THE ROLE OF GIS AND RS FOR PASTURELAND STUDY IN NORTHERN MONGOLIA

D.Amarsaikhan[1], M.Saandar[2], B.Byambadolgor[1], E.Jargaldalai[1] and D.Enkhjargal[1]

[1]Institute of Informatics and RS, Mongolian Academy of Sciences
Ave.Enkhtaivan-54B, Ulaanbaatar-51, Mongolia; Tel: 976-11-453660, Fax: 976-11-458090

[2]MonMap Engineering Services Co., Ltd
Seoul Street-12/6, Ulaanbaatar, Mongolia; Tel/Fax: 976-11-327824

KEY WORDS: Pastureland study, Geographical information system (GIS), Remote sensing (RS)

ABSTRACT: At present, GIS and RS techniques are being widely used for monitoring and management of pasture resources. As Mongolia has enormous pasture land in comparison with its 2.9 million inhabitants, the country has a great potential to use a wide range of spatial techniques. This paper describes a general overview and some methodologies to use GIS and RS techniques for the improved management of pasture resources in the country taking an example in northern Mongolia.

1. INTRODUCTION

Mongolia is situated at the Central Asian highland and borders with Russia in the north and with China in the south. The geography of Mongolia is characterized by great diversity and is divided into such zones as forest taiga, forest steppe, steppe, dry steppe, rocky mountains and Gobi. Pastureland plays an important role for the Mongolian animal husbandry, because they are grazing home to over 50 million head of livestock and are used by over 200,000 herding families. Mongolian livestock producers still contribute a lot to the national economy. For example, in 2013 agriculture dominated by the livestock sector accounted for definite amount of GDP, while livestock products such as cashmere accounted for increased percentage of the recorded value of the country's exports (Amarsaikhan, 2013).

In recent years, due to rapid development in space, communication and information technologies, RS and GIS techniques and technologies have been significantly evolved. System capabilities have greatly improved. Meanwhile, the cost of many of the data sets has drastically decreased. Now the highest spatial resolution image can be acquired with centimetres-accuracy, whereas the ordinary high-resolution images can be acquired with a few metres accuracy (Amarsaikhan *et al.* 2009). That means, it is now possible to extract different thematic information of varying scales, to integrate the extracted information with other historical data sets stored in a GIS and to conduct sophisticated analyses.

Mongolia has a very large pasture area in comparison with its over 2.9 million inhabitants. Therefore, the country has a great potential to use a wide range of different GIS techniques for the pastureland monitoring and management. As the country lacks large and middle scale thematic information, RS images with different spatial and spectral resolutions can be successfully used to update the layers of pasture database as well as for real-time land cover analysis. This paper describes how to use GIS and RS techniques for improvement of the present pastureland studies in Mongolia selecting a test site in northern Mongolia.

2. THE STUDY AREA AND DATA SOURCES

As a test site, Khuvsgul aimag (province), northern Mongolia has been selected. It has about 123,000 inhabitants and area of 100,628.82 sq.km and borders Russia to the north, west and east, and Zavkhan, Bulgan and Arkhangai aimags to the south. The aimag is one of the most beautiful places of the country with its snow-capped majestic mountain ranges, freshwater lakes, dense forests and vast river valleys. The province accounts 3,800 cubic meter of wood per capita, which makes the aimag the richest in forest resources. In addition, Khuvsgul aimag is rich in different types of mineral resources as well as in natural vegetation. The soil in the territory is grey and there is dark soil in the valleys. The annual precipitation of about 400 mm makes the area the most humid region in Mongolia.

Additionally, the aimag is famous of its Lake Khuvsgul. To be known as "The Dark Blue Pearl" among beautiful mountains, it is the second-most voluminous freshwater lake in Asia, and holds almost 70% of Mongolia's fresh water and 0.4% of all the fresh water in the world. It covers 2,760 square kilometers in surface, 136 km long and 36 km wide, and 262 meters deep and is located at an altitude of 1645 m above sea level. The lake is surrounded by

several mountain ranges. The highest mountain is the Burenkhaan /Munkh Saridag (3,492 m), which has its peak north of the lake exactly on the Mongolian-Russian border.

