Analysis on the Land Use in General and Neighborhood Commercial Areas of Ulaanbaatar city using RS and GIS

B.Chinbat[1], D.Amarsaikhan[1,2] and Tae-Heon Moon[3]

[1]Faculty of Geography
National University of Mongolia, Ulaanbaatar, Mongolia
E-mail: chin_bat2002@yahoo.com

[2]Institute of Informatics and RS, Mongolian Academy of Sciences
av.Enkhtaivan-54B, Ulaanbaatar-51, Mongolia
E-mail: amar64@arvis.ac.mn

[3]ERI, Urban Engineering Major,
Construction Division, Gyeongsang National University
900 Gazwa Jinju City, Gyeongnam 660- 701 Korea
E-mail: thmoon@nongae.gsnu.ac.kr

Abstract

The aim of this study is to analyze the land use of general and neighborhood commercial areas of Ulaanbaatar city using RS and GIS techniques. For this purpose, two urban land use sites representing these areas have been selected in different locations. For the analysis, historical GIS data as well as SPOT 5 and Quickbird images of 2002 have been used. The analysis was carried out using the ArcGIS and Erdas Imagine 8.6 installed in a PC environment and to reach the final goal, different RS and GIS techniques have been applied.

Keywords: *Land use, commercial area, RS, GIS, analysis*

1. Introduction

In recent years, Ulaanbaatar, the capital city of Mongolia has faced different urban development problems, similar to many cities in developing countries. In the city, various problems had been accumulated during the communist era and they have been accelerated by the reforms of the entire political and economic systems, unregulated market development and the rapid population growth caused mainly by migration from rural areas.

Since the transition to a market economy, the Ulaanbaatar city has experienced much more developments, which resulted in changes of the spatial and functional structures of the city and the most significant changes have been the increase of commercial functions in the city centre and inner city area; the expansion of the urbanized areas along with the growth of formal and informal ger-settlements; the formation of satellite nodes with clusters of commercial functions, and the residential suburbanization in the outer city by single family houses [5].

At present, in the country there are missing urban-oriented research activities, based on the modern urban geographical theory and methodologies, because the research on detailed urban studies, including functional and spatial differentiation of urban areas is a

relatively new research direction in urban geography of Mongolia. One of the fundamental problems in urban study could be the research on how different urban features with various profiles and duties can be spatially located better coping with each other in order to be ecologically, economically and socially efficient and satisfy the requirements of the sustainable development [4,5].

In this study, we wanted to analyze the land use of general and neighborhood commercial areas of Ulaanbaatar city using RS and GIS techniques. For this purpose, 2 urban land use sites representing these areas have been selected and for the analysis, historical GIS data as well as SPOT 5 and Quickbird images of 2002 have been used. The analysis was carried out using the ArcGIS and Erdas Imagine 8.6 installed in a PC environment.

2. The selected sites and data sources

In this study, as a general commercial area III-IV microdistrict located in the north western part, whereas as a neighborhood commercial area Sansar microdistrict located in the central part of Ulaanbaatar city have been selected. The locations of these sites represented in a SPOT 5 image of 2002 are shown in Figure 1.

As the RS data sources, multispectral SPOT 5 image of 2002 resampled to a pixel resolution of 4m and Quickbird image of 2002 with a spatial resolution of 70cm have been used. In addition, a topographic map of 1984, scale 1:50,000 and a topographic map of 2000, scale 1:10,000 as well as a general urban planning map were available. The digital forms of these maps were considered as historical GIS data sets.

