LAND INFORMATION SYSTEM OF PRECISION FARMING IN MONGOLIA USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

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ABSTRACT

Remote sensing (RS) and geographic information system (GIS) technologies have been of great use to planners in planning for efficient use of natural resources at national, sub region and rural levels. RS can be used for precision farming in a number of ways for providing input supplies and variability management through decision support system.GIS is the principal technology used to integrate spatial data coming from various sources in a computer. GIS techniques deal with the management of spatial information of soil properties, cropping systems, pest infestations, land use land cover, environment and weather conditions. GIS technology will help the farmers and scientists in decision making, as precise information on field will be readily available. GIS coupled with GPS, computers, RS and sensors is used for soil mapping, crop stress, yield mapping, estimation of soil organic matter and available nutrients.

The objective of this study to develop farming land information system and monitor in the agricultural land cover changes in the Selenge aimag as there is important agricultural producing area in Mongolia.

In this study, maximum likelihood supervised classification methodology was applied to Landsat TM and ETM images acquired in 1989 and 2000, respectively supplemented by topographic maps, fieldwork and use of other existing data. A supervised classification was carried out on the six reflective bands (bands 1-5 and band 7). From this, land cover and farmland maps at 1:10,000 with attribute data were prepared in the area.

Keywords: remote sensing; geographic information system; land information system, precision farming; Mongolia

INTRODUCTION

Agriculture is one of the most important sectors of the Mongolian economy, as it is the major source of employment and the main land and water user. Increasing the level of self-sufficiency in the production of strategic crops (e.g., wheat, barley, potato and vegetables) is one of the objectives of Mongolian policy makers. Currently, Mongolia is importing a significant part of its national requirements for these crops. For economic and social reasons, increasing national production and the level of self-sufficiency is urgently needed.

Mongolian agriculture developed slowly. In the 1930s, the government also began developing state farms. A large scale conversion of grazing land to cultivated land was initiated in 1959-1960 under the virgin lands program.

From 1990s, Mongolia entered a period of transition from a central-based planned economy to a market economy. Early efforts to introduce democracy and build a market-based economy were severely undermined by the socio-economic crisis and generalized unrest that followed the financial collapse of 1994-2000. Before 1991, the most productive agricultural areas were owned by a few public collectives. The change to a market-oriented economy had also an impact on the natural resources and their management, not only due to privatization, but also because of the strong land fragmentation as a result of the land distribution and increased urbanization. For the first time in 30 years people were free to move around. The rural population sharply decreased because of urban drift or migration abroad. The increasing pastoral economy and husbandry caused landscape degradation and natural resources depletion in many regions of the country. Uncontrolled timber harvesting, gold-mining area, overgrazing and overexploitation of wood and other forest products have changed environmental assets. The depletion of forest and water resources, particularly in accessible areas, has become alarming. Scarce possibilities of control and a lenient policy caused severe, sometimes even irremediable, damages to the natural resources of Mongolia.

In a subsequent phase many cropland areas were abandoned and changed followed by people left the rural areas to become resident in urban centers. These urban centers, however, were not prepared to receive the massive influx of people. In the turmoil of such a changing economy and the spatial and temporal dynamics of land cover/use that are continuously evolving, it is important for the Mongolian government to have accurate and timely information for natural resources management, land-use planning and policy development, as a prerequisite for monitoring and modeling land-use and environmental change and as a basis for land-use statistics.

From the 1990, Mongolian agriculture has been greatly accelerating, the natural and labor resources being replaced with the economic collapse and mining industrial inputs. At the same time, some trends appear to have reduced the environmental impact by reducing the amount of artificial chemicals released into the environment, so as to ensure its sustainability.

Crop and environmental info at field scale can be used to guide the field management and implementation of variable input to achieve the purposes of optimizing production, increasing productivity, and reducing pollution. Information-based precision farming is a trend in the development of modern agriculture. The key of precision farming is field information acquirement, including crop water stress, crop condition and crop yield. However, the current acquisition of crop and environmental parameters with remote sensing mainly focus on large scale and macro level monitoring, the operational acquisition of field scale crop and environmental parameters was restricted by a number of limitations. Due to the lack of a high-resolution (temporal and spatial), high-accuracy and low-cost technology in crop and environmental info acquisition at field level, it was difficult to provide timely information support for agricultural production and management, which has blocked the development and applications of precision farming.

STUDY AREA

The selected study area Selenge aimag (Figure1) is prime cropland region and located in the Northeastern part of the Mongolia, measuring approximately 41,152.63 sq. km and covers mostly forest-steppe, steppe and is rich in chernozem soil.

