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DEVELOPMENT OF FOREST DATABASE IN MONGOLIA

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ABSTRACT: At present, geographical information system and GIS based on web are widely used for different spatial related decision-making processes. National, regional and local forest protection and sustainable use and recovery planning measurements, national policies and programs, reports and other related documents of forest plays an important role in the development of forestry database. The main purpose of this paper was to describe and design the conceptual framework and primary forest database implementation in Mongolia and update result of the forest database using multitemporal optical remotely sensed data. Unified Modeling Language (UML) has been used for design of the database and other relevant advanced software products for implementation and development of the Web GIS.

1. INTRODUCTION

Forest is a very important natural resource that plays a significant role in keeping an environmental stability, ecological balance, environmental conservation, food security and sustainable development in both developed and developing countries (Amarsaikhan, Saandar *et al* 2012).

The forest area in Mongolia is just over 8 percent of the country, mainly located in the north central parts of the country and forming a transition zone of the Siberian taiga and Central Asian steppe. At present, forest resource are decreasing considerably due to climate change and forest fires, forest insects, diseases increasing also human related factors such as overgrazing, mining and improper management, poor enforcement of forest legislation. For this reason, there is strongly needed to implement regular, comprehensive forest database (Amarsaikhan *et al*. 2012).

In recent years, geographical information system and GIS based on web are widely used for different spatial related decision-making processes. National, regional and local forest protection and sustainable use and recovery planning measurements, national policies and programs, reports and other related documents of forest plays an important role in the development of forestry database.

The main objective of this research was to describe and design the conceptual framework and primary forest database in accordance with the law on forest or other forest related laws, policies and database implementation in Mongolia. Also, in this study modern technologies and software have been used for forest database development and multitemporal, optical satellite data used for update of the database. The satellite or aerial data provides real time and comprehensive information for land cover, consequently at present satellite data are widely used for forest resource monitoring and management.

2. DATABASE DEVELOPMENT

Before the commencement of any physical work, the real world should be modeled and the structure of a database should be defined (Amarsaikhan, Sato *et al.* 2003). As the entities in this specific case are parts of the interrelated real world objects viewed by a specific user community, their modeling within a computer environment should follow two stages, namely conceptual model and physical model (Amarsaikhan *et al*. 2000).

Conceptual model

Conceptual model 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 (Batsaikhan.V, Amarsaikhan.D *et al.* 2012). 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 data sets 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 data sets, namely, spatial and attribute. For the representation of spatial data sets a layer based approach can be used as it can easily separate different themes and store them as logically and physically independent data sets. For proper database design and implementation different issues related to the themes (e.g., how many, symbols and annotation, relationships and identifiers) and their attributes (identifiers, relationships) should be considered. 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 (Batsaikhan.V, D.Amarsaikhan *et al.* 2012).

For the attribute forest database design, data flow diagrams, flow charts and UML might be used and the physical implementation can be carried out using relational and object-oriented structures. In the present study, the forest database includes the following sets of objects:

1.1. Forest area
1.2. The protected area covered by forest
1.3. Nurseries raise seedlings
1.4. Grove
1.5. Forest 100 meters from the boundary of the area into zones
1.6. Tree felled area
1.7. Forest resources, components, and their changes
1.8. Review and distribution of forest
1.9. The number of forest fires and fire-affected area,
1.10. Forest pest species, spread and affected area
1.11. Forest maintenance and cleaning of the number and size
1.12. Forest restoration and natural regeneration measures, reforested areas and installed planted trees and shrubs type and quantity
1.13. Citizens, legal persons leasing contract forests
1.14. The quantity of wood used for heating, its fee income

Physical model

Physical model transfers the specified logical data to the internal data structure (Amarsaikhan, 2000). In our study, as we decided to develop topologically structured database, for the physical implementation of the integrated database, all necessary data sets had to be converted into a digital format using ArcGIS system. Initially, for this purpose topographic and historical forest maps represented in a raster format, have been georeferenced to a Gauss-Kruger map projection. After georeferencing, all information on the maps have been digitized and for each defined entity, the necessary attributes were entered and the entities were uniquely identified by their ID numbers.

3. UPDATE OF THE DATABASE

Over the years, for the update of developed database multitemporal optical, radar, and hyperspectral sensor data have been widely used. Once the digital database is developed, it needs to be regularly updated. In the case of missing data, information should be extracted from any available sources. In the current study, a forest layer has been generated through the processing of multitemporal optical images, such as MODIS (2008) and Landsat ETM+ (2000, 2009). To extract the forest information from the selected RS data sets, one of the advanced classification methods should be applied. For this aim, at the beginning, all images were thoroughly analyzed in terms of radiometric quality and geometric distortion (Richards and Jia *et al.* 1999). Then, the RS images should be successively georeferenced to either UTM or Gauss-Kruger map projection using topographic maps of the concerning areas.

