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DEVELOPMENT OF METEOROLOGICAL DATABASE AND ITS LINKAGE WITH RS[1]

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ABSTRACT: At present, geographical information systems (GIS) are widely used for different spatial related decision-making processes. Meanwhile, due to recent advances in space science and technology, the remote sensing (RS) images are being widely used for different thematic applications as well as for update of various GIS layers. The main purpose of this research is to design and implement meteorological database and then update it by the processing of RS data set. In our study, we firstly developed meteorological database, then Landsat ETM image for update of a land cover layer.

1. INTRODUCTION

The traditional method for storing and conveying of spatial information lacks the rapid data retrieval and update. To overcome this problem, in most of the western countries the development of the computerized spatial information systems has begun in the 80s of 20th century. In recent years, due to rapid development in information technology, the costs for appropriate hardware and software to handle both geographical and attribute information in a digital format have drastically decreased. This has given a great chance for countries of the developing world to acquire and use advanced digital technology for their spatial-related applications (Amarsaikhan, 2000).

For environmental planning and management the precise and detailed digital spatial information can play an important role. For example, such information can be successfully used for many different disciplines including weather forescast analysis, land cover change detection, forest and pasture management, water resources monitoring and many others. However, many developing countries have a lack of detailed and accurate digital spatial information, because of a lack of financial support for conducting a measurement to acquire accurate information and upgrading of the existing techniques and technologies. Consequently, they might need to find an alternative method to solve this problem in a cost-effective way and one of the approaches could be the usage of RS images with different spatial and spectral resolutions (Amarsaikhan *et al.* 2007, Amarsaikhan *et al.* 2009).

The aim of this study is to a) design and implement meteorological database of Umnugovi aimag (province), located in southern Mongolia, and b) update the developed database through a processing of RS data sets. For this purpose, topographic maps of the study area, a Landsat ETM image with a spatial resolution of 30m and other existing meteorological data sets have been used. Conceptual design of the database was carried out using a unified modelling language. Then, the database was implemented within ArcGIS system. To update the developed database by the use of RS data, a land cover layer was generated through the processing of a Landsat image. For the information extraction from the RS image, different image processing techniques were applied.

2. THE CHARACTERISTICS OF THE TEST SITE

As a test site, Umnugovi aimag, which has 15 soums has been selected. It is one of the Mongolia’s largest provinces, with a population density of only 0.3 people per sq km. With an average annual precipitation of only 130mm a year, and summer temperatures reaching an average of up to 38°C, this is the driest, hottest and harshest region in the country. The territory of the aimag is semi-desert. The average altitude is about 1,300-1,600 m above

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sea level. The world's famous Gobi desert is located in this province. Over 250 species of flora grow in the territory of the aimag. Many medical herbs, such as astragalus, gentian, flavor nitracia, cynomorium, agriophyllium, and trees such as saksaul, oleaster, populus diversifolia and elm are found in Umnugovi. The rare animals include wild horses, wild sheep, ibex and wild camels.

The area has 15 local meteorological stations. These stations are responsible for meteorological observations and local weather forecasts as well as for monitoring of regional meteorological conditions. Weather information is distributed to relevant authorities for proper environmental management, including the prevention of natural disasters during extreme weather conditions such as dust storm, heavy snow and drought. In the present study we focus on the Mandal-Ovoo soum of the aimag and use 4 weather ground control measurements such as air temperature, wind speed, precipitation and humidity.

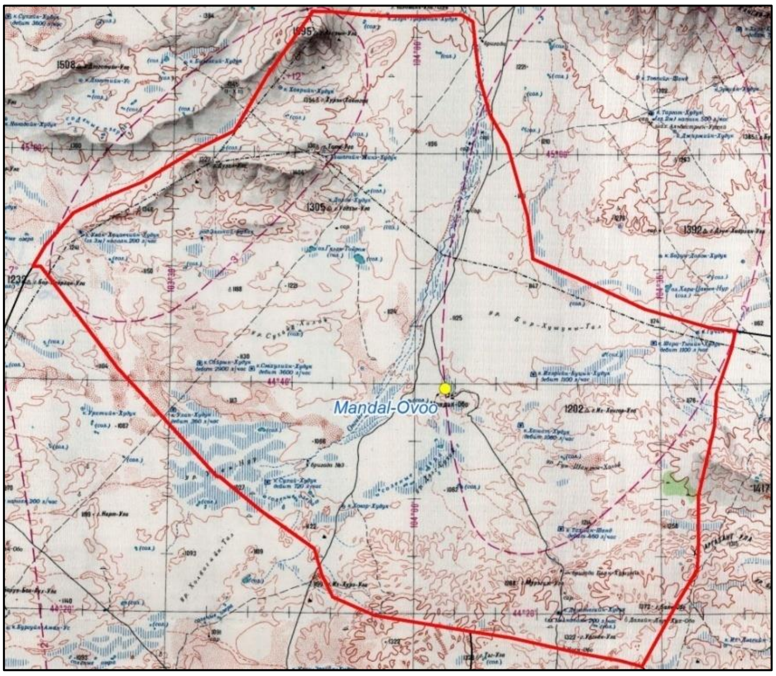

Figure 1: The location of the test area

3. DATABASE DEVELOPMENT

In general, weather information is very complex and they include a variety of different features. As most weather information is related to temperature, solar radiation, air pressure, humidity, wind speed, precipitation and cloud, the digital database could mainly contain data sets based on ground measurements. However, different spatial data sets could be gathered from other sources, mainly from RS, if there is a lack of the necessary information.

