Analysis of the State of Urban Green Zones under Climate Change Using GIS Technologies (on the Example of Samarkand and Namangan Cities)

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Abstract. Quantifying and analyzing the vulnerability of green spaces is important to ensure their resilience to anthropogenic and climate change. This study considers the possibility of assessing the dynamics of the area of green areas using satellite images. The purpose of the research is to conduct a spatio-temporal analysis of the dynamics of the phytomass of urban green zones, taking into account climatic changes using Landsat satellite images. On the basis of Landsat data, cartographic material was obtained and analyses of the influence of climatic parameters on the dynamics of the phytomass of areas of green zones in the city Samarkand and Namangan were performed. The research methodology consists in decoding satellite images in a GIS environment. The proposed study aims to raise awareness among stakeholders, providing accurate and timely information on current trends in urban forest ecosystems. Using the examples of the cities of Uzbekistan (Samarkand and Namangan), an overview and description of potential indicators of the vulnerability of urban green spaces is presented.

Key words: climate change, Landsat images, NDVI, green areas, Samarkand and Namangan, Uzbekistan.

INTRODUCTION

Climate change and its impact on urban areas pose unique challenges within cities. In this regard, the possible negative consequences of climate change include: heat stress; reduction of areas, change and violation of the species composition of urban green areas; spontaneous natural phenomena; deterioration in the quality of drinking water; an increase in the number of diseases; disruption of the functioning of urban energy systems.

The studies of Gan [1], Fritsch [2], Kabisch [3] are devoted to the study of urban green areas using GIS technologies. For example, Gan [1] conducted a study of the patterns of changes in the urban green environment in Hangzhou, China over the past two decades using Landsat-5 TM time series data obtained in 1990, 2002 and 2010. The method of spectral analysis was applied to obtain fractions of vegetation cover for various segments of the urban area. Despite the complex spectral confusion of different types of land cover in urban areas, accurate and reliable sub-pixel information has been obtained on the proportion of land cover in urban areas. Twenty concentric belts have been identified running from the city center to the edge. The results demonstrated the feasibility of applying finite-member spectral mixture analysis to accurately model the proportion of vegetation in pixels. The authors conclude that over the past two decades, the vegetation cover has declined sharply, although there have been no changes in the scenic areas. Meanwhile, in the existing urban area, there is a noticeable recovery of the green environment. Although the changes were more pronounced between 2002 and 2010 than between 1990 and 2002, this revealed the cumulative effect of rapid urbanization policies and shrinking green

spaces. In addition, research results have shown that regional comparisons of cities with different economic and natural conditions can be made using these methods to study the relationship between urban vegetation and urbanization.

Researchers from the University of Szeged (Hungary) conducted a spatial-temporal assessment of vegetation and vegetation cover in and around Erbil using Modis imagery. At the same time, an assessment was made of the spatial and temporal variations of two vegetation indices (VI) - the Normalized Difference Vegetation Index (NDVI) and the Expanded Vegetation Index (EVI) - as well as land cover in the area of Erbil and its environs for the period between 2000 and 2015. MODIS satellite imagery and GIS methods were used to determine the impact of urbanization on natural vegetation cover. Average annual vegetation indices were used to determine the presence of a spatial-temporal trend, including visual interpretation of MODIS VI time series imagery. The dynamics of vegetation gain or loss was also assessed by examining changes in land cover type to determine the impact of increasing urbanization on the surrounding areas of the city. Monthly rainfall, humidity and temperature changes over a 15-year period were also considered to improve understanding of vegetation dynamics. There was no evidence of a high correlation between climate variables and vegetation performance. Evaluation of the values of the NDVI and EVI MODIS indicators made it possible to determine the presence of an increase in the area of urban areas in Erbil and the bare areas around it. Consequently, over the past 15 years, there has been a reduction in the area of vegetation and its replacement by an urban landscape. Changes in air humidity and temperature over a 15-year period correlated well with the dynamics of changes in vegetation [2]. Along with this, these studies did not allow to separate the influence of urbanization and the climatic factor on the area and state of green zones.

METHODS

Research carried out on the territory of the city Samarkand and Namangan including field and office work. Test plots were laid when assessing tree and shrub vegetation, the technique of expert interpretation of land cover objects using satellite images of medium spatial resolution, and mathematical statistics were used.