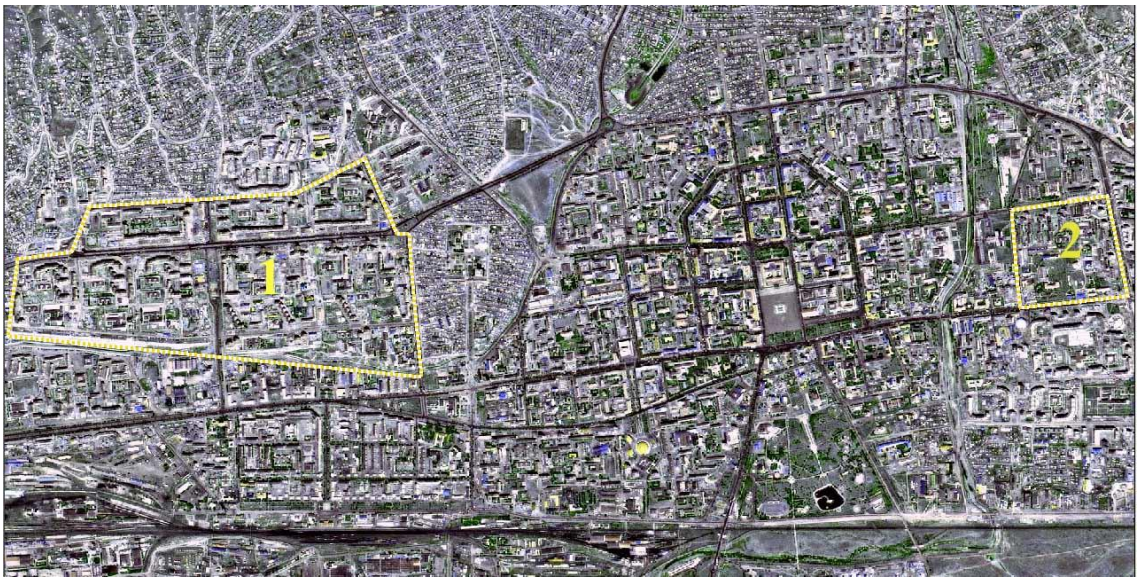

Figure 1. SPOT 5 image of Ulaanbaatar city (Red=band 1, Green=band 3, Blue=ban 2).

1-General commercial area (III-IV microdistrict),

2-Neighborhood commercial area (Sansar microdistrict).

3. Georeferencing of the SPOT 5 and Quickbird images

In order to georeference the Quickbird image to a Gauss-Kruger map projection, a topographic map of 2000, scale 1:10,000 has been used. The ground control points (GCP) have been selected on well defined cross sections of roads, streets and building corners and in total, 12 and 9 regularly distributed points were selected for the III-IV microdistrict and Sansar microdistrict, respectively. For the transformation, a linear transformation and nearest neighbour resampling approach [6,8] have been applied and the related root mean square (RMS) errors were 1.56 pixel and 1.79 pixel, accordingly. Likewise, two subsets selected from the multispectral SPOT 5 image have been georeferenced to a Gauss-Kruger map projection [3] using the same topographic map of the test area. For the transformation the same number of GCPs has been used and the related RMS errors were 1.21 pixel and 0.98 pixel, accordingly. In each case of the georeferencing, an image was resampled to a pixel resolution of 70cm.

4. Image fusion

In the present study, in order to enhance the spectral and spatial variations of different land use classes as well as to merge the images with different spatial resolutions, two image fusion techniques such as Brovey transform and intensity–hue–saturation (IHS) transformation have been used and compared. After applying corrections, data with different spatial resolutions can easily be integrated. The image fusion is the integration of different digital images in order to create a new image and obtain more information than can be separately derived from any of them [2,9]. In the case of this study, the panchromatic image provides more spatial information due to its higher spatial resolution, while the multispectral images provide the information about the spectral variations of the urban classes. Image fusion can be performed at pixel, feature and decision levels [1,9]. In this study, the fusion has been performed at a pixel level. Before applying the fusion techniques, a 5x5 size high pass filtering [7,10] has been applied to the panchromatic images in order to enhance the edges.

Brovey transform: In this method, multispectral images with a lower spatial resolution are integrated with an image with a higher spatial resolution, thus creating spectrally and spatially enhanced color images [11]. To create spectrally and spatially enhanced color (RGB) images, the sum normalized multispectral bands are multiplied by the image with a higher spatial resolution as shown below:

$$R=(B1/B1+B2+B3)*B4$$
$$G=(B2/B1+B2+B3)*B4$$
$$B=(B3/B1+B2+B3)*B4$$

where B1,B2 and B3 - multispectral bands, and B4 - band with a higher spatial resolution.

In the present study, for the Brovey transform, the bands of SPOT 5 were considered as multispectral bands, while Quickbird image was considered as higher spatial resolution band.