As data sources, a pasture map of 1990, scale 1:1000,000, a land use map of 1990, scale 1:1000,000, a topographic map of 1986, scale 1:500,000, an administrative map of 1990, scale 1:1000,000, multispectral Landsat ETM+ data of August 2013 with a spatial resolution of 30m, red and near infrared bands of MODIS data of June 2014 with a spatial resolution of 250m have been used. The administrative map of Khuvsgul aimag is shown in figure 1.

Figure 1.The administrative map of Khuvsgul aimag.

3. THE ROLE OF GIS FOR PASTURELAND STUDY

In recent years, Mongolian pasture has faced serious degradation and the main causes have been the animal overgrazing and droughts. In the country, pasture production varies from place to place and it is very much dependent on the weather conditions and grazing intensity (Sarantuya *et al.* 2005). As the pasture is important natural resource that provides forage to most of the livestock, it should be thoroughly studied and monitored using advanced modern techniques (Ganzorig *et al.* 2005).

Over the years, GIS systems that are powerful tools for storage, analysis and display of both spatial and non-spatial information have been extensively used for pasture monitoring and management. Nowadays, a GIS has become the most powerful tool for assisting in grassland resource inventories and integration of data and mechanisms for analysis, modeling and forecasting. Monitoring changes in spatial distribution and foraging behavior of grazing animals provides knowledge that can help users and decision-makers to understand the relationship between their internal state and environment (Penning and Rutter, 2004, Kawamura and Akiyama, 2010).

Compared to other regions of Mongolia, in Khuvsgul aimag, as the province mainly has forest and forest-steppe landscapes, pasture vegetation has relatively good condition. Also, it has variety of different types (about 30 different types) and relatively high amount of biomass. For example, by land use classification, 42% of the overall land of the province is classified as bushland pasture and 23% is classified as the common pasture. Forest occupies about 31% of the aimag's land and the remaining areas belong to other types of land use. The land use and pasture vegetation maps of the aimag is shown in figure 2.

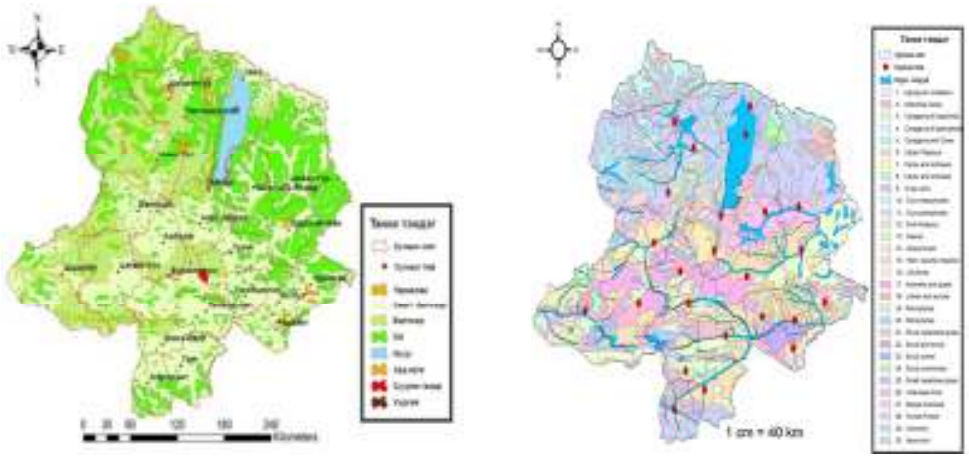

Figure 2. The land use (a) and pasture vegetation (b) maps of Khuvsgul aimag.

As the GIS is a powerful spatial decision-making tool, the land use and pasture vegetation information along with the administrative map can be used for primary pasture related planning and management in the Khuvsgul aimag. For instance, by overlaying all three layers, an analyst can analyze that which specific area or village has what types of vegetation, and whether those types of vegetation can be considered as appropriate fodder resource for the livestock of the region. In addition, combining the extracted information with the pasture biomass data, it is possible to conduct more sophisticated analyses.

4. THE ROLE OF RS FOR PASTURELAND STUDY

Over the years, RS methods have been widely used for monitoring and management of pasture resources. In years past, in Mongolia NOAA AVHRR and MODIS data sets have been extensively used for monitoring of pasture as well as other environmental resources at a national scale. For example, NDVI and biomass estimation using the data from these satellites have been successfully carried out for many years. However, monitoring at a national scale lacks a detailed study and this gap can be fulfilled by the usage of high resolution satellite data sets such as Landsat TM, Landsat ETM+ and SPOT.

