DETECTING SLUMS FROM QUICK BIRD DATA IN PUNE USING AN OBJECT ORIENTED APPROACH

Sulochana Shekhar

Central University of Karnataka, Gulbarga, India

WG, Theme or Special Session: VIII/8: Land

KEY WORDS: Slums, Quick bird data, Object oriented Analysis, eCognition, Pune

ABSTRACT:

We have been witnessing a gradual and steady transformation from a pre dominantly rural society to an urban society in India and by 2030, it will have more people living in urban than rural areas. Slums formed an integral part of Indian urbanisation as most of the Indian cities lack in basic needs of an acceptable life. Many efforts are being taken to improve their conditions. To carry out slum renewal programs and monitor its implementation, slum settlements should be recorded to obtain an adequate spatial data base. This can be only achieved through the analysis of remote sensing data with very high spatial resolution. Regarding the occurrences of settlement areas in the remote sensing data pixel-based approach on a high resolution image is unable to represent the heterogeneity of complex urban environments. Hence there is a need for sophisticated method and data for slum analysis. An attempt has been made to detect and discriminate the slums of Pune city by describing typical characteristics of these settlements, by using eCognition software from quick bird data on the basis of object oriented approach. Based on multi resolution segmentation, initial objects were created and further depend on texture, geometry and contextual characteristics of the image objects, they were classified into slums and non-slums. The developed rule base allowed the description of knowledge about phenomena clearly and easily using fuzzy membership functions and the described knowledge stored in the classification rule base led to the best classification with more than 80% accuracy.

1. INTRODUCTION

1.1 Urbanisation and Slums

Today, half the world's population lives in urban areas and by the middle of this century all regions will be predominantly urban, and according to current projections, virtually the whole of the world's population growth over the next 30 years will be concentrated in urban areas (UN-HABITAT, 2010). Above all, this rapid urban growth has been strongly associated with poverty and slum growth. It is felt that slums represent the worst of urban poverty and inequality. The increasing concentration of the urban population in slum areas is generally equated with increasing urban poverty a process recognized as the urbanization of poverty. According to new estimates presented in UN-HABITAT's report, between the year 2000 and 2010 over 200 million people in the developing world will have been lifted out of slum conditions. But in the course of the same years the number of slum dwellers will be increased by six million every year. Based on these trends it is expected that the world's slum population will continue to grow if no corrective action is taken in the coming years (UN-HABITAT, 2010).

Defining slum raises several conceptual issues, making it difficult to precisely estimate the slum population living in urban areas. Concepts and definitions of slums vary from country to country and even in the same country, slum settlements may be known by different names (Kohli.D, 2011) In order to carry out the urban planning and development tasks necessary to improve living conditions for the poorest world-wide an adequate spatial data basis is needed (Mason, O.S and Fraser, C.S., 1998) and this can only be obtained through the analysis of remote sensing data (Hofmann,P.,2001). Since traditional methods demand more labour, money and time, alternative methods that include sophisticated techniques to extract the information from remote sensing data of very high resolution (VHR) and thus could reduce subjectivity, time and labour (Naga Jyothi., 2008 et al.) and provide more reliable data are need of the hour.

1.2 Related work on detecting slums

Many studies used census and field survey as the basis for studying about slums and formed the database for GIS-based mapping (Joshi Pratima, Sen Srinanda and Hobson Jane, 1998; Sliuzas and Kuffer, 2006). Recently very high resolution remote sensing based methods for mapping slums are getting popular among the scientific community (Mason& Fraser, 1998; Sliuzas, Kerle and Kuffer, 2008; Hofmann .P., 2001; Hofmann. P., 2004 et al.) but there are only very few studies based on Indian situation (Ujjwal Sur, 2004).

In most of the remote sensing based studies visual interpretation of data has played major role in identification of slums (Angeles et al., 2009; Sliuzas R.V 2004.,Sliuzas and Kuffer 2008; Baud, Kuffer, Pfeffer, Sliuzas, and Karuppannan (2010). Visual interpretation performed by interpreters familiar with local conditions provides a flexible and useful approach to slum mapping, though it does have shortcomings for repetitive surveys of very large cities due to difficulties in controlling quality over time and between interpreters. Later pixel based image classification is widely used in slum analysis and it also helped to understand the patterns over time and space (Jain, Sokhi and Sur, 2005; Jain, 2007; Weeks et al., 2007). But pixel-based approach on a high resolution image is unable to represent the heterogeneity of complex urban environments. In most cases by using only pixels' spectral information to

describe the different types of settlements is insufficient due to variation in the structure, material, shape and so on. Hence more refined methods such as object oriented approaches are necessary to detect the informal settlements from very high spatial resolution data.

