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Remote sensing/GIS integration to identify potential low-income housing sites

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Perhaps the most notable problem in the rapid pace of urbanization in the developing world is the need for housing and the provision of related services. The quality of planning and decision making processes can be substantially improved when suitable data are appropriately and efficiently handled. This study reviews the development of remote sensing and geographic information system (GIS) techniques for urban analysis. It then applies these techniques to evaluate several types of planning related information in a raster based (GIS) to identify potential low income housing sites in the eastern portion of the Bangkok Metropolitan Area. This work demonstrates how satellite imagery can provide both site specific information on land cover for mapping urban residential land use, and also act as a medium to generate a variety of GIS coverages.

Keywords: Remote sensing, GIS, Bangkok, Low income housing

Introduction

Similar to other capital cities in the developing world, Bangkok is experiencing many of the growth related pressures that create enormous needs for land and housing that are not matched by a comparable growth in access to land, urban services, or infrastructure. Related problems include high land prices, land tenure security, and poor housing quality. As a result, most of these urban agglomerations are faced with rapid growth and the spread of informal housing settlements of high density, poor house quality, and increased pollution and related health problems.

The quantity and variety of publications on this topic in just the last few years underscores the need to obtain greater amounts of information about these settlements that can be used to find solutions to this urban dilemma (see for example, Rakodi and Withers, 1995; Abelson, 1996; O'Hare *et al*, 1998; Sen, 1998).

In an effort to address specific aspects of land and housing acquisition, and monitor the growth of these settlements, a number of technologies are increasingly used to predict where these sites occur and to better understand the processes that result in these phenomena. These techniques include digital imaging, remote sensing and photogrammetry, object recognition, environmental modeling, and artificial intelligence. All may be referred to collectively as spatial information technology even though they are not exclusively spatial (Mason *et al*, 1997). Increasingly these systems are becoming integrated within a GIS environment.

There are numerous functions a GIS can perform in its supporting role for informal settlement analysis. Inherent in this process are spatial and physical parameters, such as access to transport linkages, to employment, and to services. The GIS is well suited to deal with these factors in a common decision making environment. However, the practical success of this tool depends upon geo-spatial data collection systems that can provide low-cost data (the degree to which community level information gathering proves to be viable), the ability to integrate collected data

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into low-cost, easy-to-use GIS databases suitable for decision making at the community level, and the awareness and capacity of participants to support the GIS, eg capacity for maintenance (Mason *et al*, 1997).

Planners must take into account both the socio-economic characteristics of sites as well as the constraints of physical layout, available area, and land suitability in performing their tasks. One of the advantages of GIS for urban planning, especially in rapidly growing areas, is that the combination of digital map and database information allows for great flexibility in assessing alternative scenarios.

Unfortunately, compiling an urban GIS takes a major resource commitment in time and funding. One major cost is constructing the database information that is associated with the maps. It is estimated that up to 80 percent of time and costs involved in developing GIS are spent on database acquisition and integration (Ehlers *et al*, 1990). To meet the demand for current and accurate data, remotely sensed images have become increasingly used as an important data source for land cover analysis. Given the dynamics of informal settlements, their density, and the type and quantity of spatial data required for their management, the type of imagery that is used becomes an important decision. Although conventional image processing techniques based solely on spectral observation are often not sufficiently accurate for urban studies, a solution is to extend the classification procedure using other digital ancillary data accessed through a GIS.

Background

Satellite data can be considered an essential data source for the appraisal of urban environments as they provide valuable and timely information for interpreting the landscape (Forster, 1985; Welch, 1982). Most researchers have approached the task of characterizing an urban area by first accurately classifying the various land use types (which are a combination of land cover characteristics), and then identifying the extent of the built up area and its internal variability. The many surface materials in an urban setting, however, can produce a spectral response that is difficult to interpret. This is because the variability of land cover in close proximity produces a variety of reflectance characteristics that the satellite detects. The resulting image pixels are then comprised of different proportions of surface materials such as grass, trees, buildings, and roads.

Specific concerns addressed by researchers range from the separation of urban–nonurban land use (Jensen, 1983) to population estimates (Lo and Welch, 1977). The separation of urban–nonurban land use has been treated by many researchers (Jensen and Toll, 1982; Toll, 1984; Toll and Kennard, 1984), and some have taken the analysis to a very detailed level. Forster (1980, 1983) for example, used satellite data to examine the capability of predicting urban reflectance of surface cover, housing density, average house value, and to develop a residential quality index for residential Sydney.

In a typical urban environment of Asia, Lo (1981) has examined the capability of satellite data for mapping land use in Hong Kong. Iisaka and Hegedus (1982) were some of the first to undertake population studies of an urban area in their study of Tokyo's central business district, while Murai and Mustra (1988) used satellite data to identify preferential residential areas of Jakarta. Urban change detection has also been successfully accomplished (Gupta and Munshi, 1985).

In spite of these successes, the urban environment continues to challenge the demands of remote sensing users as the coarse spatial resolution of remotely sensed data has not been as suitable for urban surface analysis as researchers had hoped. GIS capabilities, however, can assist with this task supplying an additional tool for providing reliable information for both planning and decision-making. Although planners' experience with remote sensing and GIS has not been uniformly successful, GIS have been used frequently in planning for a host of applications.

While land cover information can be directly interpreted from a remotely sensed image, information about land use cannot always be inferred directly from the land cover data. In theory, GIS are particularly attractive because they can provide such information in a digital format, thus eliminating the need for costly and error-prone manual analysis. However, in practice extracting land cover information acquired through remote sensing is often too low for many planning tasks (Bishop *et al*, 2000).

The dual nature of this integrated approach is appreciated in the typical research issues address in the two disciplines: remote sensing is largely concerned with extracting generalized information and error detection, while GIS applications tend to focus on database management issues, cartographic modeling and presentation of spatial data. A truly operational GIS for planning purposes requires the integration and automation of at least some of the most routine procedures in both approaches.

In addition, object based manipulation (a data handling technique that uses vector data structures to identify information) is often used in GIS systems, while remote sensing image analysis can be considered a field based technique that uses raster data structures (handling data by giving each pixel in the image a unique value based on reflectance characteristics). Remote sensing is designed primarily to collect continuous data of physical surface variations, while GIS can represent not only physical land cover information but also aspatial attributes dealing with population and building activities and characteristics. Each of these data formats contributes to analysis by providing a different type of information, as they are inherently different in their purpose and