be plotted against the ridgelines to ascertain compliance with this recommendation. New buildings, and particularly the mega-towers, are advised not to intrude upon the 20% building free zone.

Vantage Positions

The Urban Design Guidelines also recommend seven vantage points surrounding the Victoria Harbor that form the bases of preservation of views to ridgelines and peaks (Figure 4). Visual access from these vantage positions to the waterfront must be maintained at status quo or enhanced by providing additional view corridors. The aim is to allow visual permeability from the waterfront into the inner areas. This guideline would help develop a better microclimate of the inner areas by facilitating air movement through breezeways.

Landmarks at Strategic Locations

The most recognizable cities in the world are often characterized by a number of towers rising from the ground. Mega-towers often have been selected as landmarks of a city, and they should be given special attention. These landmarks of certain heights should be introduced at suitable locations, such as at the harbor entrance or to mark a district. The threshold height at which a building is deemed a mega-tower is suggested at 300 meters or above from the ground level. The provision of mega-towers allows

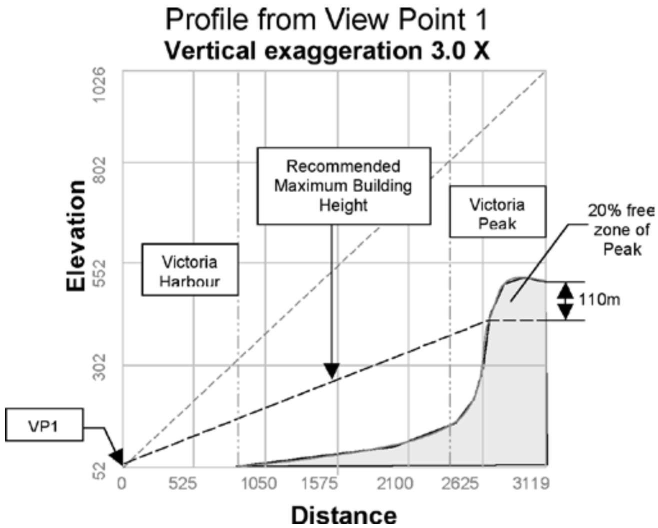


Figure 5. A Profile Analysis for Recommending Maximum Building Heights

for special consideration of new structures so that their proposed locations must be evaluated against existing setting and their ultimate presence regarded not overly intrusive to maintain the visual coherence of the city.

Variation in Building Heights

Variations in relief and building height will introduce a more vibrant and dynamic cityscape. The Urban Design Guidelines recommend that terraced-like arrangement of buildings be encouraged where appropriate. Taller developments should be located inland with lower structures closer to the waterfront. The recommendation illustrates with an example of a vertical profile between viewpoint VP1 and the Victoria Peak (as shown in Figure 5). The height of the Victoria Peak is around 545 meters, so that the 20% building free zone is approximately 110 meters below the Peak. The mark for the 20% building free zone is linked with VP1 to yield a line of maximum building heights that increases progressively from the waterfront.

Visualising Urban Design Guidelines In A GIS

GIS has been used extensively in many 3D applications (He and Tsou 2001; Zhang et al. 2000; Batty et al. 2000). It has been shown a practical means to aid decision making and terrain modeling. The 3D-Analyst extension of ArcView (ESRI 1997) was employed here to convert a portion of the Hong Kong maps in 2D representation into 3D models. Two functions were particularly helpful in this regard: (1) 3D visualization functions and (2) 3D analytical tools. The former permits integration of an orthophoto image and a 2D map to construct a more intuitive model of the same area in 3D perspective. 3D representation, as illustrated by the cross-sectional profile in Figure 5, enables graphic presentation of the 20% building free zone against the

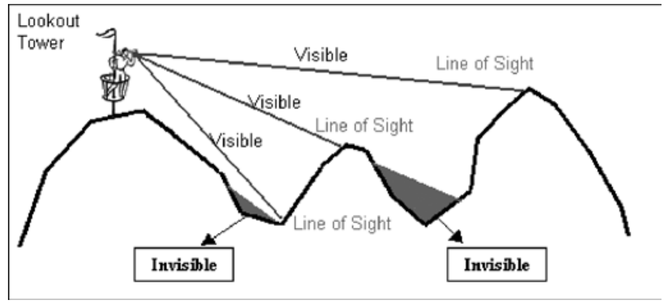
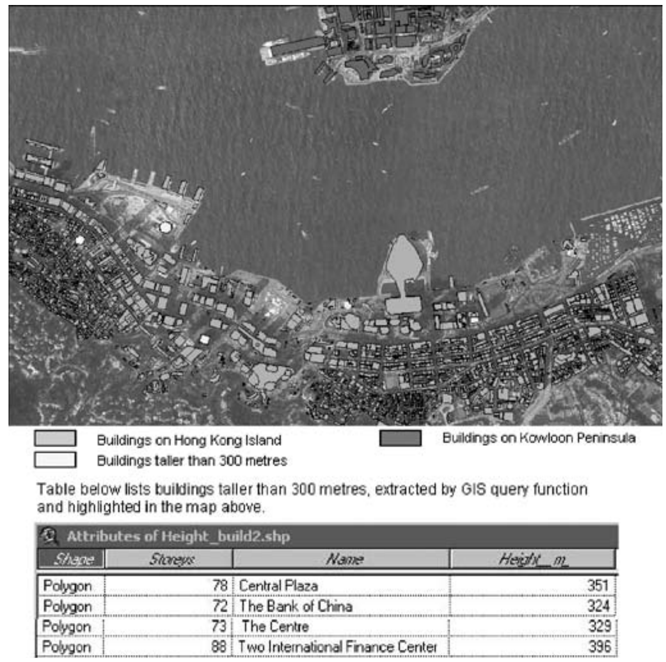


Figure 6. Line-of-Sight and Viewshed Analyses from a Vantage Point



Shape	Storeys	Name	Height_m
Polygon	78	Central Plaza	351
Polygon	72	The Bank of China	324
Polygon	73	The Centre	329
Polygon	88	Two International Finance Center	396

Figure 7. The Victoria Harbor in Hong Kong with Landmark Buildings Highlighted

ridgelines such that buildings in violation can be manifested. The 3D analytical tools, on the other hand, support visibility analyses (Figure 6) to examine if a given target is viewable from a point of observation (i.e., the line-of-sight check) and to determine the extent of visible areas from an observation point (i.e., the viewshed inspection).

Both non-spatial and spatial data were used in the 3D modeling and design of the Hong Kong skyline. The Lands and Planning Departments of Hong Kong provided spatial/map data for this study. Building or storey heights were gathered from various sources and incorporated with the spatial data. Orthophotos were also acquired from the Lands Department to provide a realistic backdrop for our skyline profiles.

The following is an account of our attempts to incorporate Urban Design Guidelines with GIS functions to examine skyline development of Hong Kong at the Victoria Harbor. Specifically, we demonstrated how GIS modeling capabilities have enabled the visualization and understanding of Urban Design Guidelines.

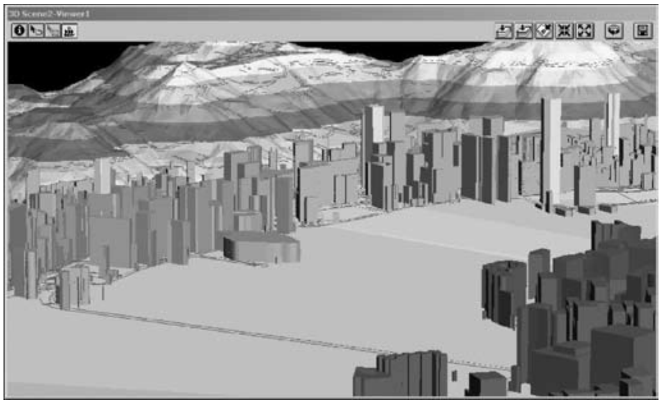


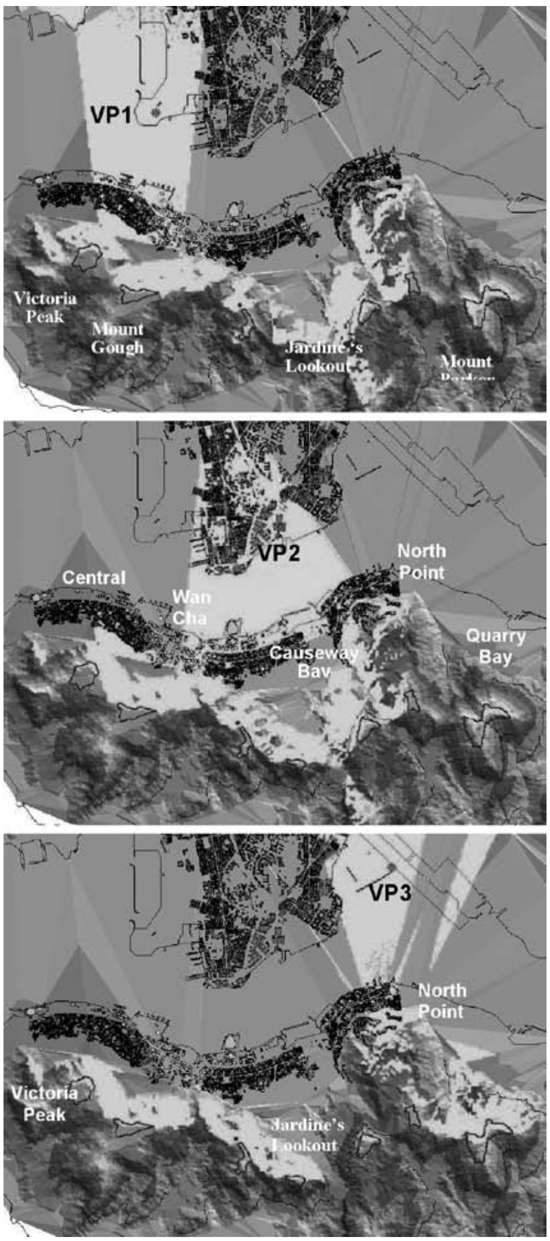
Figure 8. A 3D Representation of the Victoria Harbor on the Hong Kong Side

Procedure 1: 2D Data Compilation and Selection of Landmarks

We began by superimposing a layer of building polygons over an orthophoto image of the Victoria Harbor (Figure 7). We then identified prominent landmarks or mega-towers exceeding 300 meters in heights, as specified in the proposed Urban Design Guidelines of Hong Kong. The recognition of these mega-towers is fundamental to assessing their visual prominence and impacts on the urban scenes.

Procedure 2: 3D Representation of a Cityscape

A 3D illustration bears a closer resemblance of the location it



Areas visible from viewpoint VP1 located in the West Kowloon Reclamation are highlighted. A continuous ridgeline is not feasible given that only intermittent ridgelines (around the Victoria Peak, Mount Gough, Jardine's Lookout, and Mount Parker) are visible from VP1.

Viewpoint VP2 is at the Cultural Complex and areas visible from this vantage point are highlighted. Most of the ridgeline on the Hong Kong side can be seen. The visible areas are confined to Wan Chai and Causeway Bay as views to Central, North Point, and Quarry Bay are blocked. The inland area of Causeway Bay has a poor visual penetration because height restriction was not enforced for buildings in the foreground.

Viewpoint VP3 is situated in the South East Kowloon development zone. Visibility of the harbor area from VP3 is rather poor as highlighted. Only a small strip of the waterfront area at North Point is directly exposed. However, this vantage point yields an almost continuous ridgeline from the Victoria Peak to Jardine's Lookout.

Figure 9. Viewshed Analyses from Three Vantage Points in Kowloon Overlooking the Hong Kong Side

represents and enhances visualization of the landscape and its associated features. GIS modeling functions were used to create a 3D urban scene of the Victoria Harbor (Figure 8). The 3D urban scene shows the Victoria Harbor front overlooking the Hong Kong Island, with landmark buildings highlighted in yellow. The natural topography is shown as a backdrop to offer contrast in the elevation and enhance realism of the display. The procedure started off by erecting buildings over a terrain. These vertical structures were then shaded in different colors to mark their geographic subdivisions (whether located in Kowloon or Hong Kong Island) and unique characteristics (whether or not a landmark building). While Figure 6 is a static manifestation of a screen shot, the GIS platform actually supports an interactive operational setting to maneuver the 3D urban model from any direction, angle, or zoom level. Such flexibilities heighten exploration and review of Urban Design Guidelines from various perspectives, as exemplified in the discussions that follow.

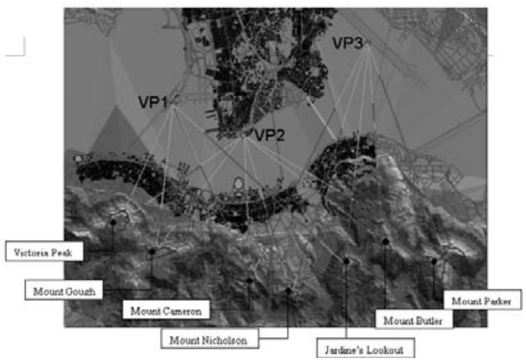


Figure 10. The Line-of-Sight Analyses from Three Vantage Points in Kowloon to Strategic Points Along the Ridgeline of the Hong Kong Island

Procedure 3: Visibility and Viewshed Analyses

Visibility and viewshed analyses are perhaps the most significant functions of GIS modeling in this study. The procedure allows the specification of a vantage point whereupon an examination of its view corridors to the ridgelines as stipulated in the Urban Design Guidelines can be conducted. Figure 9 shows the results of the viewshed analysis from three vantage points located in Kowloon (VP1, VP2, and VP3). The visible areas were derived with the assumption that the observer was 1.6 meters above sea level (i.e., the average height of a person). These visibility results indicate clearly whether the selected vantage points provide sufficient coverage of Hong Kong's scenery at the harbor front, as well as the extent of visual penetration into the inland areas. They also highlight major viewing obstacles from individual vantage points. Alternative vantage points at more strategic locations may emerge from repeated modeling and visibility analyses.