In the database development stage, before the commencement of any physical work, the real world should be modeled and the structure of database should be defined. As the spatial entities are parts of the interrelated real world objects viewed by a specific user community, their modeling within a computer environment should follow the following stages (Amarsaikhan, 2000).

- Design of the conceptual model, which describes a conceptual framework for the abstraction, simplification and classification of the phenomena and their relationships as viewed by the user community of the database. At this stage, a logical structure which specifies the logical data content of the database should be defined.
- Physical model, which transfers the specified logical data to the internal data structure.

3.1. Conceptual model

Conceptual modeling describes the conceptual framework for the abstraction, simplification and classification of the phenomena and their relationships as viewed by the user community of the database. At this stage, a logical structure which specifies the logical data content of the database should be defined. For proper conceptual database design one should clearly define different datasets and differentiate all possible entities and their attributes. At this stage, classification and grouping of classes of objects, the reduction of redundancies or duplications have to be thoroughly investigated.

The database should consist of two types of datasets, namely, spatial and attribute. For the representation of spatial datasets a layer based approach can be used as it can easily separate different themes and store them as logically and physically independent datasets. For proper database design and implementation different issues related to the themes (eg, how many, symbols and annotation, relationships and identifiers) and their attributes (identifiers, relationships) should be considered. For the attribute database design, data flow diagrams, flow charts and unified modelling language might be used and the physical implementation can be carried out using relational and object-oriented structures. Here, the entities must be uniquely identified by their ID numbers and different foreign keys should be defined on the basis of determining the relationships among the entities.

3.2. Physical model

The physical model transfers the specified logical data to the internal data structure (Amarsaikhan, 2000). In our study, to develop a topologically structured database, for the physical implementation of the meteorological database, all necessary datasets had to be converted into a digital format using ArcGIS system.

For this purpose, initially, 8 topographic maps of the study area at a scale of 1:500,000 represented in a raster format have been georeferenced to a Gauss-Kruger map projection using 8-9 ground control points (GCPs). For the transformation, a linear transformation and nearest-neighbour resampling approach were applied and the related the root mean square (RMS) errors were 0.29-0.36 pixels. In order to acquire primary digital data, the soum and aimag centers along with their existing borders were digitized from the georeferenced topographic maps using ArcGIS. Then, for each defined entity, the meteorological attributes were entered and the entities were uniquely identified by their number.

<u>Spatial</u> (eg,

<u>Theme</u>	<u>Type</u>	<u>ID</u>	.	.	.
Temperature	point	temp#	.	.	.
Precipitation	point	precip#	.	.	
humidity	point	humid#	.	.	.
. .	. .	.	.	.	.etc.)

Attribute (eg,

Temperature (ID, years, month, degrees, etc,…)
Precipitation (ID, years, month, amount, etc,…)
And all other textual, table documents).

4. UPDATE OF THE DATABASE

Once the digital database is developed, it needs to be regularly updated. In the case of missing data, information should be extacted from any available sources. In the current study, a land cover layer has been generated through the processing of a Landsat ETM image (Figure 2). For this purpose, initially, the image has been georeferenced to a Gauss-Kruger map projection using a topographic map of 1:200,000. The GCPs have been selected on well defined intersections and some geological objects. For the actual transformation, a second order transformation and nearest neighbor resampling approach were applied and the RMS error was 0.91 pixel.

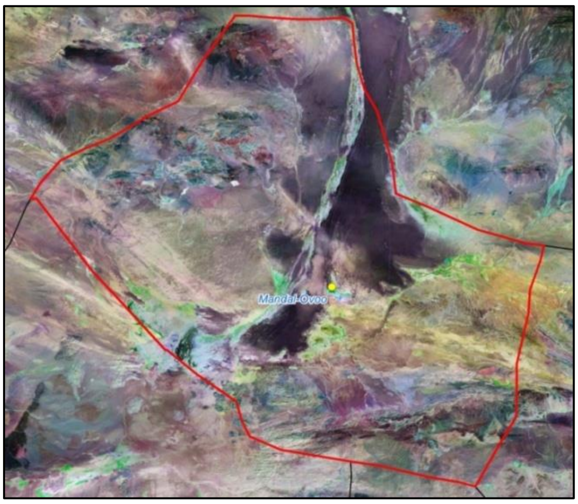

Figure 2: Landsat ETM+ image of the test area

To extract the reliable land cover information from the selected RS data set, a Mahalanobis distance classification has been used (Amarsaikhan *et al.* 2009). As the features for the classification, green, red and near infrared bands have been selected. To define the sites for the training signature selection from the image, several areas of interest have been selected for the available classes (green area, soil, bare soil and mountainous rock area). The separability of the training signatures was firstly checked on the feature space images and then evaluated using Jeffries–Matusita distance (Richards and Jia 1999). After this, the samples demonstrating the greatest separability were chosen to form the final signatures. The final classified image is shown in Figure 3.

