Study on Land Use in Industrial and Green Production Zones of Ulaanbaatar City using Quickbird Image

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Abstract: The aim of this study is to demonstrate the use of a very high resolution satellite image for a detailed study in industrial and green production zones of Ulaanbaatar, the capital city of Mongolia. For this purpose, the sites representing the selected land use classes are selected in different locations of Ulaanbaatar city. For the analysis, SPOT 5 and Quickbird images are used and different image enhancement techniques are applied. The analysis was carried out using Erdas Imagine and ArcGIS installed in a PC environment.

1. Introduction

In recent years, the urbanization and urban sprawl have become the common problem in both developed and developing countries. For example, within the last two decades, Ulaanbaatar city, Mongolia has been significantly expanded and changed due to different development activities as well as migration of people from rural areas. To control the urban environment, urban planners need to have detailed spatial information indicating where is what, and analyse the existing land use patterns and predict the future scenario [1,5].

Over the past few years, RS techniques and technologies, including system capabilities have been significantly improved. Meanwhile, the costs for the primary RS data sets have drastically decreased. Now the highest spatial resolution image can be acquired with a cm-accuracy, while the ordinary high resolution images can be acquired with a few meter accuracy. This means that it is possible to extract from RS images, different thematic information of varying scales to be used for rapid urban related decision-making processes.

In recent years, although there have been many functional and structural changes, in the current Ulaanbaatar city one can observe the most common land use classes such as residential, commercial, industrial and green areas. As the thorough investigation of each of these classes requires a large scale study, in the present study we wanted to concentrate only on the land use analysis of industrial and green production zones. For this purpose, the sites representing these zones have been selected in different parts of Ulaanbaatar city and for the analysis, SPOT 5 and Quickbird images have been used. The analysis was carried out using Erdas Imagine and ArcGIS installed in a PC environment.

2. The selected sites and data sources

In general, in accordance with urban planning strategy, an industrial zone can be subdivided into general industrial, exclusive industrial and semi-industrial zones, while a green zone can be subdivided into green conservation, green natural and green production zones [4,5]. In case of Ulaanbaatar city, it is difficult to distinguish full general industrial area, meanwhile, green conservation and green natural areas are mainly located outside of the city fringe. Therefore, in the present study, we wanted to conduct analyses on the exclusive industrial and semi-industrial as well as green production zones. As the study sites, an exclusive industrial zone situated in the region of the 3rd power plant, a semi-industrial zone situated near the carpet factory of Ulaanbaatar city, and green production zone situated near the environmental area of Devshil and Agro Amgalan have been selected. The locations of these sites represented in a SPOT 5 image of 2002 are shown in Figure 1.

Figure 1. SPOT 5 image of the selected sites (Red=band 1, Green=band 3, Blue=band 2).

1-Exclusive industrial zone, 2-Semi-industrial zone, 3-Green production zone.

As the data sources, a SPOT 5 image resampled to a pixel resolution of 4m, a Quickbird image of 2005 resampled to a pixel resolution of 70cm, a topographic map of 1999, scale 1:10,000 and a topographic map of 2000, scale 1:5,000 as well as a general urban planning map were available.

3. Georeferencing and enhancement of the Spot 5 and Quickbird images

Initially, the SPOT 5 and Quickbird images have been georeferenced to a Gauss-Kruger map projection, using a topographic map of 2000, scale 1:5,000. The ground control points have been selected on well defined sites and for the transformation, a second order transformation and nearest neighbour resampling approach [7,8] have been applied. In each case of the georeferencing, an image was resampled to a pixel resolution of 70cm.

Then, 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, different image fusion techniques such as Brovey transform [11], intensity–hue–saturation (IHS) transformation and principal component analysis (PCA) have been applied and compared. Detailed descriptions

of these techniques are given in Richards (1993) and Mather (1999). 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 the present study, the panchromatic image provides more spatial information due to its higher spatial resolution, while the multispectral image provides the information about the spectral variations of the urban land use classes. Image fusion can be performed at pixel, feature and decision levels [3,9]. In this study, the fusion has been performed at a pixel level. Before applying the fusion techniques, a 3x3 size high pass filtering [6,8,10] has been applied to the panchromatic image in order to enhance the edges.