Procedure 4: Line-of-Sight Analysis

The line-of-sight tool permits a test of visibility between a pair of pre-set points representing a viewing position and a target object. This GIS function augments visibility analysis in situations where specific target objects for viewing have been identified. A line is drawn to link the pair of points and visibility between them is not established if one or more obstacles (usually tall buildings)

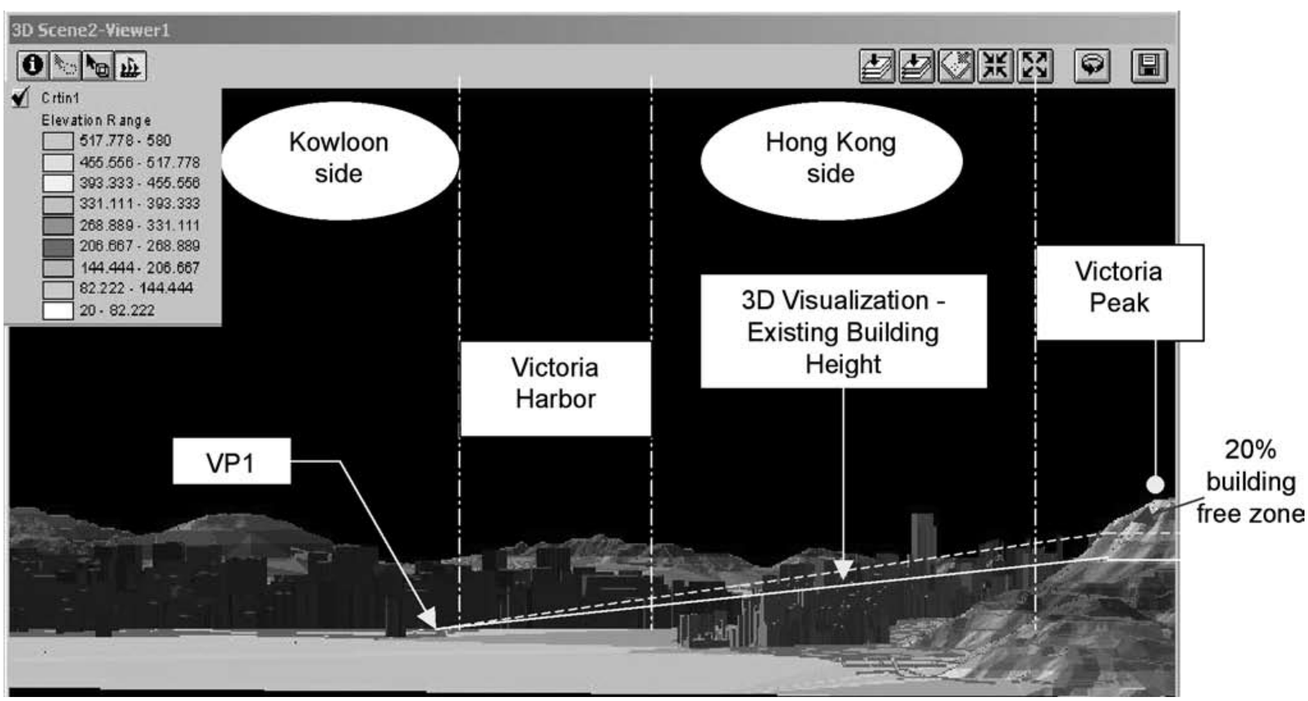


Figure 11. A 3D Visualization of Line-of-Sight Analysis from VP1 to the Victoria Peak

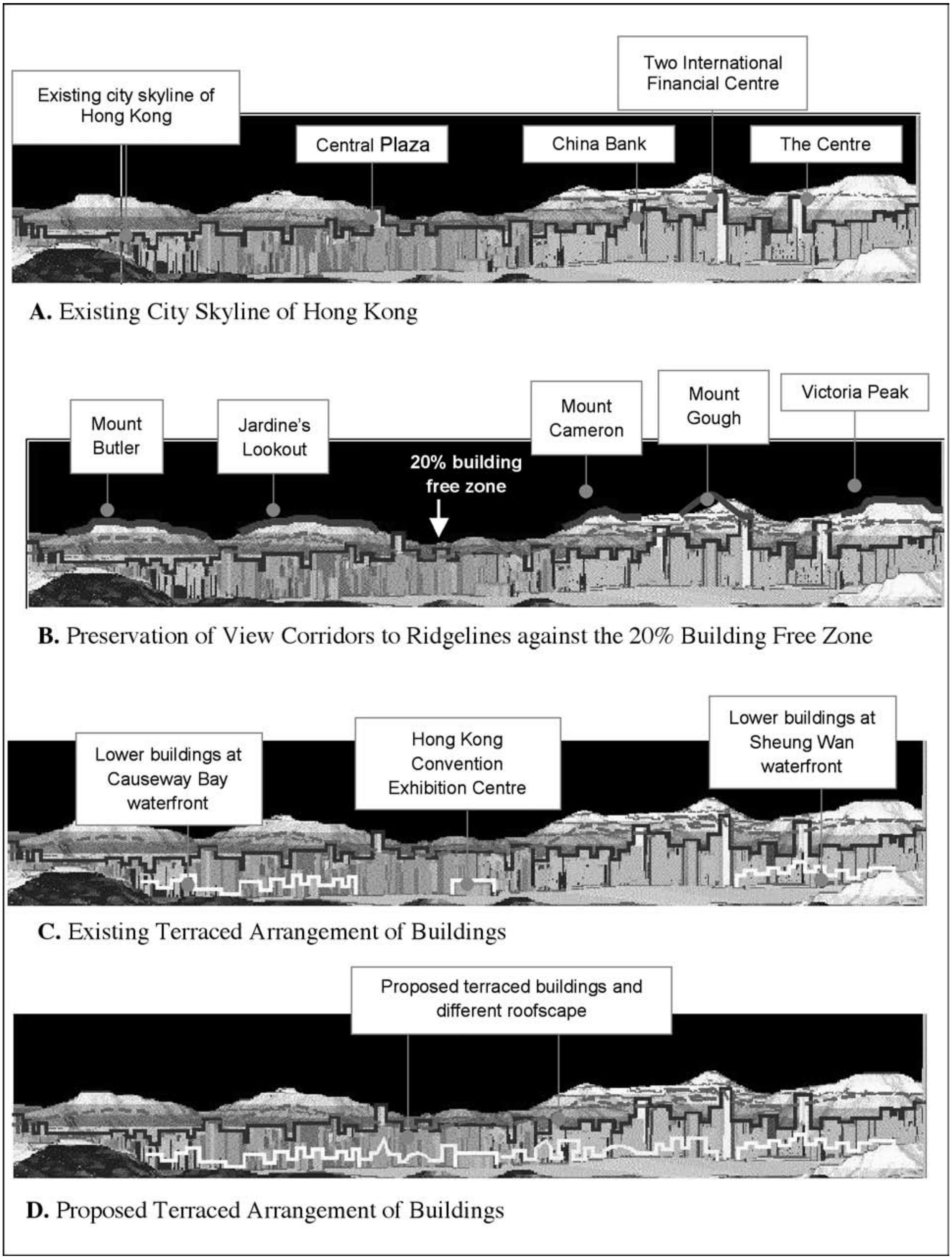


Figure 12. Cross-sectional Representations of the Development of City Skyline at the Hong Kong Island

exist along the line of sight. Figure 10 shows that Mount Parker is not visible to observers at VP2 while Victoria Peak and Mount Cameron are not visible to observers at both VP1 and VP2. However, VP3 maintains an episodic line of sight to Mount Parker, Mount Butler, and Jardine's Lookout.

Figure 11 illustrates with a 3D model the line of sight between VP1 and the Victoria Peak. Given the Urban Design Guidelines as explained in Figure 5, we can identify with some degree of certainty existing buildings that have violated the recommended building heights and infringed upon the 20% building free zone. As new buildings are expected to develop in this area in the future, the line-of-sight analysis is potentially useful in recommending or enforcing more flexible and dynamic building heights. In this way, progressively taller buildings can be staggered to provide more visual stimulus from the waterfront toward the ridgelines. The terraced approach should improve visual penetration into the inland areas to reveal greenery and other heritage artifacts.

Procedure 5: Cross-Sectional Analysis

A cross-sectional display emphasizes depths such that structures/features in the foreground are clearly distinguishable from those at a distance. The 3D model supports cross-sectional drawings of the harbor front to facilitate a perspective view of interacting and counteracting elements (Figure 12).

Figure 12A is a cross-sectional view from the Harbor to ridgelines of the Hong Kong Island. Some of the mega-towers (such as the Central Plaza, China Bank, and the Centre) have been highlighted to contrast their existence against surrounding buildings. It is also evident that building profiles to the left of the Central Plaza project a relatively flat and monotonous roofscape.

Figure 12B highlights existing silhouette of the city along with the line that delineates the 20% building free zone. It is apparent that some of the mega-towers (such as the Central Plaza, China Bank, and the Centre) have obviously intruded upon the 20% building free zone. The figure also illustrates view corridors to Mount Butler, Jardine's Lookout, Mount Cameron, Mount Gough, and the Victoria Peak. These hills that overlook the Victoria harbor are said to broaden people's spatial perception and make the harbor appear perceptually larger than its physical coverage. They also promote the identity of the city by providing "visual cues" to the people. Given their significance in complementing and contributing to vistas of the Harbor, the preservation of these ridgelines should be given unique consideration in the process of skyline development.

Some lower structures along the waterfronts of Sheung Wan, Wan Chai, and Causeway Bay are discernable from Figure 12C. Urban Design Guidelines suggest more variation in building heights to yield a terraced arrangement. It can be seen here that the diversified building heights in the Causeway Bay area does heighten the perception of depths resulting in a higher silhouette complexity, marred only by the monotonous roofscape at the far end. It is also clear that there is room in developing a more spectacular and dynamic skyline of Hong Kong as illustrated in Figure 12D.

Conclusion

This paper has demonstrated that GIS can operationalize recommendations subscribed by the Urban Design Guidelines. For example, the government of Hong Kong has identified seven viewpoints for the preservation of view corridors to important peaks given a strong appeal from the public to heighten protection of views to the ridgelines. Our study has shown that some of the designated viewpoints do not allow a deep penetration with extensive visual scopes because a few excessively tall buildings have blocked or extracted the views.

Urban Design Guidelines of Hong Kong volunteers a systematic approach to the design of its urban skyline. Some recommendations are quantitative in nature, and these can be accommodated readily in a GIS. Specifically, the 3D models constructed with a GIS can aid in the following aspects: (1) to identify violation cases, (2) to assess the preservation of views, and (3) to suggest possible areas of improvement.

The Urban Design Guidelines recommend that buildings should exist in harmony with surrounding natural features such as ridgelines and peaks. Violation cases are discernible through both visual and attribute examinations. The 3D GIS visualization affords viewing perspectives from almost every direction to determine the extent to which a built structure has infringed upon the restricted zones or the combined impact a collection of structures has on the surrounding townscape. The attribute functions can validate and pinpoint structures exceeding the 300 meter threshold in building heights or those suspected of sideway expansion. The Urban Design Guidelines also encourage the preservation of view corridors and breezeways to prominent features along the ridgelines to yield a cityscape of characteristic traits and visual aesthetics. In this regard, GIS endorses the visibility analyses along a given *line of sight* or across the entire *viewshed*. These utility functions make possible an overview of what obstructions there are and which features are visible or hidden from a given vantage point. In line with practices of cities like Manhattan, Shanghai, and London, the Urban Design Guidelines also advocate stepped-like buildings to provide visual set-backs from major parks, waterfronts, or principal roads. GIS allows the plotting of vertical or cross-sectional profiles to suggest indicator lines for controlling building heights that increase gradually from the waterfront to the city's interior. Along with violation cases and considerations in the preservation of views, elements deemed unattractive or undesirable in a townscape should be blacklisted for future replacement by more amenable structures when opportunity arises.

We believe that GIS can be an effective support tool to coordinate control measures for building heights. We further believe that GIS provides a means to engage the Government and the public in fruitful discussions toward the creation of a more spectacular and impressive skyline of Hong Kong. It is noteworthy that many recommendations of the Urban Design Guidelines (such as the introduction of more open space and greenery to the cityscape, massing the building through architectural design, and

the preservation of heritage buildings, etc.) were not examined in this paper. We hope to address these areas in future research. Our initial study has proved that GIS is an enabling technology and a support tool for better decisions and more comprehensive planning.

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Data Collection Techniques for Informal Settlement Upgrades in Cape Town, South Africa

Michael Barry and Heinz Rüther

Abstract: *Informal settlements pose a major challenge for managers and planners of developing world cities. Failure to intervene in a manner that improves residents' quality of life may lead to social and political unrest. Due to continually changing internal social and political environments in these settlements and to frequent changes in the arrangements of shacks, spatial and social data need to be collected more frequently than for conventional development tasks. What are needed are simple, low-cost techniques that preferably involve community members in collecting the data. Palmtop computers, group workshops, and voice recordings incorporated into digital records, digital still and video imagery, and semi-automated feature extraction techniques are methods that have been developed and tested in a number of settlements in Cape Town, South Africa, along with one in Dar-es-Salaam, Tanzania, and that can be used to address these needs.*

Introduction

The burgeoning informal settlements that accompany rapid urbanisation in Africa, Latin America, and Asia constitute a major challenge for land managers, because informal settlements may house 30 to 80 percent of a developing world city's population (UNCHS 1996). Improving the conditions of the urban poor is critical to social and political stability, and there is the potential for urban violence and social unrest as social disparities become more acute (Farvacque-Vitovic' and Godwin 1998).