CAMERAL RESEARCH

Cameral work included: selection of satellite images of medium resolution Landsat-8 and MODIS for the study area; correction and classification of images; assessment of the accuracy of thematic mapping; determination of indices and climatic indicators. To highlight green zones, we used Landsat-8 and MODIS Terra satellite images for the summer period to analyze climate data for 2000 -2018. All work with satellite images was carried out in the ENVI 5.0 and ArcGIS10.3 software packages.

RESULTS.

Selection of high-resolution satellite images Landsat-8 and MODIS for the study area. The results of the selection of Landsat-8 and MODIS images are shown in “**FIGURE 1**” and “**FIGURE 2**”.

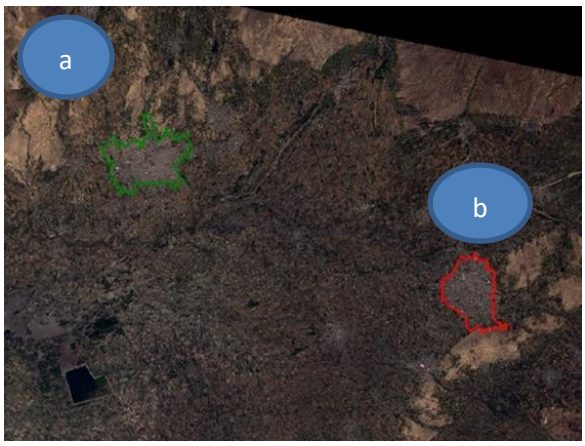


FIGURE 1. Fragment of Landsat scenes for cities: a). Samarkand, b). Namangan.

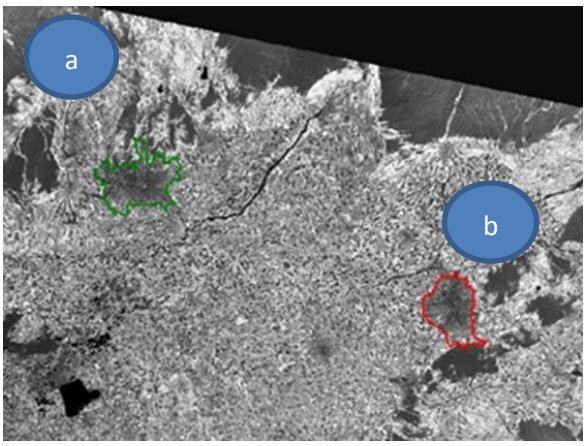
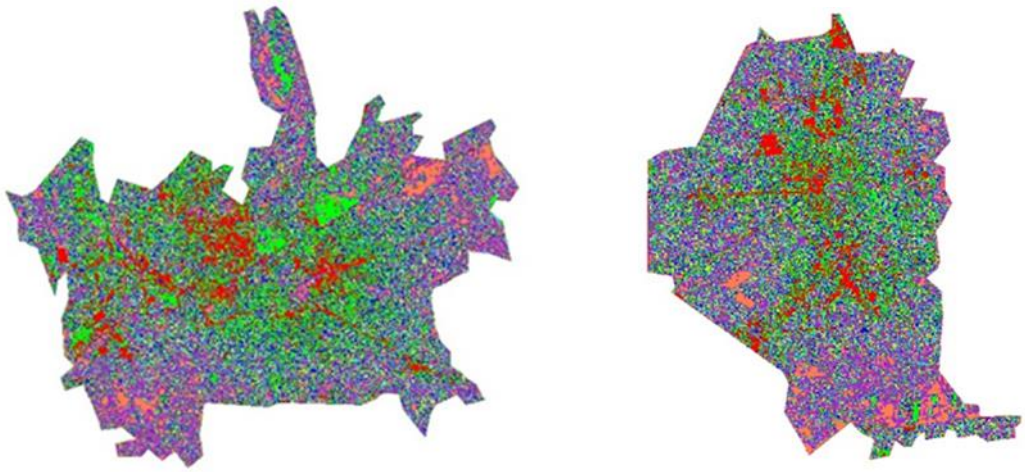


FIGURE 2. Fragment of NDVI thematic maps for the study area: a). Samarkand, b). Namangan.

CORRECTION AND CLASSIFICATION OF IMAGES

The image has been pre-processed (radiometric, atmospheric and geometric correction). The classification was carried out in two stages: primary into 25 classes and secondary included the classification of complex land cover classes into 10 subclasses "**FIGURE 3"**.



a) b)

FIGURE 3. Thematic maps on the territory of cities: a) Samarkand; b) Namangan Assessment of the accuracy of thematic mapping.

The accuracy of thematic mapping was determined by the method of statistical evaluation using cross-analysis of test and thematic data.