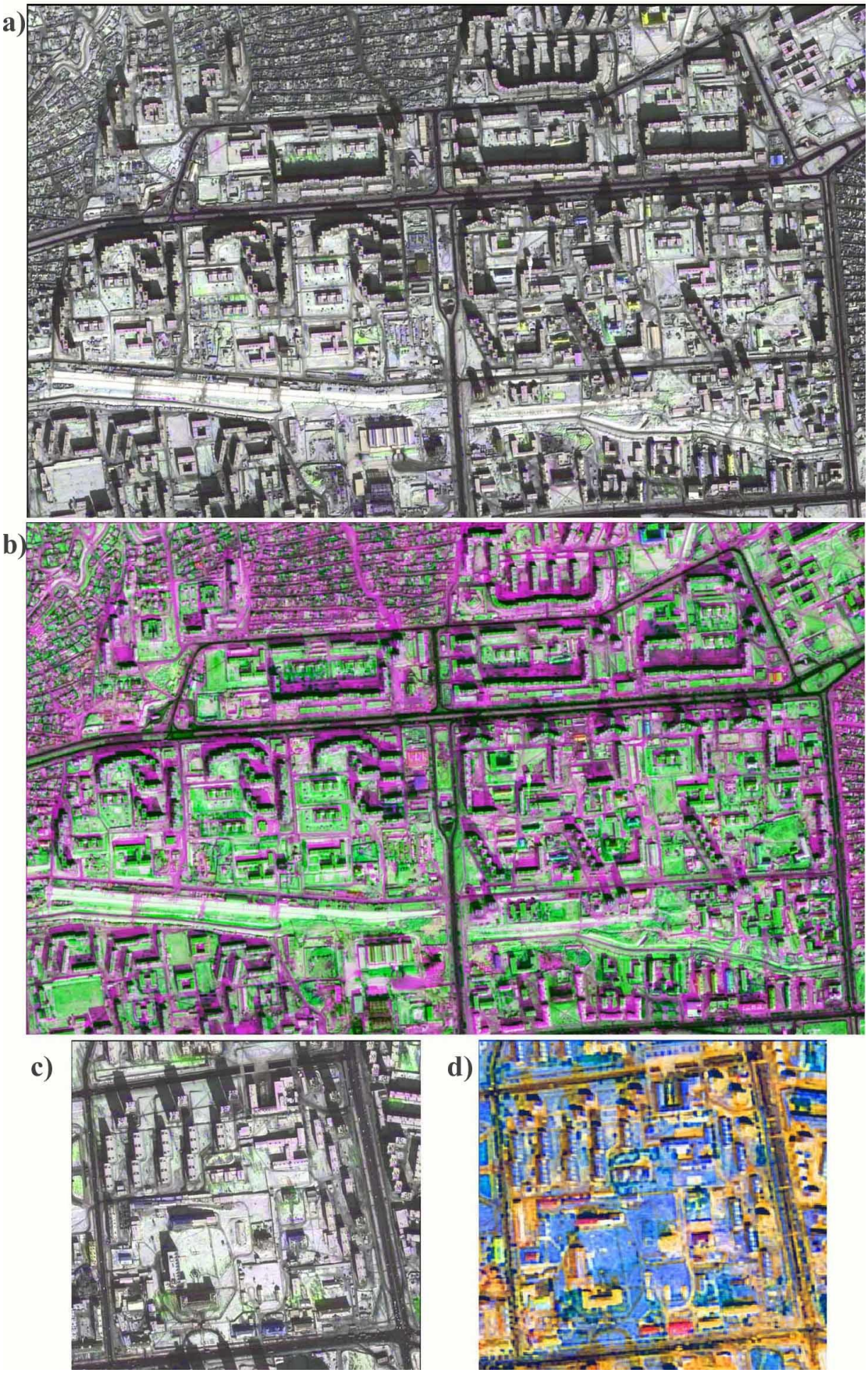

Figure 2. The fused images of SPOT 5 and Quickbird data.
a) and c) Brovey transformed images, b) and d) IHS transformed images.

