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Artificial Intelligence-based assessment of urban green spaces and heat island

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Abstract

The aim of this research is to determine the availability of green facilities per person as well as the heat island impact of the Ikh toiruu area, which is the central area of Ulaanbaatar city. Green areas are determined from year of the 2015, 2020, 2021 high-resolution imagery/Maxar/. Deep Learning was used to quantify green areas on high-resolution Maxar satellite imageries from 2015, 2020, and 2021, while Landsat-8 satellite data from 2014, 2015, 2018, and 2019 was used to assess heat islands. For the years 2025, 2030, 2035, and 2040, the correlation between population increase and green facilities has estimated. Based on the demographic study, the quantity of green space per capita was calculated, and the impact of expanding green space in public places was calculated and compared to municipal planning criteria.

Key words: Deep learning, High-Resolution image, Urban, Heat island

1. Introduction

Land cover is a collection of objects and things formed on the surface by natural and human activities, also its structure, composition, and changes are essential variables in determining the condition of the environment and long-term development. It is possible to identify the condition of a certain area and changes over time using remote sensing imagery, also various land cover and usage maps can be obtained for this purpose using various digital processing methods.

Because of the developing country's capital city stands as the center for all aspects of the economy, education, and social services, it is common for the population to be overcrowded. Ulaanbaatar, like it, is the hub of all industries and home to more than half of Mongolia's population. Mongolia, despite its small population, is rapidly urbanizing. For example, Ulaanbaatar, the capital, has expanded exponentially in recent years as a result of a variety of factors, including industrialization, marketplaces, rural migration, and land tenure [1].

Rural migrants make up the majority of Ulaanbaatar's population. As a result, overpopulation is 150 times the national average, and many of people are required to live in ger areas, which are rapidly spreading and negatively impacting the city's ecology. The chaotic development process in the section of Ulaanbaatar with an integrated engineering network has resulted in a rapid growth of engineering infrastructure, roads, and public transit that is two to three times greater than it should be and does not fulfill the population's expanding demands. Intensive urbanization is the primary cause of the heat island effect's growth and has a negative impact on the environment [2].

2. Research area

The boundary area of Ulaanbaatar or 7699266 m2 was selected for the study area (Figure 1). The built-up area of the capital city of Ulaanbaatar is 1260-1350 m above sea level, and the entire surface is a series of slopes extending from the northern highlands to the Tuul River basin.
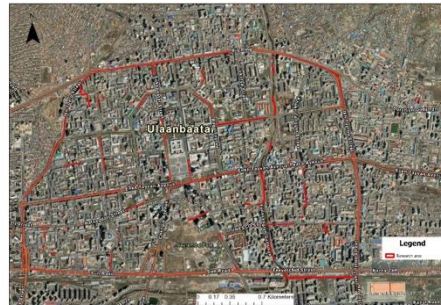

Figure 1 . Location of reasear area

Ulaanbaatar is home to the great bulk of Mongolia's metropolitan population. Natural disasters like as droughts and dzuds in agriculture have caused chaos on herders since 2000, prompting a surge in migration to big cities and towns, particularly Ulaanbaatar [2].

3. Methodology

Deep learning in GIS

Deep learning can be used with a variety of raster products in ArcGIS Pro, ArcGIS Enterprise, and ArcGIS Online. In this course, the focus will be on applying deep learning to imagery in ArcGIS Pro using the ArcGIS Image Analyst extension. Deep learning models used in GIS employ a specific type of neural network called the convolutional neural network. This type of neural network is designed for analyzing raster images and interpreting their content, which is known as computer vision. Deep learning tasks that work well in GIS can be categorized into four types: image classification, object detection, semantic segmentation, and instance segmentation [11].

Figure 2 . Methodology

4. Research result

Using deep learning and high resolution satellite data, Field, Tree, and Plant were classified.

- Tree: Identified the lack of trees at the Ikh toiruu
- Field: land that is suitable for decorating.

The area of green structures required in the future is computed based on the projected population growth in Ulaanbaatar City in 2025, 2030, 2035, and 2040.