After georeferencing, the images were merged using the above mentioned fusion methods. For the Brovey transform, the bands of SPOT 5 were considered as multispectral bands, while Quickbird image was considered as higher spatial resolution band. 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 channel. The PCA has been performed using the available panchromatic and multispectral bands. As could be seen from the PCA, the first three PCs contained almost 99% of the total variance. The inspection of the last PC indicated that it contained noise from the total dataset. Therefore, it was excluded from the final analysis.

In order to obtain a reliable color image that can illustrate the spectral and spatial variations in 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 image, they still illustrated good results in terms of separation of the available land use classes. The images created by the IHS and PCA methods contained less shadows, however, it was very difficult to analyze the final images, because they contained too much color variations of objects belonging to the same class. Therefore, for the interpretation of the selected land use types, the images created by the Brovey transform have been used (Figure 2).
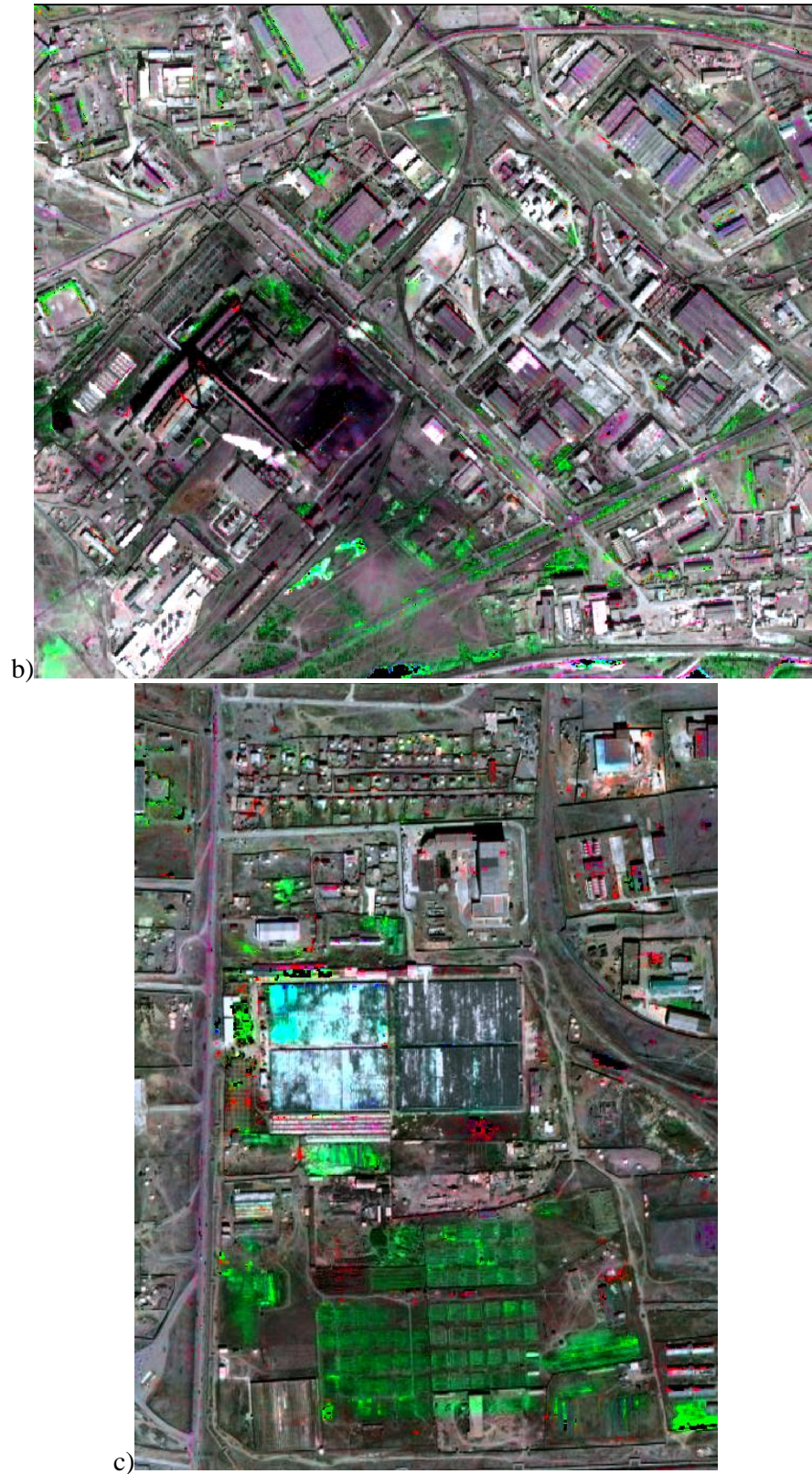
a)