IHS transformation: The IHS method is the most widely used data fusion technique. This method assumes that the H and S components contain the spectral information, while the I component represents the spatial information [1,8]. A detailed review of this approach is given in Mather (1999). For the IHS transformation, the RGB image created by green and near infrared bands of the SPOT 5 data as well as panchromatic band of Quickbird data have been used and the panchromatic band was considered as the I. When the IHS image was transformed back to the RGB colour space, contrast stretching has been performed to the I and S channels.

In order to obtain a reliable color image that can illustrate the spectral and spatial variations of the selected land use classes, different band combinations have been used and compared. Although, the images created by the Brovey transform contained some shadows that were present on the panchromatic images, they still illustrated good results in terms of separation of the available land use classes. The images created by the IHS method contained less shadow effects, however, it was very difficult to analyze the final images, because they contained too much color variations. Therefore, for the interpretation of the selected land use classes, for both test sites, the images created by the Brovey transform have been used. The fused images of SPOT 5 and Quickbird are shown in Figure 2.

5. Land use analysis of general and neighborhood commercial areas

At the beginning, from the Brovey transformed images of both test sites, the available land use types have been digitized using the ArcGIS system (Figure 3).

The general commercial region consists of the trade and service street stretched about 2 km along the Ayush avenue, which separates the III and IV microdistricts. As seen from the results of the interpretation, in this region the high rise and middle rise residential houses occupy 15,2 hectares (ha) or 49,9%; general educational schools, crèches and kindergartens occupy 6,39ha or 21%, trade and services areas occupy 3,75ha or 12,4%; research institutions, schools occupy 1,3ha or 4,3%; companies and banks occupy 0,85ha or 2.8% of the total area, thus forming the prevailing portion of the land use. These microdistricts which were constructed in 1970s and 1980s consist of several residential apartment blocks and neighborhoods together with schools, kindergartens, trade and services centers. The average radius of the apartment or neighborhood was planned to be 400-500 meters and their trade and services centers to be located neighboring each other in the Ayush avenue. During the process of the transition period which started in 1990, on the bases of the old apartment blocks, trade and services buildings there were centered many new types of land use such as supermarkets, garment shops, electronics, cosmetics diversified groceries, department stores, banks, companies as well as universities and institutes, hotels and restaurants. As results of this, this street started to play the role of a general commercial or commercial center with own local character. Moreover, inside of the residential blocks of the microdistricts there were established and opened a great number of offices, hotels, restaurants, night clubs, private universities and institutes, supermarkets, which diminished the environmental value and quality of the given residential area. In addition, one of the negative phenomena occurring in the current land use of the residential areas is that there are being constructed too many low-rise buildings designated for auto garages and