Managing informal settlements involves, amongst other things, planning and controlling where they are located and how and where they grow; improving the social, economic, and basic health conditions in them; and ensuring that residents in these settlements and neighbouring communities enjoy social justice. Addressing all these objectives requires current, accurate, social, and spatial information, and informal settlements hold certain unique challenges in this respect due to their complexity and frequently changing social conditions. Land tenure security is important in many improvement strategies because it provides the much needed stability for these strategies to succeed. Thus, much of the data collection and information management effort should be directed toward security and equity in the land tenure system.

In this paper we describe a number of techniques to collect social and spatial information. These techniques were developed during projects to upgrade informal settlements in a number of ongoing case studies in Cape Town that started in 1995.

The techniques were developed primarily in studies of the Marconi Beam and Imizamo Yethu ("*through collective struggle*" –Xhosa) settlements in Cape Town. Some of the ideas and techniques were also developed and applied in several other informal settlement upgrade cases in and around Cape Town (e.g., Brown's Farm, Wallacedene, parts of Khayelitsha), and the Manzene informal settlement in Dar-es-Salaam, Tanzania. Two of the techniques were first tested in a rural land reform case in the village of Algeria, some 230 kilmoeters northwest of Cape Town, which is not an informal settlement, because the social and local political environment in the village was far more stable than in the informal settlements. The Algeria village proved to be ideal for first testing ideas in a situation where some of the factors that may exist in informal settlements (e.g. high levels of conflict, continual change) and that may have impeded the experimental processes, were absent.

We begin by describing the historical context of the large number of informal settlements in Cape Town, followed by brief histories of the Marconi Beam and Imizamo Yethu settlements. We then describe a number of general social and political characteristics of informal settlements in southern Africa. These sections demonstrate why social and spatial data need to be collected frequently, especially when major change is occurring in the wider society. Finally, we describe in broad overview various social and spatial data collection techniques that may be useful in situations where informal settlements are to be upgraded.

To distinguish between squatting and informal settlement, as a working definition we have defined *squatters* as illegal occupiers of land and *informal settlers* as people who have some legal recognition of their occupation. In the latter case, for example, an informal settler may be permitted to occupy land until alternative shelter is found for them.

Informal Settlements In Cape Town

Since the early 1970s, Cape Town has been experiencing a significant influx of black Africans, predominantly people whose mother tongue is a Bantu language, from rural areas. Most of these new arrivals are Xhosa speakers who are migrating from the former independent homelands of Transkei and Ciskei in the Eastern Cape, some 1000 kilometers from the city. Nowadays, an estimated 48,000 people move into the city every year (Weaver 2004), and this influx has contributed to the large number of informal settlements in the city, which current estimates put at 164 settlements (Dreyer 2004).

South Africa's informal settlements are unique in some ways, in part due to the country's history of racial segregation, influx control in the cities, and the conflicts that resulted from resistance to these policies. The apartheid government tolerated an influx of black Africans into the cities during an economic boom in the early 1970s, and so squatter settlements started to spring up in periurban areas. However, it harshly repressed influx and the development of squatter settlements during a recession in the latter half of the decade (de Tolley and Nash 1984; Cole 1986). In the 1980s, the government realised that segregationist policies and influx control in the cities were unworkable. Initially, political reforms eased the rigidity of the apartheid system. Permanent land rights for blacks in urban areas were introduced and the pass laws were rescinded in the early 1980s. These reforms became a catalyst for large numbers of people to move from the rural areas into the cities (Lourens et al. 1992; Barry 1999).

The political reforms of the 1980s were paralleled by an escalation in revolutionary activity against the government and by internecine violence between and within revolutionary organisations that lasted to the end of the decade. Revolutionary activity included large-scale stay-a-ways from work, along with rent, service, and consumer boycotts. It also included the murder of black councillors, policemen, and generally any blacks who supposedly cooperated with the government (Liebenberg 1993). The effects of these conflicts influenced the local-level political climate within informal settlements, and housing projects to upgrade these settlements, throughout the 1990s, especially in settlements where many of the residents had been on opposing sides in the conflicts (Barry 1999).

In 1990, major reforms took place as banning orders on revolutionary movements such as the African National Congress (ANC) and the Pan Africanist Congress (PAC) were lifted, and political negotiations commenced. These culminated in the first fully democratic elections in 1994, when the ANC came to power. However, between 1990 and 1994, the country continued to experience internal conflict as a result of tensions between different political factions. There were also violent attempts to undermine the negotiation process.

In 1994, at the time of South Africa's first non-racial democratic elections, the newly elected government was forced to address a major housing crisis to ensure social and political stability prevailed during the country's post-apartheid transformation. The *Housing White Paper* of 1994 revealed that an estimated 1.06 million households, comprising 7.7 million people, lived in informal settlements. Coupled to this, an estimated 720,000 site-and-service dwellings required upgrading, and 450,000 people lived in various, often inappropriate, forms of hostel accommodation (Republic of South Africa 1994).

More than a million houses have been built since then, and more than a million are still needed to address the housing shortage. However, what is important during such far-reaching change is that deserving individuals receive houses, that the land tenure system to support these housing developments is appropriate, and that the administrative systems to support the tenure system, such as cadastral surveying and land registration, are appropriate and actually used by those who they are supposed to benefit.

Amidst this tense, but optimistic, atmosphere, the authors initiated a series of studies into land tenure, cadastral systems, and the upgrading of informal settlements. The Marconi Beam and Imizamo Yethu settlements, which have been accessible to researchers, have been studied comprehensively as case studies since the mid-1990s. Other settlements could not be studied comprehensively. For example, in the Brown's Farm settlement, a political group prevented the first author from conducting research that involved interviewing residents.

Marconi Beam

Marconi Beam was an informal settlement that developed on land that was owned by the telecommunications corporation in a middle-class suburb of Cape Town. Squatting in Marconi Beam dates back to the 1970s, but the number of shacks and residents mushroomed during the early 1990s.

In addition to the macro-level factors described earlier that contributed to the increasing number of informal settlers in Cape Town, settlement of Marconi Beam was also linked to a strike at the adjacent Milnerton Race Course in 1990, which employed a number of Xhosa speakers as grooms. During the strike, some 200 grooms moved into shacks on the Marconi Beam site. The local authority, the Milnerton municipality, attempted to evict the squatters, and succeeded in demolishing some 20 to 30 shacks before the squatters obtained a court order preventing the demolition. The delicate political negotiations in the early 1990s rendered it unwise for the authorities to pursue further action. Saff (1996) argues that further intervention would have had political and racial ramifications, so the settlement's rapid growth was allowed to continue unchecked. Additional squatters in Marconi Beam arrived directly from the Eastern Cape, and a number also moved there to escape violence in squatter settlements in other areas of Cape Town.

Negotiations between the squatters, the municipality, and the landowner followed, and the informal settlement was limited to an 8.02-hectare fenced in area of the parcel. In November 1990, this area was declared a transit area in terms of the *Prevention of Illegal Squatting Act* 52 of 1951 S6(1), which allowed the residents to stay on the site while accommodation was found elsewhere (Marconi Beam Civic Association et al. 1993). This also provided the existing residents with a modicum of tenure security (Barry 1999).

Following the negotiations between external agents and the informal settlement leadership, the transit site was intended to hold between 400 and 480 shacks (Saff 1996). However, by June 1993, there were 834 households and 2,835 people living in Marconi (Urban Foundation et al. 1993). By December 1996, there were 1345 shacks on site (Barry 1999).

By the end of 2000, after protracted negotiations, Marconi Beam residents were housed in formal housing developments in Joe Slovo Park and another nearby settlement, du Noon. The process was supported by a government housing subsidy that provides

a one-time-only support to acquire ownership of a permanent dwelling. Beneficiaries received a subsidy to pay for the land and infrastructure and to build a basic brick-and-mortar home.

Imizamo Yethu

The Imizamo Yethu informal settlement is situated in the Hout Bay Valley. Squatting occurred sporadically in the valley, in pockets, for more than 50 years before the Imizamo Yethu settlement was created. By 1990, more than 2000 people lived in five informal settlements in the area. Collective action by squatters to obtain legal property rights, and the reaction to the informal settlements from existing property owners in Hout Bay, forced the authorities to make formal property available for the squatters. Forestry land at Imizamo Yethu was made available in late 1990, and 429 sites were occupied in March and April 1991 (Gawith and Sowman 1992). These were registered informal settlers, as opposed to illegal squatters. The site was regarded as a transit area while the formal layout in the same vicinity was being planned. At the time, in 1991, municipal planners envisaged 700 parcels being created for a total of 2,400 people. However, as with Marconi Beam, the authorities could not control further influx, and by May 1992 there was pressure from the community for more land as squatters and new arrivals were laying claim to the buffer zones around the settlement (Nathan and Spindler 1997). By June 1997, an estimated 5,000 people occupied the settlement and surrounding greenbelt areas (Barry 1999). Currently, there are approximately 7,000 people in the settlement, including shacks in backyards and in the greenbelt buffering the settlement. A number of these early settlers are now housed in 457 formal houses that were planned in the early 1990s.

These ongoing influxes have led to conflict between the Imizamo Yethu residents and surrounding residents, conflict within community groupings in Imizamo Yethu, conflict between the Imizamo Yethu residents and the authorities, and conflict between different authorities (e.g., provincial and municipal) on how to manage the situation. For example, in July 2002, a court order was granted allowing for the Cape Town municipality to evict squatters who had recently arrived in the settlement. However, a significant sector of the community mounted the "We will not be moved" campaign to oppose this. The evictions, along with the demolition of 189 shacks, were planned for June 2003, but the Cape Town city manager cancelled these actions on the basis that this constituted inhumane treatment of the residents (van Zilla and Ajam 2003).

The situation has also led to conflict between two opposing civic organisations in the settlement itself. The Sinethemba Civic Association supported the surrounding middle-class residents' ratepayers association in exerting pressure on the city to evict the newcomers. In March 2004, the Sinethemba leader was physically threatened and his house burned down by a mob. In turn, he accused the leadership of the South African National Civic Organisation (SANCO) in Imizamo Yethu of being behind the incident (Hartley 2004).

Informal Settlement Characteristics

The Marconi Beam and Imizamo Yethu cases illustrate that informal settlements are complex, dynamic social systems that, in many cases, experience continual change. In occupying land informally, residents are often prepared to flout the law in the hope of improving their lives. Accordingly, there are a few general characteristics that an external agent should be aware of prior to intervening in a particular settlement.

In general, in an informal settlement, the internal social and political dynamics tend to be characterised by both solidarity and schism. 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. Thus, a community may act in solidarity when negotiating with the authorities or when invading land. However, while solidarity may prevail in dealings with the external agents, schisms occur within community groupings in the implementation of deals made with the authorities and in the day-to-day operation of a settlement (Fourie 1993; Barry and Mayson 2000).

Schism occurs as different groups and individuals in a settlement compete for power, land, and resources. Solidarity may be critical in pulling off a deal with external agents or perhaps pressuring government to do something that will benefit a settlement. However, once a deal is made, entrepreneurially-minded individuals may strive to maximise their own benefits. In so doing, they may attempt to manipulate internal settlement rules and agreements that have been made with outside agencies. The result is that the de facto tenure rules and practices tend to change continually, unless a very powerful faction controls the settlement (Davies and Fourie 1998; Barry and Mayson 2000).

The quality of leadership and the power wielded by community leaders is an important factor in upgrading projects. Leadership coalitions are often comprised of disparate groups. In our observations, a small group outside this clique may wield substantial power and so disrupt and overturn long-standing agreements with the authorities. Such infighting hampers attempts at reform and delays processes that are intended to improve conditions in a settlement (Barry 1999). In addition, leaders may play gatekeeper between the community and outside agents, and filter information (Cross 1999).

The above phenomena were observed in both Marconi Beam and Imizamo Yethu. For example, in spite of agreements with external agents to limit the number of people in both of these settlements, the numbers of people in the settlements continued to grow. This, in turn, caused conflict between factions within the settlements. The burning down of the Sinathemba Civic Association leader's house in Imizamo Yethu in 2004 is an extreme example of internal schism.

Thus, from the perspective of an external agent, intervening in informal settlements may be an extremely difficult task. With community leaders perhaps acting as gatekeepers, violence and intimidation often prevailing in internal conflicts, and relations with the authorities tending to be confrontational, it is difficult for

formal land administration institutions to reach agreements that can be implemented, at least not within a specified time frame.

Owing to the complexity of these situations, many upgrading projects do not achieve the results desired by external agents. Moreover, there are no easy solutions and often informal settlements involve situations that can, at best, only be alleviated or improved incrementally in any single initiative. In many cases, it is naïve to think that a project can be set up that will "solve the problem" on time and within a defined budget. While recognising that such situations can at best be alleviated rather than solved, both social and spatial information are critical in assessing a situation and initiating appropriate strategies for improvement.

In terms of data collection and management, an initial census and a map of the settlement followed by frequent, cheap, rapid data collection is required to ensure that management information is accurate and current. We now describe some of the data collection and processing techniques that we used in Cape Town's informal settlements.

Social Data Collection Techniques

The legal integrity of a system of enforceable agreements requires that official land tenure records be held to be legitimate by all parties concerned. Otherwise, the record, and indeed the system, has little value as a land administration resource. One way of cultivating such legitimacy is to make the processes of data acquisition and information management participatory and transparent. Notwithstanding the tensions that may exist in a community, community members should, ideally, participate in the definition of the information to be collected, in collecting the data, in collating the information, and in disseminating it. This is only likely to happen if the purpose and processes of the data collection exercise are generally accepted as legitimate. To further enhance the legitimacy of the information, it is also important that community members are able to understand it. This may seem an obvious criterion, but it is all the more important in communities where many people (often the most vulnerable segments of the population) are not fluent in the languages commonly used by officials.

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 are required for an initial assessment. 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 systems to support the tenure system, such as land registration and cadastral surveying, are likely to be used.

Palmtop Computers

Conventionally, census-type socio-economic data are collected using paper questionnaires. This is time-consuming and expensive. Information surveys often require skilled data collectors and the data has to be transcribed and entered into a database manually. As mentioned earlier, in informal settlements, these data need to be updated frequently to keep pace with continual changes in a settlement.