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 forest class. 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. As an example of the final classified images, the result of the MODIS and Landsat classification shown in Figure 1.

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 78.01%.

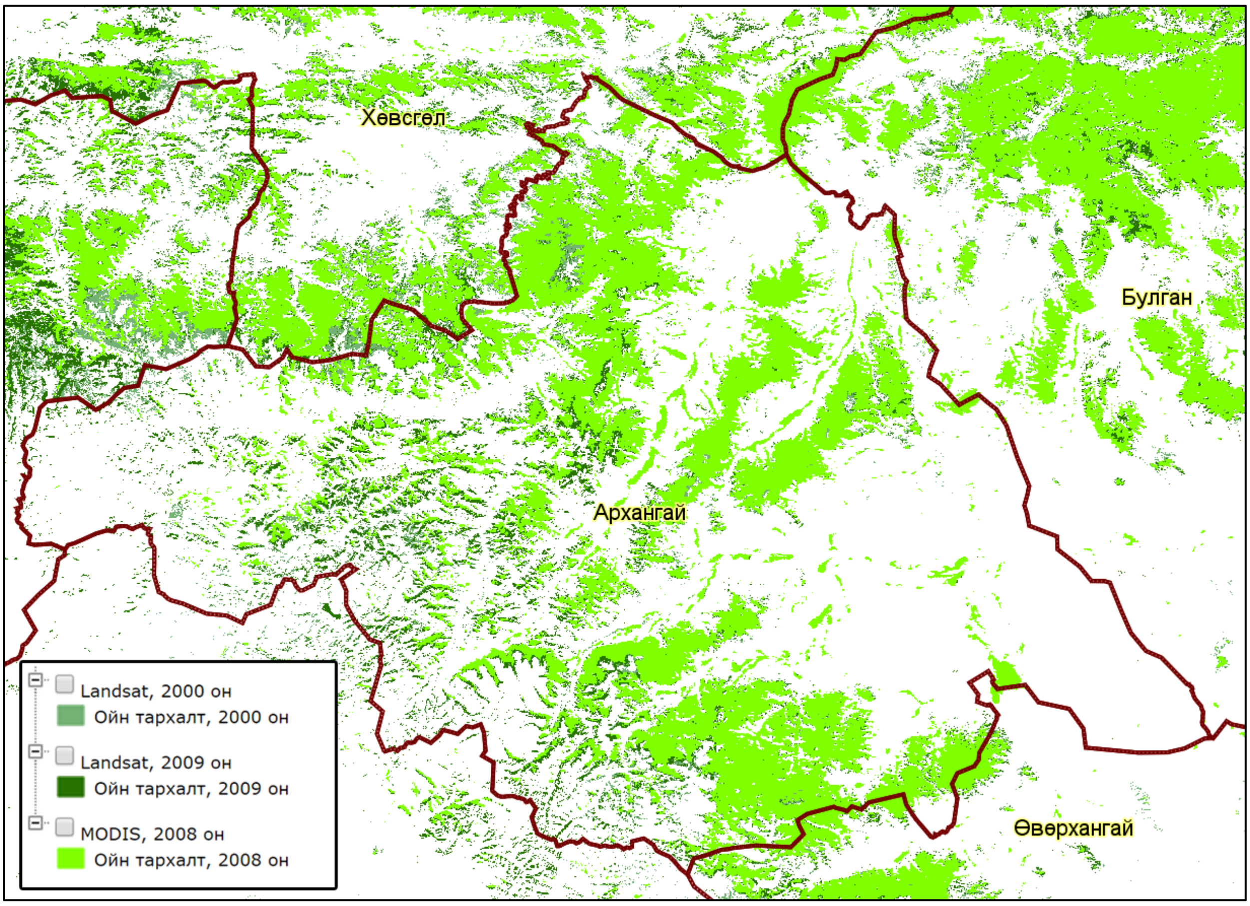

Figure 1. Update of the forest database using optical satellite images, Arkhangai province, Mongolia.

4. CONCLUSION

The idea of the research was to design and implement forest database, in accordance with the law on forest or other forest related laws, policies in Mongolia and update it by the processing of optical satellite images. Conceptual design of the database was carried out using a UML and the physical database were implemented within ArcGIS system. This forest database is useful for forest and other environmental researchers, for instance multitemporal and real-time information of forest area, resources, components, and their changes, etc.

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