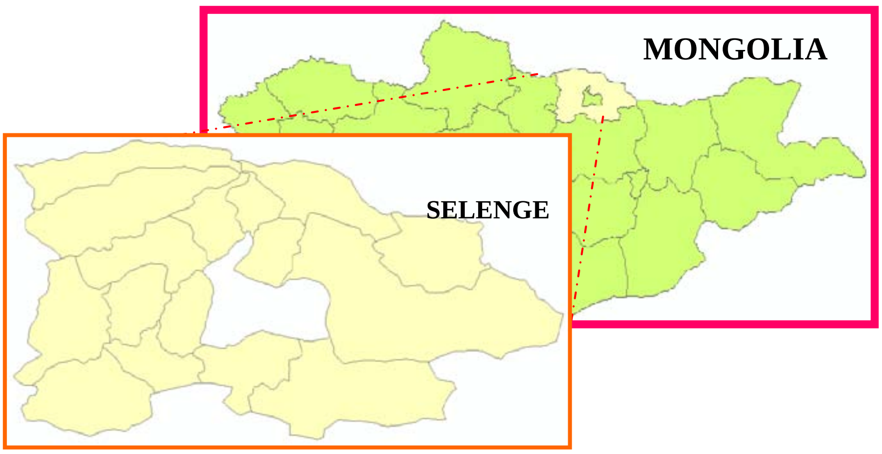


Figure1. The Selenge aimag of Mongolia.

Selenge aimag is produces 60 percent of grain of the country. The climate of the region is semi-arid and arid; and the mean annual precipitation is 250-301 mm. The main crops being grown in this region are wheat, fodder crops, potato, and some vegetables. Except for wheat, all other crops are rain fed. The planting dates of wheat and fodder crops are mostly planted in from the mid of May to October period. For vegetables planting starts in the end of May and continues until the end of August and mid-September. Almost all the crops present an important vegetative development in the June–August period. The wheat is harvested between September and early October. Vegetables are harvested gradually from late July to September.

MATERIALS AND METHODOLOGY

Precision agriculture uses geospatial technologies, like Remote Sensing (RS), Global Positioning Systems (GPS) and Geographic Information Systems (GIS) at both strategic and field-level planning to arrive at an action plan for crop production. Remote sensing technology plays a great role in agricultural activities. Remotely sensed data acquired by the operational satellites are more and more widely used for crop management and crop mapping at regional and global scales. A Geographic Information System (GIS) can be defined in a broader sense as a collection of hardware, software, data, organizations, and professionals to represent and analyze geographic data. A GIS references real-world spatial data elements (also known as graphic or feature data elements) to a coordinate system. These features are usually can be separated into different thematic types (e.g. soils and land use type, meteorological data). A GIS can also store attribute data, which is descriptive information of the map features. This attribute information is placed in a database separated from the graphics data but linked to them. A GIS allows the examination of both spatial and attribute data at the same time. Therefore, a GIS can combine geographic and other types of data to generate maps and reports, enabling users to collect, manage, and interpret location-based information in a planned and systematic way. In short, a GIS can be defined as a computer system capable of assembling, storing, manipulating, and displaying geographically referenced data.

Remote sensing technology would not be complete without merging with GIS. Remote sensing represents a technology for synoptic acquisition of spatial data and the extraction of scene-specific information. Demand for remote sensing as a data input source to spatial database development has increased tremendously during the last few years. Remote sensing derived products are particularly attractive for GIS database development because they can provide cost-effective, wide area coverage in a digital format that can be directly input into a GIS. Because Remote sensing data are typically collected in a raster data format, the data can be cost-effectively rectified or converted to a vector format for subsequent spatial data analysis or modeling applications.

Digital Landsat 7 Enhanced Thematic Mapper (ETM+) imagery has been used to produce the baseline interpretation of 2000 using on-screen digitizing and visual interpretation. For the 1989 visual interpretation use has been made of Landsat 5 Thematic Mapper (TM) images (Table).

Data processing and analysis operations were carried out using ENVI 4.3 and PCI GEOMATICA Image Analysis software.

Table- Landsat 7 ETM+ and 5 TM frames used for interpretation

Path-Row	Acquisition date	
	Landsat 5 TM	Landsat 7 ETM
131-25		11,13 and 20 September 2000 25 June 2000 24 July 2002
131-26	21 August 1989 24 September 1989 1 October 1989 23 October 1994	