When the high resolution satellite data are used for the thematic information extraction (including a land cover map and NDVI), the results can easily be integrated with other thematic information of a regional scale stored within a GIS and can be more reliably used for further spatial decision-making than the data sets of a national scale. Nevertheless, data sets from both national and regional scales integrated with other thematic and statistical information could be efficiently used for different purposes and improve environmental as well as socio-economic decision-making processes.

a) b)

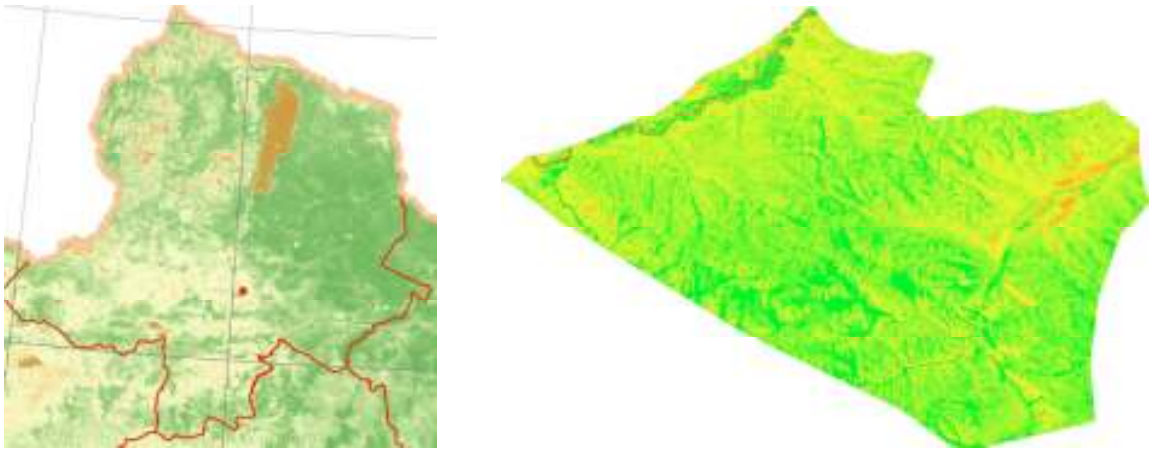

Figure 3. a) MODIS NDVI image of Khuvsgul aimag, b) Landsat NDVI image of Jargalant soum, Khuvsgul aimag.

When RS data sets are used for pasture resources mapping, thematic information may be generated by applying image classification, knowledge-based approach and NDVI (Amarsaikhan and Sato, 2003). In the image classification, various statistical (eg, Mahalanobis distance and maximum likelihood) and non-statistical (eg, minimum distance and isodata clustering) classification methods and their combinations could be applied. In the knowledge-based method, structured knowledge based on human expertise should be used for automatic image interpretation. Different types of this approach have been, and are being developed for information extraction from RS images representing knowledge in different ways. The most commonly used knowledge representation technique is the production rule type that is based on different rules whose conditions have to be fulfilled under certain constraints. Unlike the image classification and knowledge-based techniques, in pasture vegetation context NDVIs might have more applications, because it is possible to relate their values to the biomass information. Figure 3 shows, NDVI images created by the use of MODIS and Landsat data sets.

As seen from the figure 3, after a raster to vector conversion, the NDVI information generated from moderate and high resolution satellite images could be integrated with other thematic layers of the GIS and successfully used for the improved planning and management, thus supporting pasture related decision-making processes at national and regional levels.

5. CONCLUSIONS

The aim of the paper was to describe a general overview and some techniques and methodologies to use GIS and RS techniques for the improved monitoring and management of pasture resources. For this purpose, Khuvsgul aimag situated in northern Mongolia was selected as a test site. As a GIS method, ordinary thematic overlay analysis was considered, while for the RS, three different approaches such as the image classification, knowledge-based method and NDVI were considered. Overall, the study demonstrated that the combined use of GIS and RS techniques could be successfully used for the improved pasture studies.

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