With the wide availability of VHR images, automatic object delineation techniques are being extensively researched and have proven to be accurate in urban applications (Ebert, Kerle, & Stein, 2009; Sliuzas, Kerle, & Kuffer, 2008). Recent developments in "object-oriented" image classification (based on image segmentation) have taken advantage of the detailed spatial characteristics of high-resolution datasets. The research in this area has emphasized the reduction of spectral variability within the objects and the incorporation of additional information from spatial and contextual image/ object characteristics (Johnsson, 1994; Blaschke and Strobl, 2001).

OOA is capable of using multiple data types during analysis to create meaningful segments. Segmentation is an important step preceding the classification of image objects. The classification process can include a variety of information, ranging from spectral mean values for each object, to measures of texture, context and shape. OOA offers great potential because of its ability to include spatial, spectral and contextual characteristics similar to human cognitive image interpretation (Hofmann, 2001; Herold et al, 2002; Van Der Sande et al., 2003; Benz et al., 2004).

Even though several studies showed the feasibility of detecting slums by using OOA, their relatively high inner-structural heterogeneity and their varying pattern impede the generation of an automated detection process. In the present paper, the visual interpretation indicators used by experts for slum identification and ground knowledge of slums in the city of Pune, India were used to semi-automate the classification in an OOA environment

2. MATERIALS AND METHODS

2.1 Study area

Pune the city (Figure1), selected for present study is one of the fast developing urban agglomerations in Asia.

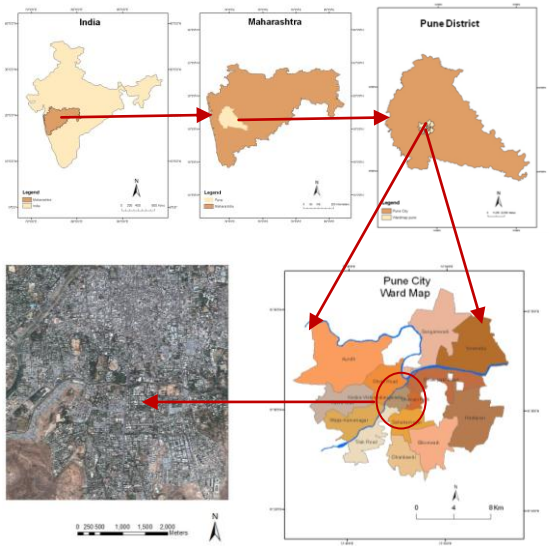

Figure 1.Location of Pune city and Quick Bird scene

It ranks eighth at national level and second at state of Maharashtra (Census of India, 2011). It has grown manifolds over the past two decades in terms of population and area.

Pune city lies between latitudes 18°25'N and 18°37'N and longitudes between 73°44'E and 73° 57'E and cover an area of 243.96 sq.km. Between 1976 and 1981 the population of Pune city (Table 1) grew by 16.7%, from 1981 to 1991 it grew by 30.2%, and between 1991 and 2001 growth increased to 62.17% (Shekhar., 2004;Shekhar.,2006).The recent census 2011 also showed decade growth rate of 22.6% (Census of India, 2011). India's Town and Country Planning Organization (TCPO), the technical arm of the ministry of urban development, ranks Pune as a city with third largest number of slums in India.

Census year	Population
1951	400902
1961	794052
1971	1029466
1981	1202848
1991	1566651
2001	2540069
2011	3115431

Source: Census of India

Table 1. Population of Pune city

Environment Status Report of Pune city for 2009-10 had stated that at the rate at which the slums in the city were growing, at least 50 per cent of the city's population would be living in slums. Pune slums are congested, have structures made of materials which are considered garbage, such as wood used for packing, plastic sheets, opened out metal tins, galvanised iron sheets, bamboo sheets, etc. and often lack the most basic of facilities for all its inhabitants. Pune's slum population is scattered across the whole city.

2.2 Data base

As data source Quick bird scene (60 cm spatial resolution) was used showing parts of Pune city (Figure 1).The image shows the central part of Pune city comprising typical urban features including slums and other formal areas. Cloud free Pan sharpened data with three bands (RGB) of the year 2006 was used for detecting slums from non-slum areas.

GIS layers of road and water bodies were also used as thematic layers in the object oriented analysis. Census data and Environmental Status reports of Pune city Municipal Corporation were used as secondary data for this study.

2.3 Methodology

The first step towards identifying the slums in OOA is to generate segments, i.e. an automatic division of an image into coherent groups of pixels (segments, objects) and the criteria used to segment an image is a degree of homogeneity within each particular object and heterogeneity among neighbouring objects (Baatz. M., A.Schape, 2000). It was done by using Multi resolution segmentation with the objective choice by using Estimating Scale Parameter (ESP) tool (Drăguţ et al., 2010). These outputs are called 'object primitives', which lead to meaningful 'objects of interest' by further refinement (e Cognition, 2010). The segmentation used all image layers as