b)

c)

Figure 2. Brovey transformed images of Quickbird and SPOT 5 for the selected sites.

a) Semi-industrial zone, b) Exclusive industrial zone, c) Green production zone.

4. Investigation of land use in industrial and green production zones

Initially, from the Brovey transformed image, the selected land use types have been digitized using screen digitizing module of ArcGIS. Then, for each of the land use types the related analysis has been carried out.

4.1. Exclusive industrial zone

As seen from the result of the interpretation, in this region, heavy industries occupy 6,35ha or 45,1%, companies and banks occupy 5,88ha or 41,8%, trade and service facilities occupy 1,85ha or 13,1% of the total land use. During the period of a centrally planned economy which was used before 1990, in this region such heavy industrial entities as an auto vehicles repairing plant, building manufacturing factory, ferro-concrete factory as well as power station were concentrated. However, after 1990 when the country entered the market economy, there have been established more than 10 companies. Currently, they are carrying out activities in the field of construction materials manufacturing.

4.2. Semi-industrial zone

As could be seen from the result of the interpretation, in this region the light industry building sites occupy 3,19ha or 38,2%, low-rise residential areas occupy 2,98ha or 35,6%, companies and banks occupy 1,55ha or 18,5%, official establishments occupy 0,46ha or 5,5%, universities and institutes occupy 0,18ha or 2,1%. During the period of a centrally planned economy, this region was a light industry production center of the capital city and it had peculiarity to plan and run the production and manufacturing zone together with the residential quarter of working people. However, since 1990 when the country entered the market economy, most plants and factories except the "Ulaanbaatar Carpet" factory were closed down. Currently, the production buildings have very little utilization. Meanwhile, there have been opened and added a few number of new production and services in the given region.

4.3. Green production zone

Devshil and Agro Amgalan companies are engaged in the running of hot and greenhouse economies and produce vegetables for the need of the consumption of the capital city. The agricultural economies operating in this region possess 44ha or 98,6% of the total land use, the light industry occupies 0,22ha or 0,5%, low-rise residential houses occupy 0,24ha or 0,54%, official establishments constitute 0,11ha or 0,24%. Over the years, land use structure in this area has been exposed to minor modifications and changes well keeping its former structure and land use types.

5. Conclusions

The aim of this study was to demonstrate the use of very high resolution RS images for a detailed study in industrial and green production zones of Ulaanbaatar city. For this purpose, the sites representing the selected land use classes were selected in different locations of Ulaanbaatar city and for the analysis, SPOT 5 and Quickbird images were used.

In order to merge the two very high resolution images different image fusion techniques such as Brovey transform, IHS transformation and PCA were used. For the final analysis the

results of the Brovey transform were selected, because the images created by this method illustrated good results in terms of separation of the available land use classes in comparison with the other techniques.

As seen from the analysis, since the country entered the market economy, there were established many companies in the exclusive industrial zone, while there were opened and added a few number of new production and services in the semi-industrial zone. Unlike the industrial zones, the land use structure in the green production zone was exposed to minor modifications and changes, thus keeping its former structure and land use types.

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