Cheap, rapid collection methods that employ members of a community are ideal for this purpose. Given the tensions and the various agendas that may exist in an informal settlement, residents might be inclined to give false information to an outsider. Because of community members' intimate knowledge of their own settlement, unless the data collectors themselves choose to provide false information, a high level of accuracy should be ensured (e.g., data incorporating verbal responses and statistics relating to the number of people living in a house). Furthermore, collecting data on a palmtop computer reduces the time required to transfer data to a central repository, and it simplifies the verification of previously collected data in the field. The challenge is whether people with limited education are able to use the technology effectively.

Palmtop computers were tested in two different settings. Techniques were first tested in a stable environment and then were further tested and developed in a more volatile case. The first case, a land reform project, was in the rural village of Algeria. In terms of the discussion above, data does not have to be collected frequently in Algeria—the case was merely used to experiment with a range of data collection techniques. For the second case, Imizamo Yethu, data relating to land occupation had to be collected frequently.

In both cases, a number of residents volunteered to collect the data, and they were provided a palmtop computer equipped with a global positioning system (GPS) module to supply position data. Icons were developed to represent different data types. Three people in Algeria and eight individuals in Imizamo Yethu collected data using the palmtop computer.

The icon-based data collection study was inspired by the *Cybertracker* project, which developed a system whereby game trackers, who may not be able to read or write, used palmtop computers interfaced with a handheld 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 (Cybertracker 2004).

The settlement studies adapted the *Cybertracker* data collection methods and software and hardware systems to collecting census-type socio-economic data. In contrast to animal behaviour observations, socio-economic data collection does require a certain level of literacy, because much of the data is textual. In Algeria, the three data collectors had two to three years of high school education, while in Imizamo Yethu, the eight data collectors had an average of four years of high school (Barodien and Barry 2004).

The data collectors designed icons to represent particular questions. As a backup they also stored the questions in text form in the palmtop 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 and Barry 2004).

All but one of the eleven data collectors proved to be competent in using the palmtop computer after a brief 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 Algeria, all three subjects reverted to using the textual expression of the questions, and they recorded the responses in textual format. In Imizamo Yethu, the eight subjects used a mixture of icons and text to pose questions and record the responses (Barodien and Barry 2004).

The study suggests that palmtop computers are, in principle, feasible for socio-economic data acquisition. Data collection in text form can be carried out successfully by members of a community provided they have a level of education that equips them for basic computer tasks. However, the use of icons to represent questions and answers was found to be of limited suitability if employing people from a particular community to collect the data is a major objective. If someone collects data as a full-time occupation, then using icons to represent questions and answers will probably be more efficient in the field. However, this defeats the objective of eliciting local community participation in land information system development.

We found that employing literate members of a community to collect and update socio-economic data, using current technology, makes it possible to maintain the currency of the population register in the settlement.

Photographs and Video Imagery

In the informal settlement studies in Cape Town, disputes arose among community members over who should or should not be assigned land rights. It was found that the people who initially occupied land in a settlement tended to be the first ones in the queue when government-subsidised houses were allocated. However, in many cases, once there were signs that houses might be allocated to people in a settlement, this became a catalyst for a rapid influx of people into the settlement, presumably in the hope of also benefiting from the housing program. In addition, the official records that were intended to reflect transactions in land rights were often inaccurate shortly after the initial adjudication, largely due to unrecorded transactions in land rights, which led to further disputes when the time came to register land. In Marconi Beam, even though the community maintained a record of transactions in a book kept in an administrative office in the settlement, for various reasons, many transactions were not recorded. Moreover, at the time that people were being moved into formal houses in Joe Slovo Park, a faction challenged the legitimacy of this set of records and intimidated the administrative staff to the extent that the administration office had to close, disrupting the formal delivery of houses (Barry 1999).

Subsequently, based on the experiences in a similar settlement to Marconi Beam, the project managers took photographs

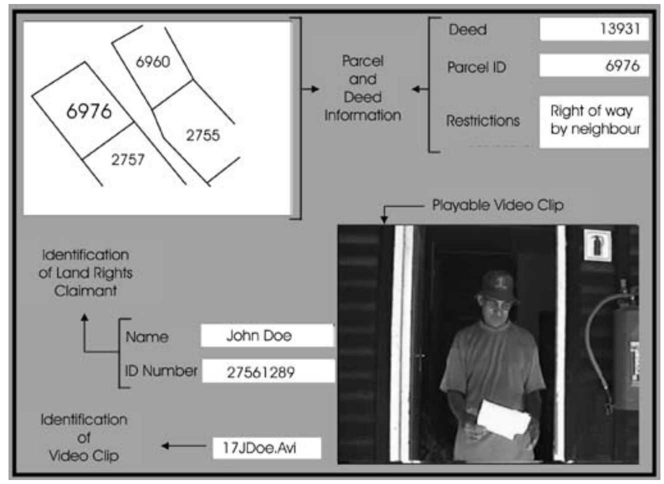

Figure 1. On-screen Title Certificate

of every person in a household who had met the requirements for a grant of 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 leadership and the rules pertaining to that agreement were reduced, arguably as a result of the publicity and transparency in managing the tenure system.

In spite of this, a group of people attempted to disrupt the delivery process, arriving in the settlement after the adjudication had been completed. Most of this group lodged with families who were expecting to be granted a house. It was in the interests of the group of lodgers to disrupt, and hopefully manipulate, the land delivery process in order to acquire ownership of a house themselves. However, arguably because the information was updated continually and it was publicly available, in the end this group could not raise a credible claim.

Another option first tested in the village of Algeria and then tested in Imizamo Yethu was the use of video imagery to record information relating to land rights. Video clips were included in a relational database in which an on-screen title certificate was created, enabling 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 geographic information system (GIS) used to manage the transition to permanent land rights for the community.

In the initial development and testing of the video imagery system in the Algeria case, people claiming rights in land were recorded on video while they read an affidavit in front of their house, which noted the subject of their claim of interest in land. The contents of this affidavit were determined by the people

Figure 2. Group Discussions in an Informal Settlement

themselves. This proved to be unsatisfactory because people were unsure what should be included in such an affidavit. Some affidavits included superfluous information with the result that they were too long and required a large amount of disk storage space. In addition, a number of people had not prepared the affidavit when they were due to be filmed, hence delaying the recording process (Roux and Barry 2001).

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

The system is currently being redeveloped for the application of multi-media land record systems in real situations because technology has improved so that storing and retrieving large video files is now feasible. The initial study and prototyping showed that incorporating video evidence in a land record system (or, if appropriate, a land registration system) has potential in situations where conflict exists over land rights, provided that the use of video itself is regarded as legitimate by the members of a community. An adjudication record that incorporates video clips should be more readily accepted by people in informal settlements than a record based solely 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, filming in the street tends to attract onlookers and family members, thus creating a large population of witnesses to the transaction (Roux and Barry 2001).

Land Tenure, Boundaries, and Registration

Issues that warrant further exploration include the desired system of tenure, and predictions and factors concerning the actual adoption and use of boundaries and registration by settlement residents. 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. Significant questions relating to land registration include the usefulness and likelihood of the use of the registration system to record transactions in a secondary land market or when dealing with deceased estates. Boundary questions should be explored if a particular boundary type (e.g., fixed, general, or vaguely defined) is likely to be adhered to.

These questions are best addressed through interviews with influential people in the settlement, that is, a representative sample of people who will make decisions about their land rights in households in the settlement, and agents outside of a settlement (e.g., officials). 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 ascertain the beliefs underlying the land tenure system. However, beliefs on their own 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 control over their actions, what should be measured is their intention to perform or not to perform a particular action. If it is not possible to measure intentions, it is best to attempt to measure attitudes toward performing a particular action (Ajzen 1991). For example, a sample of residents in Marconi Beam and Imizamo Yethu demonstrated strong negative attitudes to the possibility of a neighbour encroaching over their legal boundary. Moreover, they expressed an intention to evict the encroacher (Barry 2005).

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, some of which were held in the streets and public areas (Figure 2) and others in private. In addition, some groups were composed of men only, others of women only, and others included both men and women. To reduce the likelihood of particular opinions being clustered according to particular areas in a settlement, a grid was superimposed on an aerial photograph of a settlement and at least one group discussion was held in each grid cell. In the public group discussions held in the streets, group participants could find themselves challenged as passersby would stop to observe the process and often joined in the discussion.

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, and scenarios were created to elicit statements of intention to perform or not to 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 expecting to be granted to them. What action did they intend to take in such a

case? In this way, a variety of responses was 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 regarding cadastral systems, garnered from verbal responses, needs 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 subsequently moved into formal housing.

There are a number of reasons why predictions about cadastral system usage based solely on interview data may prove to be inaccurate. First, people may choose to provide a response to a question that they know does not accord with their actual beliefs, attitudes, or intentions. Direct verbal statements of sampled members of the public may not provide a reasonable guide to their likely future action (Wilkins 1986). Second, 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" answer in an interview or group discussion. Third, land tenure systems are not static, particularly in volatile situations, such as in the informal settlements that were studied. 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 delivery may differ from the response that they might give at a later date. An interview or group session provides a snapshot of a situation. Fourth, what Ajzen (1991) refers to as "control factors" may prevent people from carrying out their intentions.

Control factors fall into two distinct categories. First, a lack of resources may prohibit a person from performing an intended action. For example, people may say that they intend to use the land registration system to transfer land but, when the time comes for the transaction to be effected, they may find that they cannot afford the registration costs. Consequently, they may transfer the land informally and the transaction may not be legally recognised. Second, power factors, such as the actions of a squatter lord or a similarly powerful individual or group, may prevent the performance of an intended action.

Spatial Data

Spatial information and GIS provide the means to measure some of the discrepancies observed between predicted behaviour and actual behaviour. Spatial information is critical for making informed decisions about community growth projections and infrastructure planning. GIS can integrate the different information types for administration and analysis.

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

The rationale for more sophisticated techniques is best illustrated in the case of Marconi Beam. As mentioned above, the authorities and the private landowner reached an agreement with the community leadership to move the residents to a new development. Based on a census survey in 1993, 750 households would be moved to Joe Slovo Park and the shacks demolished. Within a few months of this agreement being struck, there were a total of 1,345 shacks 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. Given the political climate of the time, the landowner could not evict the additional householders, and he 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, 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 polynomial 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 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 20 years (Nicolin and Gabler 1987; Huertas and Nevatia 1988; Liow and Pavlidis 1990; Haala and Hahn 1995; Henricsson and Baltsavias 1997; 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, however, informal settlements are not built in structured patterns. Shacks are irregular in shape and height, and roof materials vary in structure and colour. Moreover, different materials are often used to waterproof and cover the same roof.

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 (2002). In this method, off-the-shelf software is combined with code developed for the specific application.

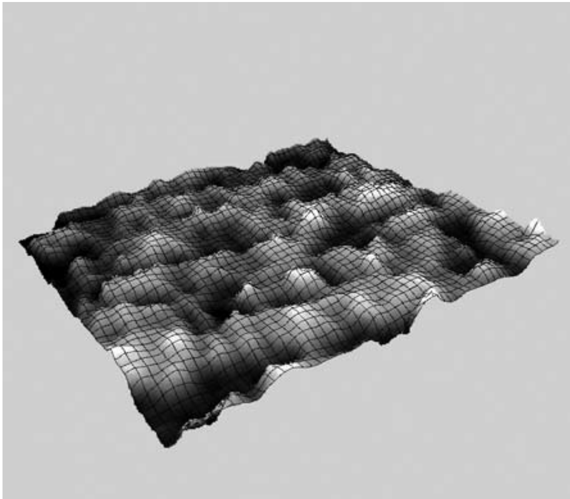

Figure 3. DSM of Marconi Beam with Shack Blobs

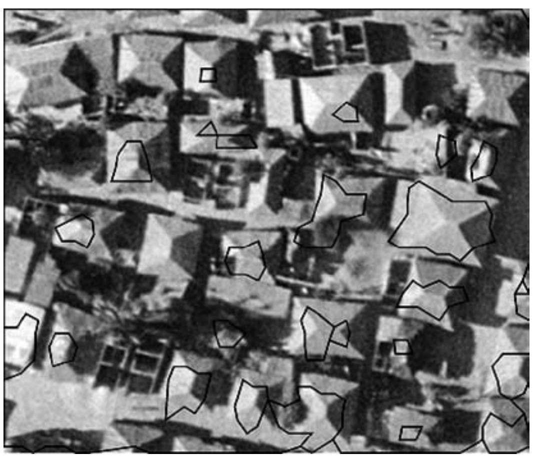

Figure 4. Intermediate Processing Stage Showing Detected Blob Edges

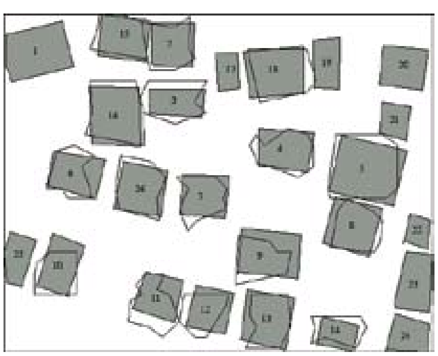

Figure 5. Intermediate and Final Shack Outlines

Two test cases, one in Marconi Beam, Cape Town, and one in Manzene, Dar-es-Salaam, were investigated. The Manzene images were scanned from conventional aerial photographs of relatively low photographic quality and had to be enhanced using the image pre-processing algorithm known as the 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 (DSMs) (Figure 3) and orthoimages 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 (Figure 4). This stage is followed by the generation of 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 that segments the image into shack/ground sections by global height thresholding of the DSM supported by the DTM (Figure 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 feature 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 the 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. Ideally, during slithering, the optimal delineation of buildings as defined by contours is attained.

