MULTI-LAYER PERCEPTRON-MARKOV CHAIN-BASED ARTIFICIAL NEURAL NETWORK FOR MODELLING URBAN EXPANSION IN ULAANBAATAR, MONGOLIA

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Abstract:

Urban growth in various cities across the world, especially in developing countries, leads to change in land use. Thus, predicting future urban growth in the rapidly growing region of Mongolia becomes a significant endeavor.

The vast majority of Mongolia's population lives in Ulaanbaatar. Since 2000, natural disasters such as droughts and dzuds in agriculture have hit herders hard, and migration to large cities and towns, especially Ulaanbaatar, has increased. The availability of reliable jobs in urban areas is attracting more people and expanding the urbanization process. In the near future, migration is expected to continue having a significant impact on Ulaanbaatar's population growth. This is due to the over-concentration of social forces in Ulaanbaatar, such as education, health, economy, infrastructure, public administration, and culture. In the “ger district” (circular nomad’s tent-yurts detached to a land lot is a type of slum settlement district in Mongolia) sprawl area, which covers about 32% of all territory of the city, urban expansion has accelerated so far so it adversely impacts green belt areas, wetlands, riparian zones, open space, and public land.

According to the 2019 survey, 67.2 percent of the total population of Mongolia lives in urban areas, of which 45.3 percent or one in two people live in the capital city. Ulaanbaatar, which accounts for only 0.3 percent of the country's territory, is densely populated, with a large population. In particular, 95.1 percent of the total population of the capital city lives in the six central districts.

Mongolians are starting to use GIS with remotely sensed data and artificial neural network modelling techniques for urban expansion studies. The aim of this study is to simulate urban growth using multiple Landsat data of 2018, 2019 and 2020 by integration of multi-layer perceptron neural network and Markov model. This study primarily considered Ulaanbaatar, the capital of Mongolia, which experienced rapid Land use land cover (LULC) change due to anthropogenic factors. Multi-layer perceptron neural network approach has been used to calculate conversion probabilities for urban growth. These conversion probabilities have been used in Markov model for urban growth simulation. This method has been implemented to Ulaanbaatar to find out urban growth.

The satellite data were classified in the most similar way by creating a total of 5 class segments: buildings, forests, plants, soil, water, and sand. Landsat-8 was classified using the most similar method using satellite data. In the calculation of the change, each classified class had different spatial increases and decreases, which resulted in significant changes in the size of the constructed area depending on the redevelopment. The greatest change occurred in the soil, and in terms of location, a significant amount of soil cover was reduced in the southern part of the study area. Clark Lab’s (Clark University) Geospatial Monitoring and Model software had been used for the urban expansion prediction.

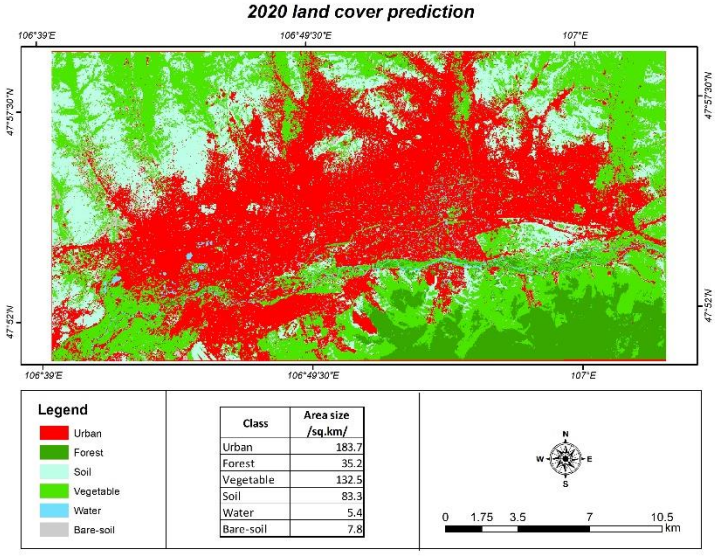
A new 22.4 sq.km built-up area or residential area has been created within the study area, of which 20 sq.km, or the largest change, has been converted from soil to built-up area. Between 2018 and 2019, the location of

the newly constructed area has increased significantly to the southwest, west, and suburbs of the study area. The new settlements indicate that Ulaanbaatar is expanding in an unorganized and chaotic manner.

The results of the 2018 and 2019 classifications were used to calculate the surface change using the "Land Survey Calculation Model" (LCM). To calculate the probability of the transition, the multi-layer perceptron model, one of the artificial intelligence network structures, was used as the baseline, using the results of ground cover changes and sub-data such as roads, city centers, surface water, and buildings. When using multi-layer perceptrons, 7 hidden layers were created to make the calculations more accurate, with an accuracy of 70.63 percent.

In 2018-2019, the vegetation cover in the study area increased by 26.9 percent, while the soil cover decreased by 13.1 percent. The results of the study show that the urbanization trend in Ulaanbaatar is to the west and southwest, with vegetation and built-up areas increasing, while soil cover tends to decrease.

For the data validations, and accuracy assessment error matrix was calculated to compare with archived field reference data mapped in two years 2018 and 2019. The simulated urban growth for 2020 is cross tabulated and validate with actual urban growth of 2020. Based on the LULC analysis the classification results showed that the overall accuracy of LULC maps achieved from 59.2 to 94.4 percent. We found that the land use/land cover map resembles previous field survey data assessments of areas with the same classes of land use. Our Markov chain model map corresponded with the field reference map. The Kappa coefficient of urbanized area in 2020 had a positive 0.88 value, which indicates that the classified map has a strong agreement with ground truth data. This result showed that the CA-Markov chain model has good potential to accurately predict future land-use changes.



Keyword: simulation validity; land use/land cover; growth prediction; Ulaanbaatar