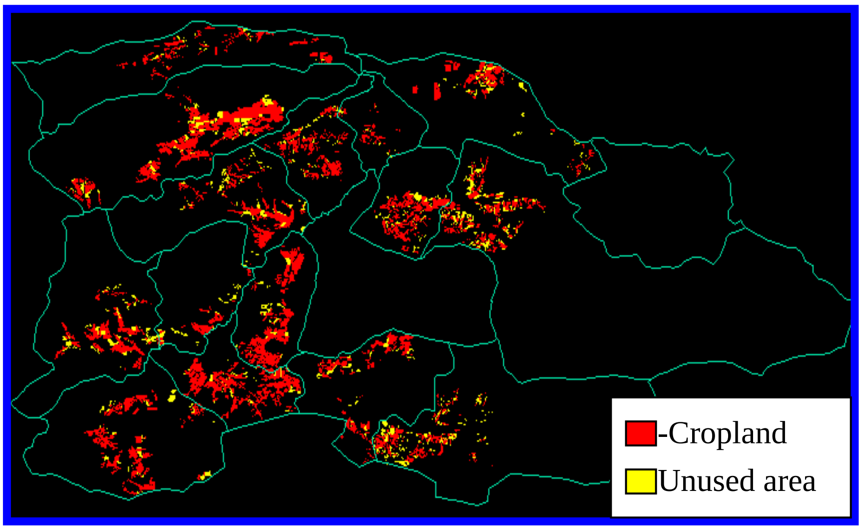
The preliminary data processing was performed in this study using development of vector datasets. To create the vector coverage of the study site, the vector field boundaries were built and digitized from the ground truth data using with ARCMAP software. To do that the each polygon points was then registered to Geographic lat/Long (Zone-48 WGS84 using) projection and the evenly distributed. The registration was based on first-degree polynomial and nearest neighbor re-sampling techniques. The accuracy of the registration was measured using independent check grids, which were not included in the transformation.

Each polygon was assigned a numeric code, owner’s name, location and the crop types of the ground-visited fields were recorded as attribute information. The polygon topology was then created and the attribute database was linked to the polygons to make polygon selection possible through a database query. This map was used to validation of classification result.

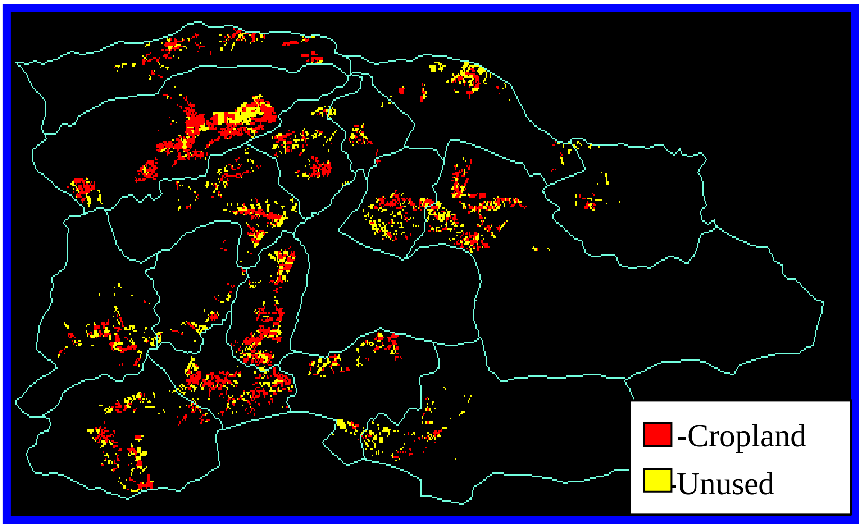
Supervised classification was done using ground checkpoints of the study area. The area was classified into four main classes: cropland, bare land, water body and forest. To assess the accuracy of the classification, the reference data were compared, by-field, to each of the classified images. For each classified data, those fields set aside to be used as independent check fields were compared with the reference data to establish whether or not it had been classified correctly. There were not many vegetables and fodder crop fields. Therefore, for these classes, all reference fields were used to compute the accuracy. For each classified output, the error matrix was generated and the overall accuracy and the producer's and user's accuracy were calculated.

RESULTS AND CONCLUSION

Supervised classification using six reflective bands of the images acquired on 1989 and on 2000, respectively was carried out using maximum likelihood classifier. Figures 2 and Figure 3 show the result of the classification.



Figur2. Croplands map in Selenge aimag, Landsat TM 1989.



Figur.3. Croplands map in Selenge aimag, Landsat ETM+ 2000

A standard overall accuracy for land-use maps is set between 85 (Anderson, Hardy, Roach, & Witmer, 1976) and 90 percent (Lins & Kleckner, 1996). In this study the overall classification accuracy was found to be 87 percent for 1989 and 91 percent for 2000.

In the present study only two years are available: 1989 describing the land-use situation under the centralized government and 2000 in a market-oriented economy. The mid 1990s are not represented but stand for the moment in which the land was distributed to rural households and registration as private property took place. Considering the above-described limitations of remote sensing for analysis of land-use dynamics, one could state that the present results are more likely an underestimation of change than an overestimation. If more land-use aspects and information would be integrated into the study, the area subject to change would be likely to be more extensive.

Precision farming based on information represents the developing trend of modern agriculture, and its key is crop and environment information acquirement, including water stress, crop condition, crop yield, and so on. Field-scale agricultural parameters monitoring by remote sensing can meet this information need, yet the current acquisition of agricultural parameters remain in large scale and macro level. Restricted by temporal and spatial resolution, accuracy of crop and environment parameters, the operational acquisition of field scale crop and environment parameters has not been realized. Besides, the lack of effective information releasing channel also prevent the monitoring result from being applied in precise farming. .

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