РАЗДЕЛ XII. АРХИТЕКТУРА

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Land use/cover changes using RS/GIS techniques: a case study of Belgorod, Russian federation

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Abstract

Land use/cover studies are significantly required for a range of themes and issues due to the case that the changes can affect almost all the aspects of urban areas. Sustainable development depends greatly on controlling the effects of the alteration that occur in urban areas within any metropolitan system. This study discusses generally the changes that occurred during a 42 years of time of Belgorod city within Belgorod oblast of the Russian Federation. The factors that were studied are built up areas, vegetation and green canopy, water bodies, and bare soil areas. The changes that were studied are for the periods of 1975 to 1992, and 1992 to 2017 respectively. The data were acquired from the USGS data collection archive, and EOS Land Viewer. The accuracy of the modeled changes have a limitation, that were taken under considerations, due to the radiometric and spatial limited accuracies of the data. The modeled results of the changes were dramatically diverse and varying, as each period has different direction of growth. The method of classification that were used in this comparative study is neural network supervised classification. The results of this study gave an overall indication of the growth measure and direction of the urban development of Belgorod city during the past 42 years.

Keywords: Urban planning, Remote sensing and GIS, Land use/cover, change detection.

1-Introduction

Land-use and land cover are two separate terminologies that are used often interchangeably, yet there are some differences that must be highlighted. Land-cover can be defined as the physical characteristics of the surface of the earth. It is the distribution of water bodies, vegetation, soil and rocks, and other features that take a space of a land (Dimiyati, Mizuno et al. 1996). This definition includes the activities and consequences of human activities and natural disasters. On the other hand, land-use refers to the purposes, the functions, and the values meant for a space of land. In short, land-use is a term that is associated with the use of the lands, the laws, the codes, the standards, and the developments models of governmental and non-governmental organizations, mainly for economical purposes (Canty 2014). The natural and socio-economic factors utilization in time and space convolute the land use/cover patterns of a region. The sustainable growth of population all over the world, and especially in Russian Federation, are demanding to monitor the dynamics of land use/cover and their growth quality, quantity and direction. Nonetheless, a large number of shifting in the land use patterns, driven by an assortment of social causes, often result in changes that directly affect the biodiversity, water bodies, radiation budgets, greenhouse emissions and other factors that eventually affect the climate and the biosphere (Riebsame, Meyer et al. 1994). In order to formulate a better understanding of the landscape dynamics between two different periods, it is essential to conduct such studies. Due to the case that without these kinds of studies it will be more complex to maintain a sustainable management of resources. The accelerating process and wide spreading changes, that usually entitled with land use/cover changes, usually occurred and caused by natural phenomena and anthropogenic activities. Consequently, these phenomena and activities can erupt the sustainability of the ecosystem (Alonso-Pérez, Ruiz-Luna et al. 2003, Narumalani,

Mishra et al. 2004). The advanced image processing techniques, high spatial resolution satellite imagery and, GIS technologies, formulated a quite effective routines and steady monitoring and modeling of land use/cover patterns. The huge library of RS's data that were acquired over the years and the daily basis of RS data collection made it, also, a necessary tool in land use/cover mapping and modeling(Lo and Choi 2004). During the last three decades, Landsat series imagery represented a valuable and unceasing process of data recording that cover, almost, the whole earth's surface(Li, Jiang et al. 2013).

2- Study area

Belgorod is a city in Belgorod oblast of the Russian federation that is located on the south west of Russian federation only 40 km from the Russian-Ukrainian borders. The area of Belgorod city is 153 km² that represented mostly, according to the results of this study of 2017, by urban areas which is 54% of the city, 44% green areas and bare soil, and 2% as water bodies. Belgorod is the capital city and the administrative center of Belgorod oblast. Seversky Donets river divides the city into two parts and it is considered as one of the main attraction of Belgorod city. Belgorod population, according to the official records, of 2012, is 369,815(UN 2012). The geographical coordinates of Belgorod is located between 50°35'N, and 36°35' within the 38N zone of UTM. The city relief can be noted on the DEM of the city in fig 1. The highest elevation are 223 m above sea level, and hilly areas are on the north and the south west of the city. Obviously the highest point, as can be seen in the DEM, is located north of the city. While the lowest elevation, which is 107 above sea level, can be seen distributed in the middle and east of the city. This DEM can give an obvious indication of the erosions that made the current semi-valley of Belgorod. What can be noticed is that the river basins were, logically, the main cause for these erosions.

Figure 1 Belgorod location and DEM

3. Materials and methods

3.1. Database preparation

Landsat Multispectral scanner system MSS, Landsat Thematic Mapper TM, and Landsat 8 Operational Land Imager OLI were the resources of the data to build the database. The sensors spatial resolution of Landsat TM of 1975 was 60 m, while Landsat TM of 1992, and Landsat8-OLI of 2017 were only 30 m. The data were downloaded from USGS imagery archive. The data sets were imported to IDL ENVI 8.4, to start the pre-processing of the data. False color

composite FCC were made to give a preliminary view of the dataset, and to determine the regions of interest that will be used to guide the classification. In the case of Landsat8-OLI, a layer stack was made to be able to generate it's FCC. The sub-setting of the data were performed to extract the area under study from all the images by taking geo-referenced out line boundary of Belgorod as an Area of Interest AOI. Spectral indices of vegetation, like Normalized Difference Vegetation Index NDVI are widely implemented as a numeric indicator for cross-comparative analysis. NDVI can provide a detailed representation of the green canopy and its health. Low sensitivity to the uncertainties in atmospheric correction and the variety in the satellite viewing, are the advantages of implementing vegetation indices as proxy variables for inter-calibration among other existing sensors (Canty 2014). Furthermore, visible spectral channels, which are blue, green and red bands RGB, generally lead to some extent of spectral band difference effects SBDE. These effects usually formulated with vegetation indices constructed with visible bands. (Wang, Coburn et al. 2014) pointed out that the SBDE often caused by the interaction between the spectral dependence of atmospheric gas transmittance and the spectral response profiles of sensors. NDVI is derived from the red and near-infrared NIR bands, equation 1, results in some SBDE that must be taken under consideration.