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

Concluding Remarks

We have presented a number of data collection techniques that were used in the management of informal settlements upgrades, some of which involved participation by members of a particular community. As the general discussion on informal settlements indicates, negotiating this participation is often a major task in itself.

Globally, the management of informal settlements poses one of the most serious development challenges for the next 20 years, and increasing the level of land tenure security is a key factor in improving the residents' quality of life. Collecting relevant, current, and accurate social and spatial data in support of land tenure security and intervention decisions pose unique challenges. Due to the rapidly changing, and at times violent, social dynamics

that often characterise informal settlements, social and spatial data need to be collected frequently, at low cost, and, where possible, in a participatory manner. The above techniques and processes provide a foundation for developing and applying data collection and management methods that may be suitable for a particular situation.

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Improving the Design and Implementation of Beach Setbacks in Caribbean Small Islands

Edsel B. Daniel and Mark D. Abkowitz

Abstract: *Beach erosion presents a hazard to coastal tourism facilities, which provide the main economic thrust for most Caribbean Small Islands. Traditionally, strategies such as seawall and beach nourishment have been used to address this problem. However, these strategies tend to be very expensive and serve as short-term solutions. More recently, beach setbacks have been widely adopted as an effective long-term approach to addressing the impacts of beach erosion. Research has been directed at developing a GIS-based beach analysis and management system (BAMS) that has tools to assist coastal managers and planners with managing coastal resources and hazards. This paper presents and discusses the results of the third phase of BAMS development, which focuses on developing prototype GIS tools that improve the design and implementation of individual beach setbacks in Caribbean Small Islands. The Southeast Peninsula of St. Kitts is used as a case study to develop these tools and to demonstrate their functionality. Also discussed is a framework for evaluating beach setback and how these setback tools can be applied.*

Introduction

Caribbean Small Islands,1 like most developing coastal regions, continue to concentrate their settlements and tourism activities along the coastline. Unfortunately, these areas are prone to natural hazards such as beach erosion, storm wave attacks, and coastal flooding. These islands have adopted the integrated coastal zone management (ICZM) approach to address such concerns, particularly to minimize the impacts due to beach erosion. Seawalls, beach nourishment, and setbacks are strategies often used to address this problem, with the use of beach setbacks emerging as the preferred approach. The drawback, however, is that in most Caribbean Small Islands (e.g., Nevis, Anguilla, St. Kitts), setback distances have not traditionally been based on any scientific foundation, for example, long-term erosion trends and the influence of events such as storms and sea level rise.

The development of a geographic information systems (GIS)-based beach analysis and management system (BAMS) has enabled the use of existing coastal data and analysis techniques for implementing a variety of ICZM tools in Caribbean Small Islands. This paper documents the third phase of BAMS development, which focused on developing tools for designing and analyzing beach setbacks. The method used for improving setback calculations is discussed. An integral part of this method is the use of existing erosion modeling techniques to estimate short-term beach changes due to episodic events such as storms. A sample beach setback calculation is also presented. Further discussion is also presented on a framework for evaluating setbacks that will be considered as the foundation for future BAMS tools.

Beach Analysis And Management System Overview

BAMS is a GIS-based decision support system developed as part of a research effort to improve existing ICZM tools and expand the results from a coastal erosion hazard assessment that was completed as part of the Post Georges Disaster Mitigation Project for St. Kitts and Nevis (<www.oas.org/pgdm>). It was designed for the management of coastal resources and beach erosion hazards. The Southeast Peninsula (SEP) was chosen as a case study area for developing and demonstrating system tools and functionality. The following sections briefly describe the case study area and the BAMS tools developed in earlier phases.

Case Study Area: The Southeast Peninsula, St. Kitts

The SEP is a 4,000-acre region that constitutes almost 10% of the area on the island of St. Kitts (Figure 1). It was created as a result of volcanic action, originally giving rise to a series of islands that, through sand accretion and marine deposits, were eventually joined. These natural processes have created diverse characteristics such as beaches, steep hills, mangroves, coral reefs, sand dunes, and salt ponds. The SEP was made accessible by a new road, which was opened in 1990. While presently the SEP is relatively undeveloped, it is expected to experience significant

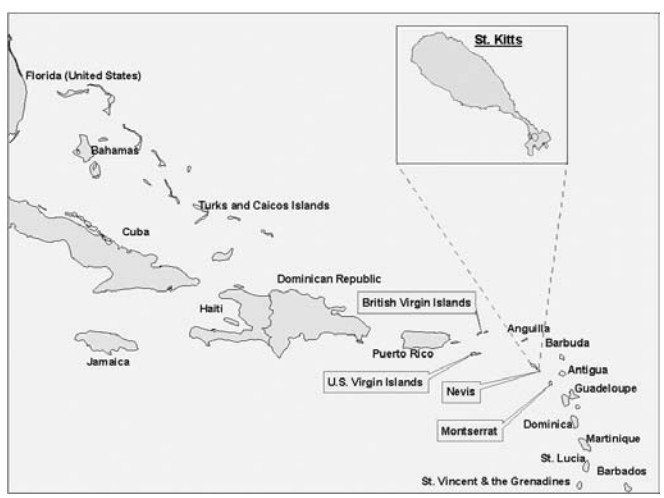

Figure 1. St. Kitts—Located in Eastern Caribbean

Table 1. South East Peninsula Physiographic Area

1. **Sir Timothy's Hill**. This 500 feet (183-meter) high hill separates the SEP from the Frigate Bay area. Steep slopes and thin soil cover present a constraint to any major development.
2. **Friar's Bay Area**. The main features of this area include two beaches on the Caribbean (2A) and Atlantic (2B) Sides, a mangrove fringed Friar's Bay Salt pond (2C) and a sand dune (2D) located along the North Friar's Bay beach.
3. **The Isthmus Area**. This area is a narrow strip of land with steep slopes, which present constraints to major development. The only area along here that has any real potential for major development would be the Canoe Bay area (3A) with its moderate slopes.
4. **Salt Pond Hill**. This hill stands 850 feet (268 meters) high with steep slopes. This area, which is covered with thorn shrub and mature stands of forest, will probably remain in its present form.
5. **Great Salt Pond (5A), Little Salt Pond and Sand Bank Bay (5B)**. This area consists of ecological communities including mangrove forest, Caribbean and a dry forest, major sand dune. The area is considered to possess the greatest potential for development on the SEP.
6. **Major's Bay Area**. This area includes the Major's Bay Bluff, the Majors Bay beach, the Major's Bay Salt pond, and the lowlands stretching to Great Salt pond between Major's Bay Bluff and the Nag's Head area.
7. **Banana Bay (7A), Cockleshell Bay (7B) and Mosquito Bay (7C).** This area consists of a complex of three bays, two dunes, and one salt pond. Both dunes run along Cockleshell Bay and Mosquito Bay beaches.
8. **St. Anthony's Peak**. This hill stands at 1,000 feet and dominates the southern end of the SEP. The steep slopes of this hill also represent constraints for major development.
9. **Nag's Head Area**. This area has been identified as a principal nesting area for many birds (mainly Brown Pelicans and Great Frigate birds). Nag's Head, even though it has steep slopes, still has potential for development on the top area that forms a plateau.
10. **Little Salt Pond (10A) and White House Bay (10B).** This area consists of two bays (White House Bay and Ballast Bay) and one salt pond.

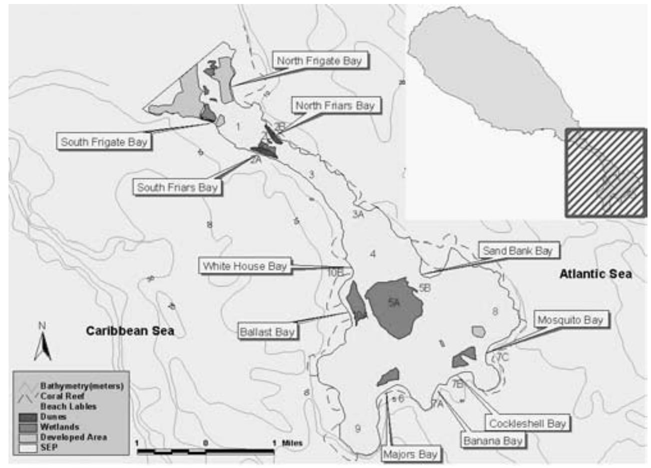

Figure 2. Location of the Southeast Peninsula Area, St. Kitts

tourism growth in the near future.

Field (1991) identifies ten physiographic areas on the SEP. These are briefly described in Table 1 and shown in Figures 2 and 3. Beaches are generally categorized as Caribbean and Atlantic based on the obvious naming of the corresponding seas. Normally, Atlantic beaches experience waves of higher energy relative to Caribbean beaches; however, due to the SEP orientation, four beaches on the southeast end fall between both categories. For convenience, these beaches are categorized as Channel beaches because they face the channel separating St. Kitts and the neighboring island of Nevis.

Under the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Coast and Beach Stability in the Lesser Antilles (COSALC) project, 11 Caribbean Small Islands2 are able to survey and profile their beaches. Appendix I outlines the survey method used. Beach width and cross-sectional area data are extracted from beach profiles. Since 1991, 11 SEP beaches have been monitored on a quarterly basis, although during the first two years of SEP monitoring (1991–1993) beaches were surveyed monthly. COSALC beaches were selected because of the expected impacts from proposed coastal developments and/or severe erosion observed in the past. SEP beach characteristics are shown in Table 2.

BAMS Components

BAMS was developed with ArcView 3.2 GIS software under three phases. The main application components developed under these phases are Beach Analysis, Predict Episodic Beach Changes, and Setback Analysis.

The Beach Analysis component consists of tools for displaying coastal data layers, analyzing beach erosion data, and disseminating this information on a stand-alone system and via the Internet. The available GIS layers are listed in Table 3 and the system interface is shown in Figure 4. Options are available to integrate beach profile data and link it with the corresponding COSALC reference sites. Routines are available to calculate long-

Table 2. Southeast Peninsula Beach Characteristics

Beach	Mean Annual Beach Change Rate: Erosion (-) /Accretion(+) [meters/year]	Average Beach Slope (b)- [Degrees]	Tan (b)	Beach/Dune Retreat for Cat 4 Storm [meters]	Dune Toe Elevation (TD) [meters]	Annual Maximum Beach Width Change During Storm Events [meters]	
						Mean (μ)	Std. Dev. (σ) [LS2]
North Frigate Bay	0.73	6.34	0.111	—	0	6.60	4.52
North Friars Bay	-1.88	7.00	0.122	21.52	3.11	19.35	11.58
Sand Bank Bay	-2.88	3.42	0.059	10	5.15	8.28	4.10
Mosquito Bay	-0.78	6.50	0.114	4.78	2.84	6.62	3.20
Cockleshell Bay	-0.05	5.78	0.101	12.2	2.16	1.91	2.35
Banana Bay	-0.53	9.92	0.174	8.22	1.96	3.06	1.10
Majors Bay	-1.02	10.08	0.177	15.45	0.66	2.70	2.48
Ballast Bay	0.09	10.17	0.179	2.04	3.02	1.72	1.20
Whitehouse Bay	0.36	9.33	0.164	2.00	3.06	1.93	1.20
South Friars Bay	-1.77	11.67	0.206	19.09	0	3.60	3.41
South Frigate Bay	-0.56	9.57	0.168	—	0	1.92	1.01
Source: Extracted from beach width data change (1992–2001) provided from the Department of Environment, Ministry of Health and Environment, St. Kitts.							

Figure 3. Aerial Photo of the Southeast Peninsula Area (Photo by Aerofoto, www.aerofoto.com)

Table 3. Southeast Peninsula GIS Layers

Format	Layers	Feature Type
Shapefiles	Sediment Rate Monitoring Sites	Point
"	COSALC Monitoring Sites	Point
"	Coastline	Line
"	Contours	Line
"	Beaches	Line
"	Roads	Line
"	Coral Reefs	Line
"	Bathymetry	Line
"	Wetlands	Polygon
"	Dunes	Polygon
"	Developed Areas	Polygon
"	SEP Area	Polygon
Source: Matenet 2000 and Opadeyi 2000		

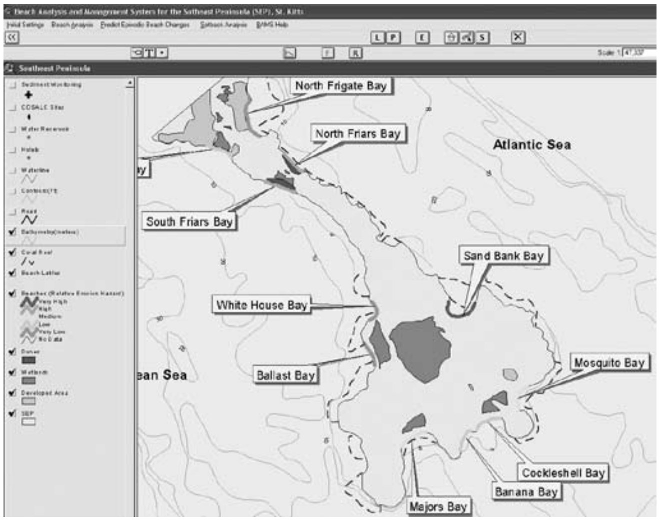

Figure 4. Beach Analysis Management System Interface

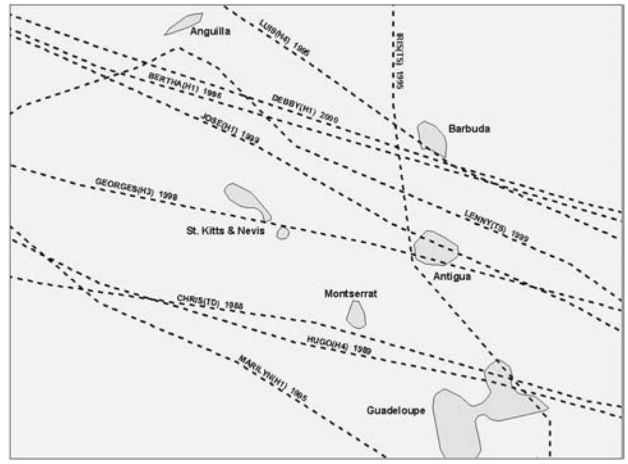

Figure 5. Tracks of Atlantic Storm for St. Kitts and Nevis during 1988–2002. Source: NOAA, http://hurricane.csc.noaa.gov/hurricanes/viewer.htm

term beach change rates and sand volume changes for individual beaches. This allows the user to investigate various trends between different time periods, as well as to identify erosion hot spots.