Heat island

Using imagery from the Landsat-8 satellite obtained in 2014, 2015, 2018, and 2019, the land surface temperature was estimated. Other years, the study area's heavy cloud cover prevented the computation from being done.
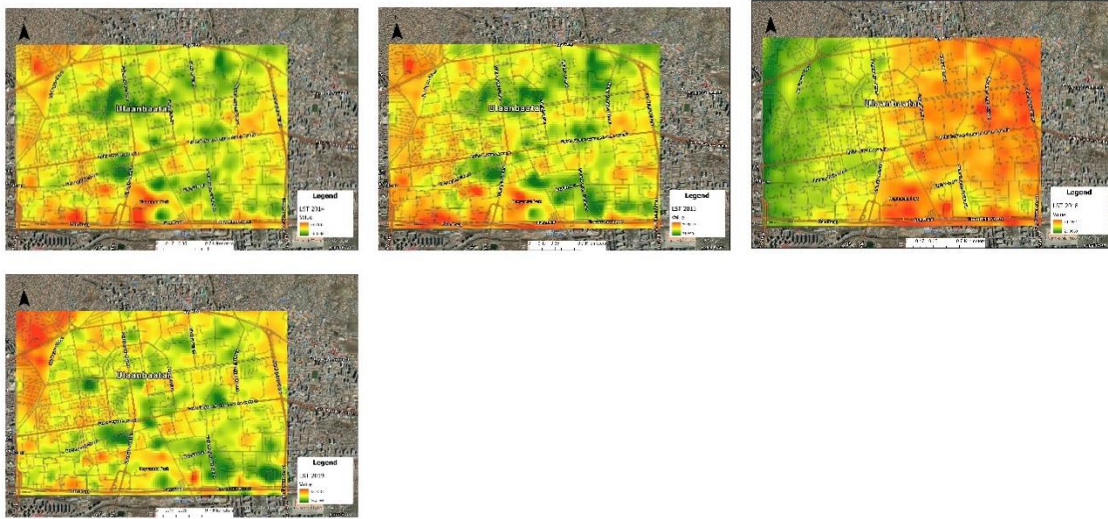

Figure 3 . Heat island of Ulaanbaatar
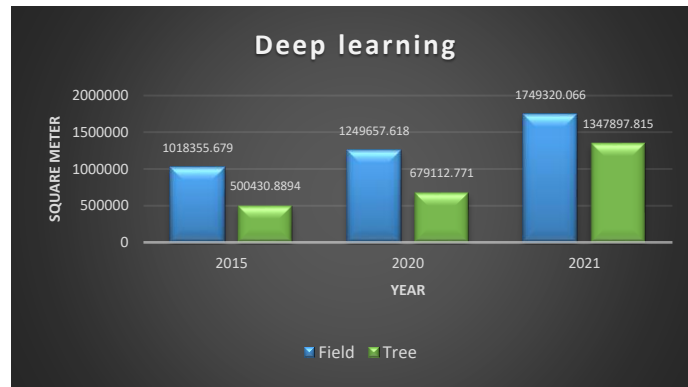
Deep learning үр дүн

A combination of red, nir, and blue bands were created in the MAXAR satellite images from 2015, 2020, and 2021 in order to highlight plants and trees, and the following classification was made using deep learning. It contains:

- Plants and tree
- Field

Figure 4 . Deep learning classify of Ulaanbaatar
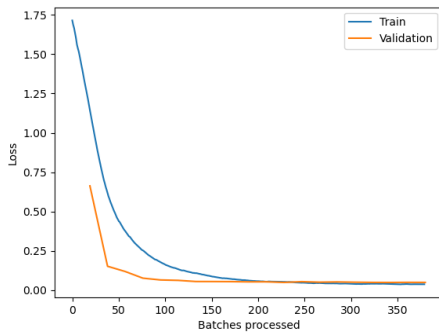
Graphic 1.. Deep learning classify of Ulaanbaatar

Analysis of the model

Backbone: resnet34

Learning Rate: slice('4.3652e-06', '4.3652e-05', None)

Table 1. Training and Validation loss

|	NoData	forest	field
precision	0.989943	0.946840	0.934186
Recall	0.999869	0.920341	0.984952
f1	0.994881	0.994421	0.955644

Figure 5 . Training and Validation loss

The process of creating sample data for artificial intelligence model is shown in the image above, along with the errors occured in each batch as the model is being trained.