$$NDVI = (NIR - Red) / (NIR + Red) \dots \dots \dots \text{Equation 1}$$

Atmospheric correction where conducted using dark-object subtraction DOS technique. This technique allows the users to select a relative atmospheric scattering model to predict the haze values for all the spectral bands and apply the calibration. DOS method normalizes the predicted haze values for the different gain and offset parameters for each data set under study. Neural networks classification method offers to classify data based upon a fast match to overall patterns employing previously calculated weighting factors. Neural network uses a point-by-point comparisons involving algorithmic logic applied to individual data values (Miller, Kaminsky et al. 1995).

3.2. Land use/cover detection and analysis

To complete the land use/cover classification, Neural Network supervised classification method was applied in the IDL ENVI 8.4 Software. As it was mentioned earlier, Neural Network is one of the most popular supervised classification methods used with remote sensing image data. The essence of this method is that it is not only depends on the probability that a pixel belongs to a particular class, yet it will examine each single entry by comparing it to the whole set. The basic theory hypothesize that these probabilities are balanced for all classes and that the data input bands have normal distributions. Nonetheless, according to (Miller, Kaminsky et al. 1995), this method requires long time of computation, depending on the size of the data. And relies heavily on a normal distribution of the data in each input band. Also, it tends to over-classify signatures with relatively large values in the covariance matrix.

4. Results and discussions

The results that were obtained of the multi-temporal satellite imageries of 1975, 1992, and, 2017 have a quite interesting information about the development of Belgorod city. The stages that Belgorod city went through within a period of 42 years are an example of when there is a proper management of resources and city planning, especially in the sense of green canopy. According to the world economic forum (WEF 2017), the highest percentage of green canopy of a city in the world is 25.9% of Vancouver, Canada. Belgorod city has a 21% as green canopy in 2017, 9% in 1992, and 12% in 1975. The green canopy of the city between 1975 to 1992 was heavily deteriorating due to deforestation that occurred during this period. Economic, society, atmosphere, and even politics can play main roles in such alarming deteriorating of the green canopy. Yet, when comparing between 1992 and 2017 it is a quite on the contrary of what occurred in that era, as there was a leap in the size of the green canopy area, or high healthy NDVI areas, in 2017. In this study it is not possible to confirm from the results whether the changes were due to natural causes or by humans interventions. However; the logical possibility is that it was due to human development, taking in consideration that all the reforested areas are within the borders of Belgorod city. All in all, there are 5 classes land use/cover, built up area,

high vegetation area or forests, water bodies, low vegetation, or shrubs and small plants, and finally bare soil. The classification of 1975 has a 24% of the city area as a built up areas, 12% forests, 3% water bodies, 48% shrubs, and 13% bare soil. In the classification of 1992 the percentages differs remarkably. As the percentages were, 54% of the city area is built up, 9% forests, 1% water bodies, 25% shrubs, and 11% bare soil. In the classification of 2017 the numbers are quite relieving in the sense of green canopy of the city. The percentages were as 55% of the total area is a built up, 21% forests, 1% water bodies, 19% shrubs, and only 4% as a bare soil. The statistics of the results are shown in the chart of fig3. What can be noted obviously is that the area of built up in Belgorod has not changed in respect to a 25 years period. The possible explanation is that the training of the computer using ROI's can be a little complicated process. Hence, it is not possible to make the computer differentiate between rural and highways, or between houses complex and a group of caravans or small villages. Usually this happens due to the case that the signature of the examined areas are carrying the same radiometric values, or within the same range.

Figure 2 1975 classification results

Figure 3 chart of the results

5-Conclusion

In conclusion, the land use/cover studies can provide a, reasonably, full picture of what has happened within the urban aspect of a city. And such studies are very vital to decision makers in the sense that it can direct the positive and negative aspect of an urban growth. In this study it was shown the changes that were occurred within two period of not only land use/cover changes but also social and political critical changes. However, such studies requires data with high resolution, or an effective resolution to some extent, to formulate a better understanding of the changes. Due to the case that in RS, the data has four types of resolution, which are spatial, radiometric, spectral, and temporal and each one must be taken under consideration. If the spatial resolution of the imagery data is 60 m, that mean any object less than 60 m will not be modelled properly, or at all. One of the issues that the author faced in this study is that the image of Landsat MSS of 1975 has a 60 m spatial resolution, yet in some areas the main river in Belgorod has a less width than 60m. that meant the river was not modelled into water bodies. These inaccuracies are expected which is why the limitation of the data must be respected to not get a p-hacked results either intentionally or non-intentionally. Temporal, radiometric and, spectral resolution also must be complying with the main objectives of the study. The authors of this study advice the future studies to be carried out with higher resolution data to provide more adequate results, and consecutively a better evaluation of the land use/cover changes of Belgorod. Withal, the results of this study can play an authentically vital rule in directing the urban development of Belgorod city.

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