The Predicting Episodic Beach Changes component consists of tools for predicting beach erosion during storm events and for calculating erosion damage probabilities. Two options for erosion models are available: the geometric model and the extreme value distribution model. For more details on both components, see Daniel and Abkowitz (2003a, b). The remainder of this paper discusses the development of the Setback Analysis component.

Why Consider Beach Setbacks?

Beach erosion takes place when sediment is removed from beaches at a rate that exceeds its replacement. The removal of sediment is driven primarily by waves and currents, sea-level rise, and sand deficiencies. The most dramatic erosion of shorelines in the Caribbean occurs during storms when high-energy waves are prevalent and their eroding effects are greatly increased. Every year, storms affect the coastlines of the Caribbean islands. Figure 5 shows the historical path of Atlantic storms that have impacted St. Kitts and Nevis over the past 20 years.

Figure 6 shows how a typical beach profile changes during a storm. After the passage of Hurricane Luis in 1995, it was estimated that the average beach size decreased by 28% on seven Caribbean islands, although there was considerable recovery after the hurricane (Cambers 1998).

In the past, a number of strategies for addressing beach erosion have been effective to some degree in coastal countries. As shown in Table 4, these strategies are categorized as “Hard” and “Soft” engineering solutions (Hayes 1985). “Hard” engineering solutions are usually permanent structures built to reflect or dissipate energy from incoming waves. “Soft” engineering solutions do not involve any hard structures.

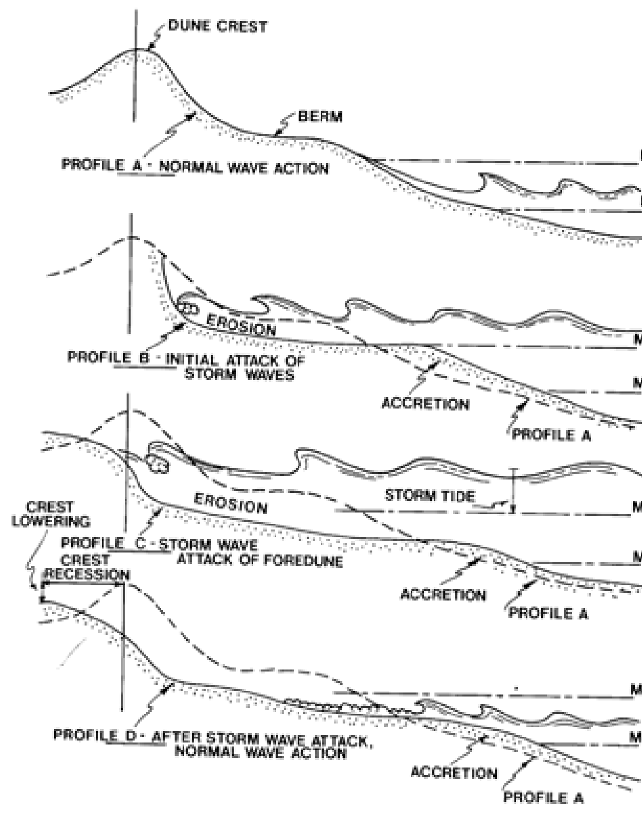

Figure 6. Typical Profile of Beach before After Storm. Source: Hayes 1985

Table 4. Hard and Soft Solutions

Hard Solutions	
Seawalls	Vertical or sloping structures that are placed parallel to the shoreline in an attempt to stop, or at least retard, wave energy.
Breakwaters	Similar to seawalls except that they are placed beyond the coastline itself. Designed to break up wave energy and prevent it from reaching the coastline and inducing erosion.
Groins and Jetties	Short structures that are attached perpendicular to the coastline. The concept behind these structures is that they are designed to trap longshore sediment movement and thus maintain the beach areas that would have eroded.
Soft Solutions	
Beach Setbacks	A prescribed distance landward of a coastal feature (e.g., the line of permanent vegetation), within which all or certain types of development are prohibited. The intent of shoreline setbacks is to establish a coastal-hazard buffer zone to protect beachfront development from coastal beach erosion.
Dune Preservation	Sand dunes are a very important source of sand for coastal beaches. Dunes trap windblown sand, store excess sand, and serve as a buffer for inland areas during storms and high wave activity. Healthy dunes are heavily vegetated with species that have a high salt tolerance and deep roots for stabilizing the sand.
Beach Nourishment	Beach nourishment is a process where sand is transferred from a rich sand source (e.g., dredge spoil from waterways and deltas) to eroding beaches.
Source: Hayes 1985	

Caribbean Small Islands have traditionally used hard engineering solutions, particularly sea walls, to protect their coastlines that experience severe erosion. However, this often carries high construction (e.g., material, labor, and capital) and maintenance costs. In addition, "hard" engineering solutions tend to accelerate sand loss and, once installed, they are difficult to remove, making it almost impossible to correct faulty designs (Hayes 1985).

"Soft" engineering solutions provide a viable alternative, but with limitations as well. For example, beach nourishment has significant costs (labor, capital, and material) associated with importing and placing sand on the beach. The costs are usually recurring, because imported sand eventually washes away (Parsons and Powell 2001). The approach of using setback lines in tandem with dune preservation is less costly to implement. In addition, setbacks establish a buffer zone where coastal development and infrastructure can be located. They also allow the natural accretion and erosion processes to work and maintain the beach access for recreational uses.

Adopting Beach Setbacks As A Planning Strategy

Adopting beach setbacks can introduce conflict between developers who want to take advantage of beachfront property and policy makers whose primary objective is public safety. Islands such as Dominica, with limited flat lands in coastal areas, have a difficult task in balancing these interests. Countries also run the risk of losing much needed tax revenues from prime beachfront properties if they are zoned for non-development. Despite these drawbacks, setbacks have emerged as a cost-effective strategy for minimizing beach erosion impacts in most Caribbean Small Islands. Already, many islands have incorporated setback provisions into their planning and development control legislation. One of the most recent is the St. Kitts Development Control and Planning Act (Government of St. Kitts and Nevis 2000), which requires the preparation of a development plan that designates any area for non-development due to its susceptibility to erosion.

Historically, beach setbacks in Caribbean Small Islands have not been established on a scientific basis. In the mid-1990s, this changed somewhat as guidelines on fixed beach setbacks were based on the elevation normally reached by high seas (Wason and Nurse 1994; Cambers 1997):

Slopes less than 1:20 30 m (100 ft)
Slopes 1:4 to 1:20 15 m (50 ft)

Consequently, islands such as Barbados and the British Virgin Islands adopted fixed beach setback distances of 30 meters (100 feet) and 15 meters (50 feet), respectively (Cambers 1997).

A problem with fixed setbacks is that they do not consider the historical nature of specific beach erosion trends. However, there are more advanced setback calculation methods that address this shortcoming by incorporating quantitative assessment of long-term beach erosion. For example, Keillor (1998) developed routines using lake shore recession rates to calculate setbacks along the Great Lakes Basin. Also, on the North Carolina coast, a 50-year erosion rate is used to determine setbacks. Most single-family homes, regardless of size, have setbacks that are determined by multiplying the erosion rate by 30. For buildings larger than 5,000 square feet, the setback is determined by multiplying the erosion rate by 60, with a minimum setback being 120 feet (DCM 2001). Even though these setbacks account for long-term erosion trends, they may fail to factor in sea level rise and the variation in erosion due to episodic events such as major storms.

Improving Setback Calculations

Gibbs (1981, 1983, 1995) offers a basic formulation for calculating setback distance (EHZ) and takes into account a more quantitative assessment of both long-term and short-term erosion:

$$\mathbf{EHZ = [\ \overbrace{(EBW + D)}^{\text{Short term}} + \overbrace{(RSB*TP) + (RSL*TP)}^{\text{Long term}}\ ] \times \overbrace{FS}^{\text{Safety factor}}} \quad \mathbf{[1]}$$

The first horizontal distances (EBW and D) represent the short-term processes resulting from the immediate impacts of a storm event. EBW is the maximum beach or dune retreat (meters) during an extreme storm event (e.g., 25-, 50-, 75-, or 100-year storm). D is the dune topographic stability factor, representing a further retreat of the eroded dune.

The second horizontal distances are the long-term rates (RSB and RSL) multiplied by the planning period (TP), which is typically 50 or 60 years. RSL is the beach and dune retreat erosion due to relative sea level rise (meters/year); RSB is the shoreline or dune retreat over the long-term (meters/year); FS is a factor of safety that is expressed on a scale from 1.0 (no uncertainty) to 2.0 (large uncertainty).

Considering the expected increase in the intensity of future storms and the potential erosion hazards that coastal developments (especially tourism facilities) will face, the assessment of short-term processes would be a major concern for designing beach setbacks in Caribbean Small Islands.

Cambers (1997, 1998) adopted a similar approach to Gibbs and has made initial steps towards improving guidelines for calculating setbacks in Caribbean Small Islands. The assessment of short-term erosion caused by storm events uses at most one or two observational data points. This approach is fairly simplistic and lacks the analytical rigor needed to account for an episodic erosion process, which is highly variable.

Cambers also prescribes estimating long-term shoreline retreat distances by using historical erosion rates. For some Islands (e.g., Anguilla and Nevis), Cambers was able to use annual beach change rates calculated from beach profiles collected under the UNESCO Beach Monitoring project. For shoreline recession from predicted long-term sea level rise (SL), Cambers uses a standard term (100 times SL) based on the Bruun (1962) model.

For the short-term/episodic beach recession distance, Cambers suggests that estimates can be based on observed coastline recession likely to occur during a major tropical system (hurricane category 4). Data for beach changes for two category 4 hurricanes is limited but available for some Islands. Where data is not available, it can be extrapolated for Islands with similar geographical and geomorphic characteristics.

Cambers also uses factors for off- and on-shore feature changes, coastal geomorphological and anthropogenic features, and planning considerations. However, it is not clear how these factors would be determined and whether they are additive like the dune stability factor D or incorporated into a multiplicative factor like FS.

The most important point here is that beach erosion is a complex process and is influenced by a variety of factors. The use of these factors demonstrates the level of uncertainty associated with the process.

In Anguilla, Cambers's method is currently being used and individual beach setbacks for this island range from 18 m (60 ft) to 92 m (300 ft). This method has provided an important foundation for calculating setbacks in Caribbean Small Islands, but some improvement is still required. Coastal managers and planners are interested in seeing the application of setbacks performed using a more consistent approach. The development of a BAMS prototype is an attempt at achieving this objective.

To improve the functionality of BAMS setback tools, interviews were conducted with officials representing the Planning Unit, Fisheries Unit, and Environmental Department in St. Kitts. The interviews included a presentation on the design concept for a prototype, following which respondents were asked to discuss tool functionality and features. Interviewees agreed that the setback tools should offer users the flexibility to

a. calculate individual beach setback distances;
b. display results in a spatial format;
c. analyze components of setback; and
d. identify facilities that are within the setback area.

The design and development of the setback tools presented in this paper were guided by the aforementioned requirements. In addition to these requirements, there is also a need to enhance setback tools so that additional capabilities are available to evaluate various setback policy scenarios at a particular beach. A theoretical framework for achieving this task and developing additional BAMS tools is presented later in this paper.

Expanding Beach Analysis And Management System Capabilities

Setback Analysis

The Setback Analysis component adopts Gibbs's setback equation (see Equation 1). Short- and long-term beach erosion calculations are discussed below, along with a sample application using Majors Bay.

Short-term erosion. Marra (1998) suggests that observations can be used to obtain the maximum or extreme beach retreat/change (EBW) values, but should not be relied upon exclusively as it is not possible to associate them with the magnitude of the storm event that caused the erosion. Therefore, he suggests empirical observations are probably best used to confirm the results of other types of analyses, in particular predictive models. Komar et al. (2001) adopt this approach with Gibbs's setback equation to calculate setbacks on the Oregon coast. Predictive models, such as numerical models (e.g., U.S. Army Corp of Engineers's SBEACH model), were used to estimate short-term erosion. Care must be taken when selecting and understanding the limitations of these models because they can oversimplify coastal processes

Table 5. Storm Probabilities and Associated Maximum Values for St. Kitts

Storm Probability	Return Period	Atlantic Coast				Caribbean/Channel Coast			
		Wind Speed (m/s)	Storm Category*	Sig. Wave Height- Hs (m)	Storm Surge - STS (m)	Wind Speed (m/s)	Storm Category*	Sig. Wave Height- Hs (m)	Storm Surge - STS (m)
0.1	10	34	1	4.4	0.4	31	TS	2.6	0.2
0.04	25	43	2	4.5	0.6	41	1	2.7	0.4
0.02	50	49	3	4.7	1	46	2	2.7	0.5
0.01	100	55	4	4.9	1.2	52	3	2.9	0.7
Source: Wagenseil 2001.									
*The Saffir/Simpson Hurricane Scale is used to categorize storm probabilities based on maximum wind speeds.									

and generate coastal evolution predictions that are not appropriate for coastal planning applications (Thieler et al. 2000). In the case of Caribbean Small Islands, limited coastal data has dictated the use of two less sophisticated models: the extreme value distribution model and the geometric model. See Daniel and Abkowitz (2003b) for a complete discussion on both models.