Table 2. Population growth of Ulaanbaatar

	2020	2025	2030	2035	2040
Developed cities	1990966	2038070	2011342	1893783	1766742
Mongolian standard	1433495	1467410	1448166	1363524	1272055
Current situation	1347898	1347898	1347898	1347898	1347898

Estimates of required green space

Graphic 2.. Need for green spaces
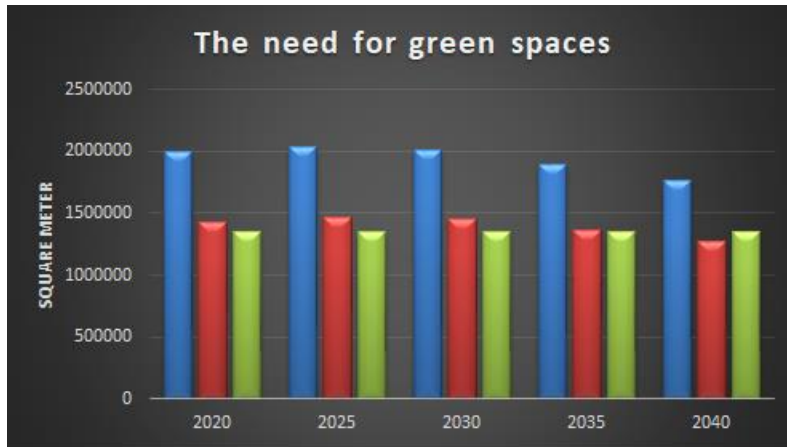
Trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Shaded surfaces, for example, may be 20–45°F (11–25°C) cooler than the peak temperatures of unshaded materials.1 Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2–9°F (1–5°C)[10].
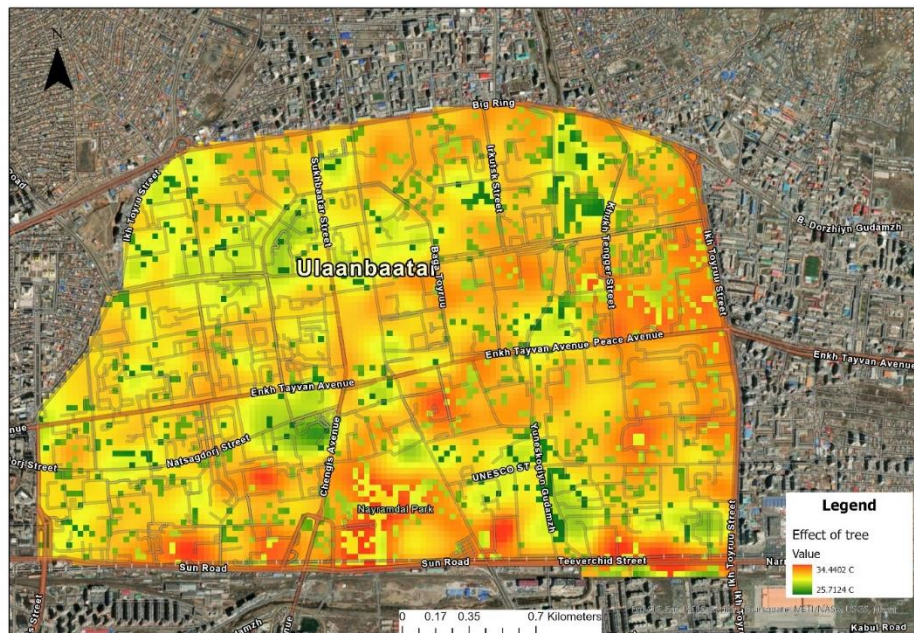

Figure 6. Possibility of temperature drop

The research's results show that by converting the categories that are now categorized by field into green structures, it could be possible to reduce the research area by an average of 1 degree celsius while also increasing the number of green structures by 1749320.066m^2. By 2040, there must be twice as much green space per person in the Ikh toiruu than there is now in order to reach this goal—a total of 16 m2 per person.

5. Conclusion

In this study, the center of Ulaanbaatar was chosen as the research area, and the demographic figures for the five-year period between 2020 and 2040 were used to compute the number of green facilities per person.

We developed a model using Maxar satellite data using deep learning, and we calculated the quantity of green space in Ulaanbaatar city center. It is expected that this model will be able to calculate the quantity of green spaces using the very accurate Maxar satellite data in the future.

Ulaanbaatar will gain various advantages by converting the field into a green space, one of which being is a 1-degree drop in the heat island's temperature. Even while a 1 degree drop in temperature may not seem like much, the average world temperature has increased by 1 degree during the past 50 years, and as a result, several changes are taking place. Therefore, constructing more green areas is one of the most effective methods for preventing changes in the environment.

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