For the accuracy assessment of the classification results, the overall performance has been used. This approach creates a confusion matrix in which reference pixels are compared with the classified pixels and as a result an accuracy report is generated indicating the percentages of the overall accuracy (Amarsaikhan *et al.* 2011). As ground truth information, different areas of interest containing pure pixels have been selected. The overall classification accuracy for the selected classes was 86.16%.

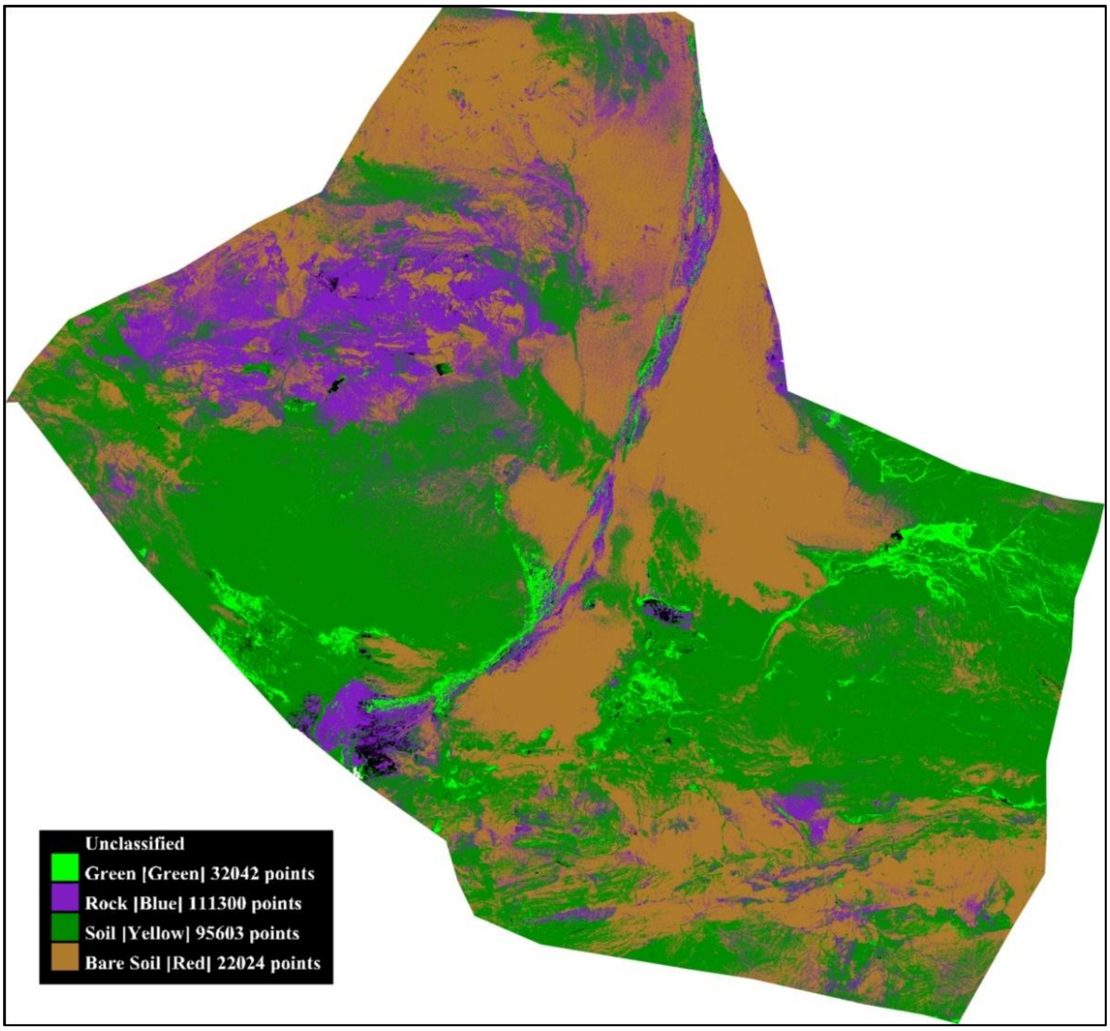

Figure 3: Classified image of the test area

5. CONCLUSIONS

The overall idea of this research was to design and implement meteorological database and update it by the processing of Landsat ETM satellite image. Conceptual design of the database was carried out using a unified modelling language and the database was implemented within ArcGIS system. In general, the development of this kind of information system in Mongolia has been not really organized well. The meteorological database should be extended because it is not only regional weather information, it must provide information for industrial activities related to agriculture, manufacturing, construction and also for public activities and human daily life in total country.

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