The extreme value distribution is used to predict the beach recession or beach width change for a specified storm probability using the equation below:

$$F(d) = exp[-e -a(d-u)] ; a = p/s \div 6 \text{ and } u = m-(0.577/a) \quad [2]$$

The variable (d) represents beach width change (meters) where m and s are the average and standard deviation of the annual maximum beach width changes. m and s values for SEP beaches are given in Table 2.

The geometric model defines the maximum recession, R, due to total water level, S, associated with an extreme storm (e.g., 30-, 50-, 100- year) using the relationship below (Bruun 1962):

$$R = [(S-TD) +DBL]/\tan b \quad [3]$$

where b is the average slope of the beach face (remains constant); TD is the elevation of the dune toe or beach/dune junction; and DBL is the vertical shift in the beach profile that results from the presence of a rip current (considered a safety factor). b and TD values for SEP beaches are given in Table 2.

Total water level (S) is comprised of storm surge (STS) and vertical wave run-up height (WR), which is derived using the relationship below:

$$WR = 0.7*Hs \quad [4]$$

where Hs is the significant wave height value.

Table 5 presents extreme probabilities of STS and Hs values from a study completed by Wagenseil (2001) on Caribbean storms that provided valuable information for calculating total water level (S). Hs values are used to determine WR.

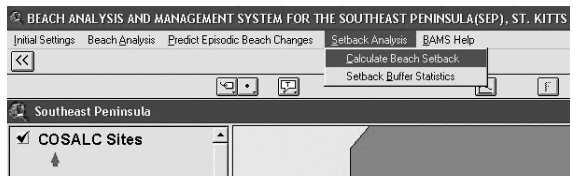

Figure 7. Setback Analysis Menu Options

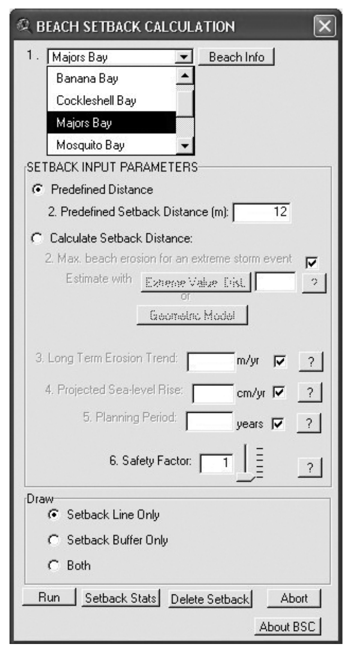

Figure 8. Beach Setback Dialog in Predefine Mode

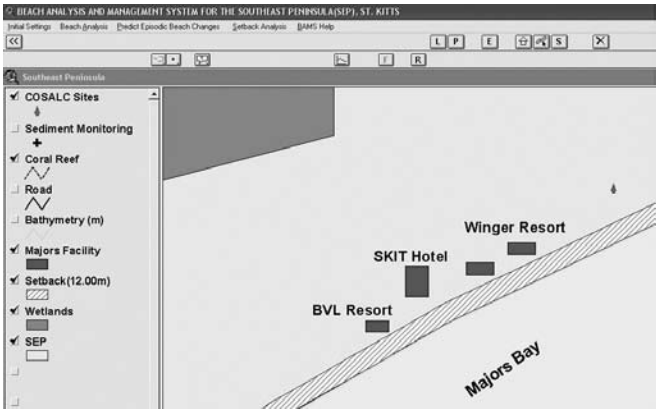

Figure 9. Sample Beach Setback (12 meters) Using Predefine Mode

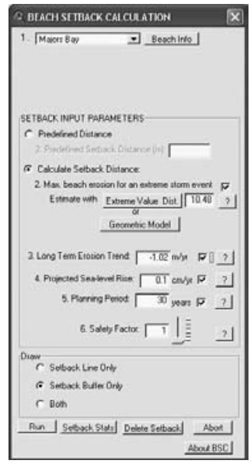

Figure 10a. Beach Setback Dialog in Calculate Mode Using Extreme Value Distribution Option

Figure 10b. Extreme Value Distribution Dialog

Long-term beach erosion. In Equation 1, RSL is the beach and dune retreat erosion due to relative sea level rise (meters/year). Long-term beach recession due to relative sea level rise (RSL meters/year) is estimated using the Bruun model as RSL = S/tan b, where S is the sea level rise and b is the average slope of beach face. Values for b are used as the average beach slope from Table 2. Beach change rates values in Table 2 are used to estimate RSB, the long-term rate of beach erosion or dune retreat (meters/year).

Sample Setback Calculations

The automated tools for calculating beach setbacks are found in the "Setback Analysis" menu option (Figure 7). The "Calculate Beach Setback" tool operates in two modes: Predefine or Calculate Setback Distance. The "Predefine" mode allows the user to enter a predefined setback distance, and to create and display the setback as a line and/or polygon (buffer) layer (Figures 8 and 9). In this example, a 12-meter setback line theme is created (shown as a light dashed line). The relative spatial relationship with the facilities at Majors Bay is also shown. In this example, no facilities are located within the 12-meter setback buffer.

BAMS currently measures setbacks from the coastline in a landward direction; ideally, it would be prudent to measure from the high water mark. Unfortunately, the available coastline layer does not have the level of accuracy and detail required to delineate this point. As GIS base maps with greater accuracy become available, this feature can be improved.

The "Calculate Setback Distance" mode uses Gibbs's setback equation as discussed earlier (Equation 1). The dune and other coastal factors (e.g., D) were not considered because dune slope and vegetation cover information was not available. The example shown in Figure 10 designs a beach setback at Majors Bay based on the likelihood of a 100-year storm during a planning period of 30 years.

The maximum beach width change caused by the 100-year storm can be estimated with the *Extreme Value Distribution* by Equation 2. Clicking the "Extreme Value Dist." button provides access to the input dialog for entering the storm probability, annual mean (m) and standard deviation (s) for the extreme beach width change at the beach of interest (Figures 10a and b). At Majors Bay, m and s are 2.7 meters and 2.48 meters, respectively. Therefore, EVD parameters are: a=0.52 and u=1.59. The probability that d100 will be exceeded in a given year for a 100-year (1/100) storm is 1/100= 0.01. By solving Equation 2 below, d100= 10.48 m:

$$Prob\ (d>d100) = 1-F(d100) = 0.01 = 1-\exp[-e^{-a(d100-u)}] = 1-\exp[-e^{-0.52(d100-1.59)}] \quad [5]$$

The Geometric Model is the second option available for estimating the maximum beach width change caused by a 100-year storm using Equations 3 and 4. This estimation is accomplished with the Geometric Model dialog, which is activated by clicking the "Geometric Model" button on the Beach Setback Dialog (Figures 11a and b). The Geometric Model dialog provides for the input of beach slope (b) and total sea level rise (S) due to storm surge (STS) and wave height. Total sea level rise is calculated with the Sea Level Rise dialog, which is activated by clicking the "Calc. Sea Level Rise for Storm Prob." button on the Geometric Model dialog (Figure 11c). The Sea Level Rise dialog provides for the input of storm surge and wave height values that are associated with selected storm probabilities.

Using Equations 3 and 4, the maximum beach recession (R100) at Majors Bay for a 100-year storm is estimated as R100 = [(S-TD) + DBL]/tan b = [(3.39 – 0.67) + 0]/0.1771 = 15.35 m. b and TD values are taken from Table 2. For this calculation, DBL (safety factor) is assumed to be zero.

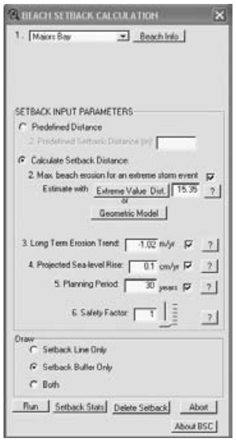

Figure 11a. Beach Setback Dialog in Calculate Mode Using Geometric Model Option

Figure 11b. Geometric Model Dialog

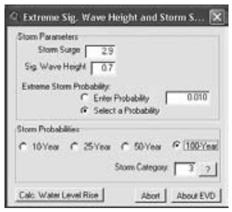

Figure 11c. Sea Level Rise Dialog

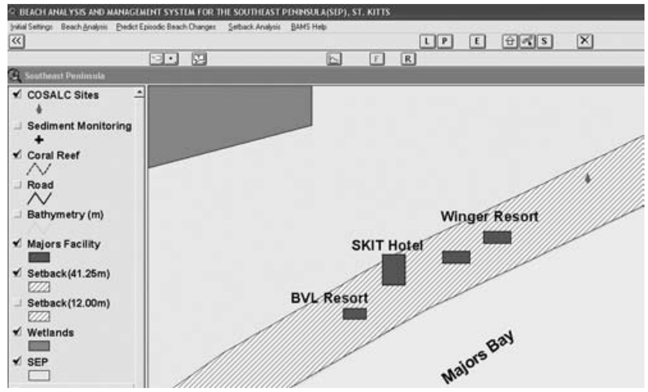

Figure 12. Illustration of Sample Setback (41.25 meters) at Majors Bay

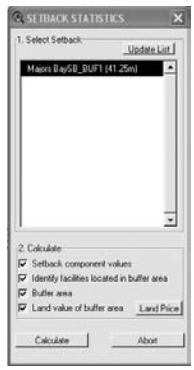

Figure 13a. Setback Statistic Dialog with the 41.25-Meter Setback at Majors Bay

Figure 13b. Summary Report for 41.25-Meter Setback

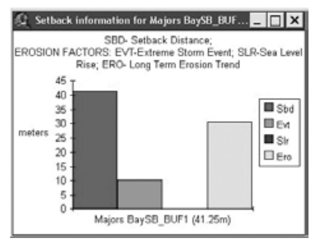

Figure 13c. Bar Graph Showing Components for 41.25- Meter Setback at Majors Bay

Long-term beach erosion trend (RSB meters/year) is estimated from annual beach change rates in Table 2. Where the annual beach change rates are positive (i.e., accretion), RSB is assigned a value of zero. The long-term beach recession at Banana Bay, defined as RSB multiplied by the planning period (TP -years), results in: 1.02 m/yr _ 30 years = 30.6 m.

Long-term beach recession due to relative sea level rise (RSL meters/year) is estimated using the Bruun model as RSL = S/tan b, where S is the sea level rise and b is the average slope of beach face. For this example, the projected annual sea level rise is 0.1 cm/yr (0.001 m/yr) and the average beach slope is 0.177. Therefore, RSL = 0.001/0.177 = 0.0056 m. The total beach recession for the planning period TP is 30 _ 0.0056 = 0.168 m.

Assuming a safety factor of 1, two designs for the beach setback at Majors Bay using both models respectively are:

Extreme Value Distribution: [10.48 + 30.6 + 0.168] _ 1 = 41.25 m.

Geometric Model: [15.35 + 30.6 + 0.168] _ 1 = 46.14 m.

Figure 12 illustrates the generated polygon for the 41.25-meter setback buffer that is applied across the entire beach segment. It is important to note that each setback line and buffer area is created in the native ArcView shapefile format, which remains with the system during the session and is reconstructed upon reloading the system. The option is also available to delete these themes.

An additional BAMS tool is available to extract more information about the setback buffer area. Accessed via the "Setback Statistics" menu option (Figure 7), users may generate summary reports on each setback that include: 1) the setback buffer zone area and land value (the user can also adjust the land price in calculating land value), and 2) a bar chart displaying the calculated setback components (e.g., short-term erosion, long-term erosion, and sea level rise). A sample summary for the 41.25-meter setback is shown in Figures 13a, b, and c.

The user also has the option to save or print these summary results. The advantage of this tool is the flexibility it offers the user to design, display, and compare different setback scenarios for a specific beach.

Despite these benefits, there are limitations and areas that will require future improvements. BAMS has two specific limitations: GIS layer and short-erosion modeling errors. We briefly discuss them below.

As the GIS layers used in BAMS were generated from topographic maps that were developed in 1984, the accuracy of the GIS layers can be improved. Recognizing that coastal lines will have shifted since then, remote sensing (e.g., IKONOS imagery and aerial photography) is being considered to provide more accurate and current geospatial data for identifying and establishing base lines from which setbacks can be measured. Depending on the characteristic of the beach, possible base lines could include a stable line of vegetation or primary dune.

The models used to calculate short-term erosion have not been fully tested or calibrated. The use of these models was limited by available data. Future coastal data collection is currently being investigated to improve the quality of information that can be used to test these and more sophisticated models, such as the USACE ADCIRC model (USACE 2003) that attaches frequencies to surge events based on historical storm surges.

Setback Evaluation Scenarios

As a potential coastal zone management strategy, setback policies must be evaluated for their cost-effectiveness (Coastal Zone Management Centre 2001). BAMS provides the foundation for developing additional tools to accomplish this task. Future research will investigate these tools further. Here a brief discussion of a framework for evaluating setbacks is presented. Central to this framework is the use of a cost/benefit analysis (CBA). Traditionally, CBA is used to evaluate the efficiency and effectiveness of a "specific policy," with "policy" referring to a project, program, or regulation (Fuguitt and Wilcox 1999). While development of a comprehensive CBA for setback policies is beyond the scope of this paper, a theoretical construct of the framework is presented here.

A CBA can be performed from the perspective of either the private sector or the government. The government-oriented approach is more appropriate here because: 1) setback policies are typically implemented and enforced by government agencies and 2) BAMS tools were designed to support the needs of government planning agencies.

To adequately assess the costs and benefits of implementing a setback policy, it is necessary to perform a "with" and "without" setback policy analysis. This would entail establishing a baseline scenario (i.e., what are the consequences "without" the setback policy), and then identify and calculate incremental benefits and costs "with" the setback policy over a prescribed time period. A typical baseline scenario might include the following:

1. The establishment of one or more tourism facilities (primarily hotels) on beachfront area
2. Beach erosion induced by extreme storms (e.g., one storm every two years on average)

"Without" Setback Policy—Baseline Scenario

For purposes of this discussion, three key assumptions are made: 1) the focus is on beachfront areas that are designated for tourism development; 2) without a setback policy in place, the typical developer would choose to take advantage of the beach amenities by building facilities as close as possible to the shoreline; and 3) maximum storm winds can be modeled using EVD, and Monte Carlo simulation can be used to randomly generate storms. It is important to note that setback and beach erosion values are applied across the entire beach segment. BAMS has the ability to generate the erosion lines for different designed storms for the baseline scenario as shown in Figure 14.