TABLE I. Classification accuracy of thematic mapping

Coefficient	**City**	
	Samarkand	**Namangan**
AMA	**0,72**	**0,76**
Kappa	**0.64**	**0.67**

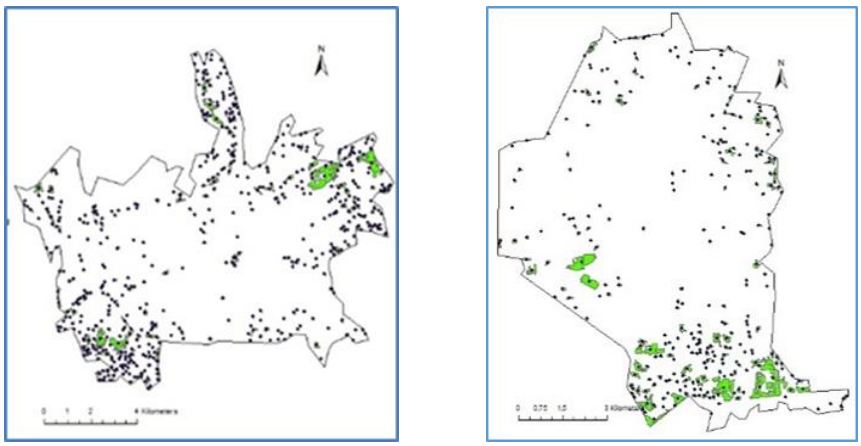
VECTORIZATION OF RASTER THEMATIC LAYERS AND IDENTIFICATION OF URBAN GREEN ZONES

According to the results of the secondary classification, layers were obtained for the territory of the cities of Samarkand and Namangan. Then, from them, based on the results of expert interpretation and field research data, the final vector layer of urban green zones was obtained "**FIGURE 4"**.

a) b)

FIGURE 4. The final vector layer urban green zones for the territory of the cities of Samarkand (a) and Namangan (b) for 2018.

To analyze the relationship of tree and shrub vegetation and obtain the values of climatic parameters for the selected "green zones" from satellite data, vector layers were converted into a point format "**FIGURE 5**"



a) b)

FIGURE 5. Point vector layer on the territory of Samarkand (a) and Namangan (b)

Determination of index and climatic indicators

According to the data obtained based on the processing of MODIS images, the values of the index NDVI, as well as the values of climatic parameters: precipitation and temperature, were obtained from a series of thematic maps from 2000 to 2018. The extraction of indicators of the selected parameters was carried out according to the principle of one point - one value. The values were taken for each month throughout the year for the entire estimated period. As a result, a database was formed for two indicators for the subsequent assessment of their relationship.

Identification of patterns of spatio-temporal relationships

The regularities of the relationship of the dependent parameter NDVI characterizing the dynamics of phytomass and the general state of the vegetation cover of green zones and independent parameters in the form of climatic data, temperature and precipitation were assessed using the method of two-factor regression analysis in the Excel software environment. The analysis was carried out both for averaged data for two urban areas, and separately for each of the objects. Analysis of statistics showed that both key climatic factors, temperature and precipitation, have a significant impact on the vegetation cover of urban areas, regardless of location. The relationship between climatic parameters and NDVI values for the territory of cities was: for Samarkand – $R^2 = 0.63$, for Namangan – $R^2 = 0.57$

CONCLUSIONS

The paper studies urban areas using GIS technologies. Field studies were carried out within the distribution of urban green zones. Based on the results of the thematic classification, cartographic material was obtained in the form of a layer of "green zones" for two large urban areas of Uzbekistan. The article presents a methodology for assessing the relationship between the index indicators of the vegetation cover of areas of "green zones" of urban areas with climatic parameters based on satellite data. Comparative regression analysis revealed a stable influence of climatic parameters (temperature and precipitation) over the study period of 18 years on the state and volume of phytomass (NDVI data). The temperature regime has the greatest influence on the NDVI dynamics, i.e. the onset of the growing season corresponds to an increase in temperatures. Precipitation, in view of their unstable and uneven fallout on the study area, has a weak positive relationship with the phytomass of green zones. Spatial analysis revealed a moderate degree of variability in NDVI dynamics in green areas of the city for the estimated time cycle of 2000-2010-2018. The use of satellite data for monitoring green spaces is a highly effective opportunity for multi-level and sequential assessment and analysis of urban ecosystems. The use of this technology will make it possible to obtain objective data in the form of cartographic material and statistical data at minimum cost for making responsible decisions in monitoring the sustainability of the urban environment.

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