



## THE ESTIMATION OF URBAN EXPANSION EXTENT AND FRACTAL DIMENSION

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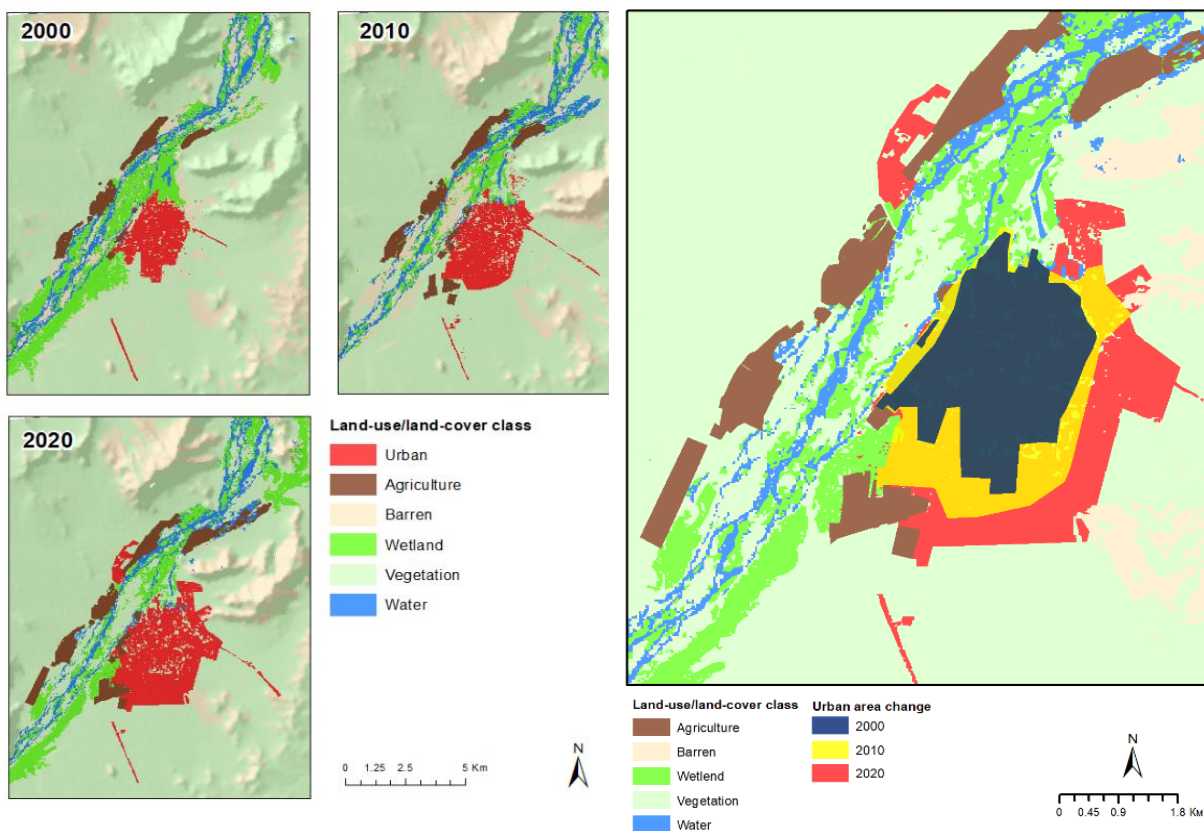
**Abstract:** Urban expansion leads to severe negative impacts such as an increase in motorized transport, air contamination, water and noise pollution, excessive energy consumption, a loss of agricultural land and a reduction of pre-urban biodiversity. Information on current urban extent spatial metrics and the dynamic of land use/cover change is essential for urban planning as a "crucial clue". The aim of this study is to measure the shape of the Khovd town and to prove the 20-year time series change of spatial expansion through the fractal geometry of urban land use with the help of mathematical procedures and GIS analysis. The study area is located in the north-western part of Mongolia in geographic point location N 48 ° 00' 15 " latitude and E 91 ° 38' 26 " longitude, at an altitude of 1380 m above sea level. Khovd town was chosen for the study area as a major hub for the western economical region and political administration.

The shape, land patches distribution, and expansion of the urban area were analysed based on the created feature layer of the Geographic Information System (GIS). GIS feature layers were developed based on data from cloud-free Landsat images of thermal mapper (TM), enhanced thermal mapper (ETM), and operational land imager (OLI), which were acquired for the nearest same month time frame 2000, 2010, and 2020. The time-series satellite images were downloaded from the website of the US Geological Survey. The Landsat images were additionally rectified to datum WGS84, and resampled using the cubic convolution algorithm with a pixel size of 30 by 30 m for all time-series 3 satellite images. The supervised classification with sampled objects was used for the classification of the land use classes and urban expansion extent. Maximum likelihood classification is one of the well-known parametric algorithms and it was used for supervised classification in our study. To be more accurately represent the urban land use, Landsat imageries (30 m resolution) were reclassified and the accuracy and detailed classes added through onsite land surveyed map layers for the detailed sub-classification of urban land use, such as low-density residential (slum area) and sparse suburban land (peri-urban area) classes.

The fractal dimension index is an accepted method in international urban research, and is especially important for accurately determining urban expansion. Concepts from fractals can be used to optimize the spatial structure of cities in future urban planning. A compactness ratio is a key urban geography index for research on urban spatial expansion extent. Compact urban shape extent is one of the most effective solutions for sustainable development under the rapid growth of the urbanization

The concept of a “compact city” was first proposed by Dantzig and Saaty in 1973, and since then a methodology of measuring urban compactness has been an interesting topic on urban study. The novelty of our study is an application of a compactness index together with fractal dimension index which is not widely used in urban study.

A slight decrease in fractal dimension ( $D\Delta t = 0.01$ ) indicates that in 20 years the urban envelope was already started to extend but in the right geometrical shape forms. The density index in Khovd has increased over 20 years (0.25-0.28) and is relatively stable and the densest urban land patches are concerted right behind and around the downtown center. The expansion of Khovd town shows relatively stable and correct shape form extent and the areal expansion of urban area was 3238 ha or average annual growth of 162.4 ha /years in 20 years, while perimeter growth is 43325 m (2166.25 m/years), which is represented quite compact and relatively stable expansion. Briefly, Khovd town development is sustainable in sense of land management. However, need to pay attention to the slight growing increase in the urban expansion. There’s no significant readjustment plan for the low-density slum district reconstruction and therefore urban expansion sustains the most possible way to land exploitation. For that reason, at the municipal level, there are should look at rural area sustainable development in parallel to the town readjustment urban planning. Our study results indicate that it is more effective to study urban expansion (especially fractal geometry), to use GIS and remote sensing methods for urban spatial metric study.



**Figure 1.** Main land use/land cover change of Khovd town (2000-2020)

**Keywords:** Spatial metric; Urban growth; Urban remote sensing; Urban area perimeter relationship