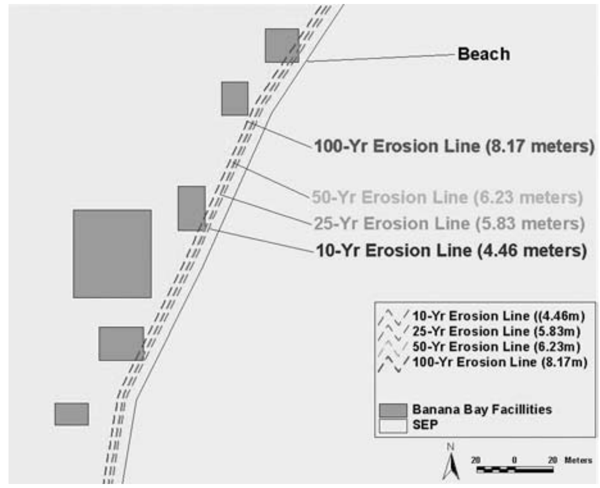

Figure 14. "No Setback Scenario" at Banana Bay: 10-, 25-, 50-, and 100-Year Storm-Induced Erosion Zones and Location of Tourism Facilities

The consequences of the baseline scenario would include the following cost estimates:

1. *Tax revenue loss from partial or total closure of facility due to erosion damage*
   During an extreme storm event, it is assumed that erosion damage can undermine a facility's foundation, thus making it unsafe for public use. This may result in a partial or total facility closure, with direct and indirect impacts on Caribbean Small Islands' economies. The implication for government is the loss of tax revenues. BAMS currently includes a tool that estimates the erosion damage exposure a facility is likely to experience during an extreme storm but not the extent of damage. More detailed and site-specific information (e.g., construction material) is required before BAMS can accommodate this component. The U.S. Army Corps of Engineers (2001) depth-damage curves for coastal flooding can be a possible source for estimating erosion damage.
2. *Cost of public services*
   As part of a storm event, the government will need to dedicate resources for activities such as evacuation and public infrastructure repairs (e.g., roads, utility lines) in high erosion hazard areas. The resources needed would depend on the extent of damage. Similar to the previous discussion, this component would also require more detailed and site-specific information prior to BAMS implementation.

3. *Costs associated with the removal of coastal ecosystems (e.g., mangroves, vegetation)*
   Coastal tourism development often involves the destruction of beach vegetation (e.g., mangrove, grass) that trap and filter nutrients and sediments that can block sunlight, essential for coral growth. Coral reef ecosystems are critical inputs needed to sustain the fisheries sector and related businesses (e.g., tour and dive operators) as they serve as habitat for juvenile marine species (e.g., lobsters and fish), and they are a major draw for various users (e.g., snorkelers, scuba divers, and recreational fishers). If properly managed, reefs can yield an average of 15 tons of seafood per square kilometer per year (Burke et al. 1998). The indirect impacts on coral reefs can significantly affect the fisheries and related sectors. This can translate into loss of government tax revenues.

These indirect impacts on the fisheries sector, while an important component, are particularly difficult to quantify. The assessment of these impacts would require ecological model development.

"With" Setback Policy—Setback Scenario

With the baseline scenario established, the setback scenario can then be formulated (Figure 15). This scenario would assume the same facilities and storm-induced erosion defined under the baseline scenario. However, these facilities are situated at or behind the setback line.

The consequences of this scenario would also include the cost elements defined in the baseline scenario as well as the following items:

1. *Setback administrative costs*
   This cost is associated with the formal delineation of setback distances (e.g., signage), and with implementing education and enforcement programs. The cost of delineating the setback is considered a one-time cost.
2. *Tax revenue loss due to low land value in buffer area zoned for non-development*
   Once the setback has been delineated, the buffer of land between the beach and setback lines is zoned as non-development area. The expected reduced land value in this area would diminish tax revenue. BAMS offers a tool (under "Setback Statistics" menu option) to estimate this component.

Once these scenarios are formulated, the annual incremental costs and benefits for the setback scenarios can be estimated and compared over the time horizon. To be consistent, future dollar values must be discounted to obtain present values.

Concluding Remarks And Future Direction

This paper presented the results of the third phase of BAMS development, which provides tools for designing, analyzing, and displaying individual beach setbacks. These tools not only offer

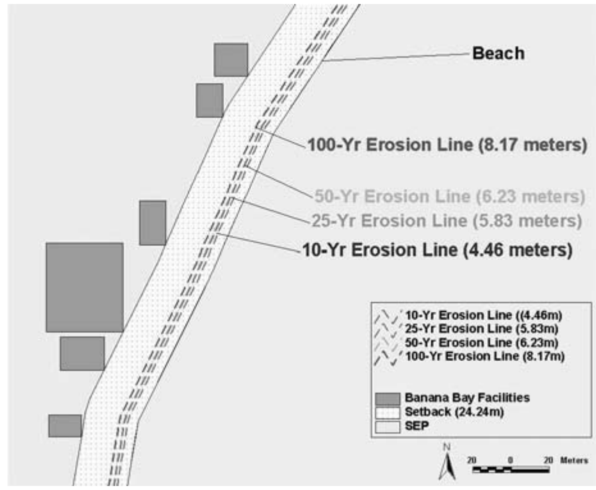

Figure 15. "Setback Scenario" at Banana Bay: 10-, 25-, 50-, and 100-Year Storm-Induced Erosion Zones and Location of a Facility Unit

the flexibility to perform these tasks, but they also address the inability to account for short- and long-term erosion patterns in earlier beach setback calculation methods. Within BAMS, variations in storm-induced beach erosion and long-term erosion due to sea level rise are explicitly considered. BAMS has demonstrated how simple erosion modeling techniques and existing data could be utilized to predict storm-induced beach changes in Caribbean Small Islands. This provides the ability to analyze the potential impacts of different storm scenarios and improve current methods used to calculate individual beach setbacks.

In its current state, BAMS contributes to the ICZM requirements for analyzing and evaluating various setback scenarios. A theoretical framework for performing evaluating setbacks was presented. Central to this framework is cost/benefit analysis. It was demonstrated that existing setback tools have an integral role in this analysis. It is anticipated that BAMS will be further expanded to include setback evaluation tools that are guided by this framework.

The ultimate goal is to promote the wider use of GIS technology and use BAMS as a vehicle to support ICZM-related activities in islands that collect beach profile data under the UNESCO-COSALC program. Despite some of the GIS data and erosion modeling limitations, the system can serve an important role of educating and sensitizing policy makers and coastal managers to the wider issues that relate to implementing beach setbacks. To increase BAMS exposure, seminars/meetings can be organized with potential users and other interest groups. To date, the feedback received has been positive, with an overall indication that user requirements are being met. Future activities and collaborative work on BAMS improvement include the following:

- Test/evaluate BAMS prototype with potential users in the St. Kitts Department of Environment, Fisheries Unit, and Physical Planning Division.
- Assist the UNESCO-COSALC program with investigating the implementation of BAMS in other Islands, and improving data collection methods.

- Investigate the possibility of integrating BAMS with other existing coastal information systems.
- Update GIS layers.
- Investigate more advanced and robust erosion modeling techniques.
- Migrate BAMS from ArcView 3.2 to the new ArcView 8.3 version.

Endnotes

1. An island with land area of less than 5,000 mi2 (13,000 km2) and a population of less than 1 million. These islands include Anguilla, Antigua & Barbuda, Aruba, Barbados, Bermuda, British Virgin Islands, Cayman, Dominica, Grenada, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Turks, and Caicos.
2. Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad, and Tobago.

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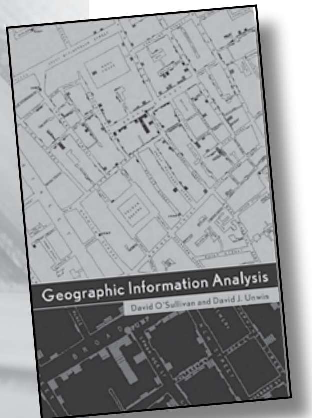
BOOK REVIEW

Geographic Information Analysis

David O'Sullivan and David J. Unwin. 2003. Geographic Information Analysis. John Wiley & Sons, Inc. 436 pages. ISBN 0-471-21176-1. Hard cover only.



For many GIS users spatial analysis is at the very heart of any GIS; however, there are few books on the subject of spatial analysis that describe analytical techniques in a thorough yet accessible manner. Geographic Information Analysis by O'Sullivan and Unwin (2003) promises to "present clear and up-to-date coverage of the foundations of spatial analysis in a Geographic Information Systems environment" – and it delivers on this promise. Compared to several other books covering similar subject matter, this text stands out because of the clarity of its explanation of spatial analysis concepts, consistency in its use of mathematics and statistics, and comprehensive coverage of a wide range of analytical techniques.

One of the book's main strengths is the clear organization of each chapter. Each chapter starts with a set of objectives, uses a set of well-named sections and ends with a chapter review. Each section is also usually not longer than a few pages, making it easy to go back and find specific topics. There is also a wealth of very informative figures and tables, which almost without exception contribute substantially to developing a better understanding of the concepts being described.

The book contains a total of 12 chapters. The introductory chapter provides some of the needed background in terms of definitions of basic concepts and what the authors mean by geographic information analysis: "the study of techniques and methods to enable the representation, description, measurement, comparison, and generation of spatial patterns". Chapters 2 and 3 then describe more fundamentals, including the characteristics of spatial data which are most relevant for analysis, and the nature of spatial processes and patterns.

Chapters 4 through 11 describe a series of spatial concepts and analytical techniques applicable to them. First of these concepts is point pattern analysis in Chapters 4 and 5, followed by Chapter 6 on lines and network, and Chapter 7 on area objects. This follows the logical hierarchy of points, polylines and polygons as representation types. Next are Chapters 8 and 9 on fields (i.e. surface representations like raster and TIN), which primarily deal with spatial interpolation techniques such as nearest neighbor, inverse-distance weighting and kriging. Chapter 10 describes map overlay techniques, including Boolean overlay and more sophisticated alternatives. Chapter 11 covers multivariate data, multidimensional space, spatialization and principal component analysis.

The final chapter 12 on new approaches to spatial analysis describes a number of emerging techniques such as expert systems, artificial neural networks, genetic algorithms, agent-based systems and cellular automata. While many techniques described in earlier chapters have made their way into GIS software, these techniques are much more in the development stage and their implementation is not as widespread.

Each of the various spatial concepts is described in a clear and concise manner and with considerable depth. The book's main strength, however, lies in the fact that it is able to describe such a broad range of concepts and analytical techniques in a single volume in a consistent manner. Even for those who have substantial experience in using GIS for spatial analysis, the book is therefore likely to provide some new insights into alternative

approaches to a particular analysis problem. On the other hand, a number of common analytical techniques are not covered in any detail, most notably several forms of proximity analysis (like buffering), raster-based analyses (including overlay, focal and zonal analysis), and spatial regression analysis.

Another strength of the book is its rigor in terms of statistics; basic statistical concepts are described and explained throughout the book and their relevance is clearly demonstrated. This reflects the authors' conviction that spatial analysis requires a consistent recognition of basic statistical considerations. This is severely lacking in most general GIS textbooks, which usually dedicate a few chapters on spatial analysis but rarely do a solid job of including the relevant statistical concepts. For those in need of a refresher on basic statistics, Appendix A of the book describes basic probability theory, sampling distributions and hypothesis testing.

As could be expected for a book of this nature, it includes a fair amount of mathematics. Basic mathematics are not reviewed, but Appendix B does provide a very helpful review of matrices and matrix mathematics.

Each chapter uses a number of "thought exercises" which enforce the concepts described by encouraging the reader to apply the concepts to a specific example. Virtually all these exercises can be done by using pen and paper, and no computer software is required. Unfortunately, no answer key is provided.

While the exercises are very meaningful, it would have been very useful if most of these were presented in a computer-based environment. And herein lies one of the major shortcomings of the book; given that the emphasis of the book is on spatial analysis in a GIS environment, it is somewhat surprising to see that no effort was made to show how the concepts are implemented in current GIS software. Many of the concepts in the book lend themselves to GIS-based exercises, and an accompanying CD-ROM or website with such exercises would have been a very welcome addition. Even without including GIS-based exercises, the book could have benefited from using more real-world datasets as examples. With a few notable exceptions, most of the examples use simplified and sometimes hypothetical example datasets.

A related shortcoming of the book is that no reference is made to any software that might be used to carry out the spatial analysis techniques described. When used in a course environment, this would obviously be the task of the instructor, but for others using the book as a reference it will take considerable effort to identify how GIS and related software has implemented the various techniques. Most importantly, most commercial GIS software does not include many of the statistical techniques referred to in the text, and the use of a statistical software package is pretty much a requirement for anyone who wants to carry out many of the techniques covered in the book. This is not really a weakness of the book itself, but simply the reality of how most current GIS software has been developed. An appendix describing some of the GIS and statistical software packages which are most suitable for the analytical techniques described in the book would have been helpful.

This book will be most useful as a textbook for upper level undergraduate or graduate courses in GIS; for example, a second course in GIS or a specialized course in spatial analysis. For GIS professionals or scholars with some experience in spatial analysis this book will provide a meaningful reference on a wide range of analytical techniques. While some effort is required to identify exactly how each technique is implemented in a particular GIS software package, for most skilled GIS users this should not prevent them from substantially strengthening their analysis skills by using the concepts explained in this valuable addition to the spatial analysis literature.

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