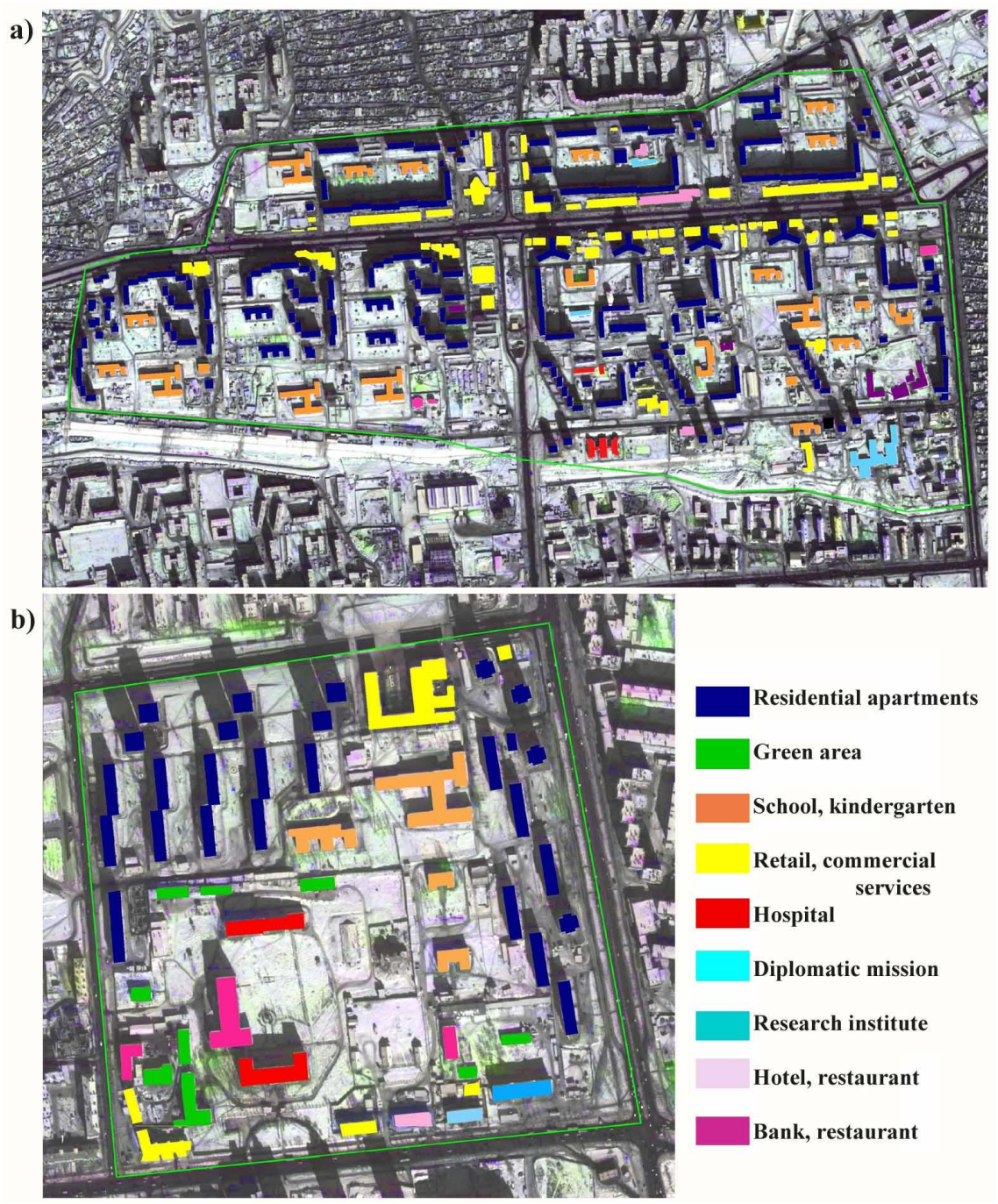

Figure 3. The land use types interpreted from the Brovey transformed images.

a) General commercial area, b) Neighborhood commercial area.

other construction facilities of cheaper value and quality. This deteriorates the friendly environment and living conditions of the people inside of these areas.

Neighborhood commercial zone refers to commercial area within the residential area. As seen from the results of the interpretation, in this microdistrict, the middle rise apartments occupy 1,9ha or 42,2%; high-rise residential houses occupy 0,61ha or 13,5%; trade and services facilities occupy 0,234ha or 5,2%; general educational schools, crèche and kindergartens occupy 0,69ha or 15,3% of the total area. The service

radius of the given service center is 500 m. The services center was planned from the beginning and constructed with a supermarket, grocery shop for consumer goods, bookshop and communal services center. During the transition period, all of these including the sewing, hairdressing, photographic, postal, cinema and dry cleaning services as well as TV repair shop were privatized. After the privatization, the profile and designation of significant part of these services had been altered and changed to night clubs, entertainment places, hotels and so on. Such a change deteriorates the surrounding environment and makes too much noise, thus worsening the living conditions of people living in this region.

6. Conclusions

The aim of this study was to analyze the land use of general and neighborhood commercial areas of Ulaanbaatar city using RS and GIS techniques. For this purpose, two urban land use sites representing these areas have been selected in different locations. For the analysis, two urban land use sites were selected and historical GIS data as well as SPOT 5 and Quickbird images of 2002 were used.

As seen from the analysis, since the irreversible transfer of the country into the market economy, commercialization became the most important process in these regions and it has influences on the changes of spatial and functional structures. Also, it is seen that there are being formed new types of land use which might deteriorate the residential zones of the urban population. Therefore, thorough urban planning and management based on modern theory and methodologies are urgently needed.

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