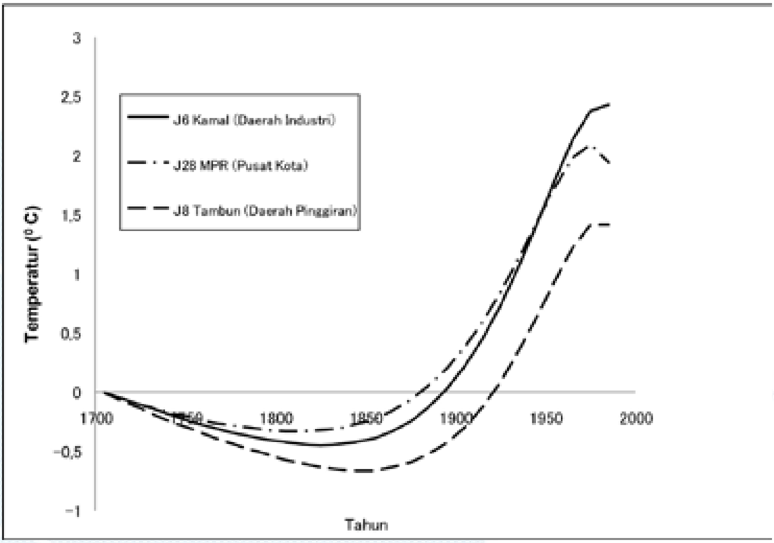

Figure 5. Change of subsurface profile temperature at some observation well in Jakarta.

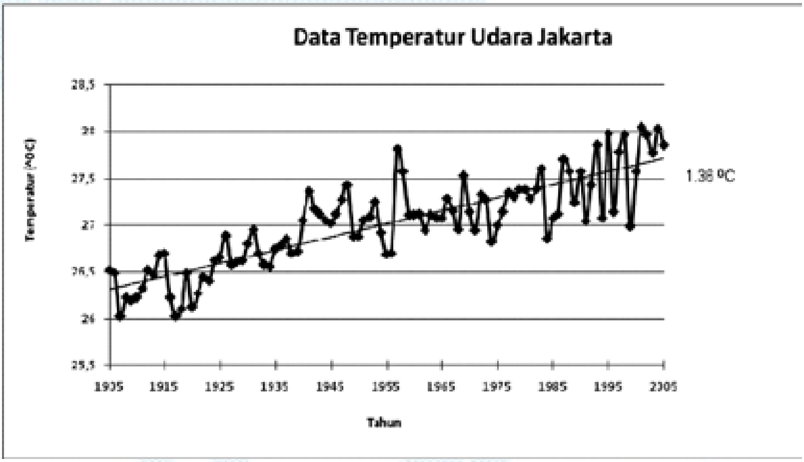

Figure 6. Change of air temperature in Jakarta in the period of 100 years (KLH, BMG, NOA, 2007)

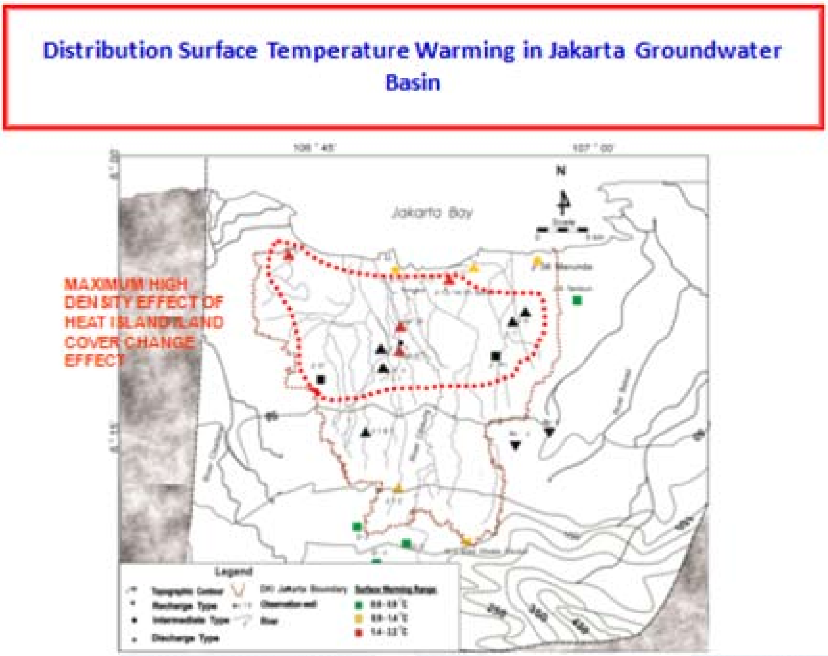

Figure 7. Distribution of subsurface temperature warming in Jakarta Basin

Conclusions

The change of subsurface in Jakarta area is higher than the average global warming. It is showed that the change of subsurface temperature in Jakarta is not only due to global warming, but also due to another factors which is assumed to be an effect of urban heat island. This urban heat island phenomena occurred in the area where land cover has been changed to building area.

This temperature change will give some impacts to human activity in the future. Some adaptations to decrease this impact, especially urban heat island phenomena, should be planned this time. The adaptation strategy needs integrated policy on sectors and process of development planning as it can be executed effectively.

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Land Cover Change in Mongolia

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ABSTRACT

In this paper we included land cover classification and change detection results based on remote sensing techniques using different satellite data, such as Landsat TM/ETM+ and MODIS and NOAA satellites NDVI (Normalized Difference Vegetation Index) data.

The satellite data products are generated to support assessment of land degradation, drought/desertification, snow and fire monitoring and also the research works are focused on land cover/use mapping, forest and surface water, glacier monitoring and their change detection.

Land cover maps were produced not only for whole territory of Mongolia, but also for local areas including mining, cropland, forested areas and lakes and river resources.

The land cover products are delivered to the decision/policy makers through internet and to the end users at aimag level via existing VSAT network of the National Remote Sensing Center (NRSC)/Environmental Information Center (EIC).

Key words: NOAA, MODIS, Landsat, Land cover, applications

1. INTRODUCTION

The previous land cover maps were applied using 1 km resolution NOAA/NDVI data over whole territory of Mongolia from 1992 and 2002 and the results were presented in various conferences and workshops.

Later land cover maps of Mongolia derived from 250 m resolution MODIS/NDVI data sets and further it will be produced in regular basis as decadal. Using MODIS/NDVI data of 2006 and 2008 we have been classified 15 main land cover types of Mongolia and produced the seasonal land cover maps and the accuracy of land cover map of 2008 was calculated as 93 percentages.

Mongolia has very large territory with different landscapes among the different natural zones, therefore for identification and change detection of land cover types in local area needed higher resolution satellite data. There were published some papers on land cover types (glacier, forest, water body etc) classification over local areas of Mongolia using Landsat TM and ETM+ data.

We have used the global land cover scheme of the International Geosphere-Biosphere Programme with modifications to the Mongolian conditions.

2. DATA AND METHODLOGY

The 1 km NOAA/NDVI, 250 meter MODIS/NDVI composites and multispectral data of Landsat TM and ETM+ are the core data set used in land cover mapping. In addition, other data include SRTM digital elevation data, forest, vegetation maps, and Landsat scenes. We used geographic projection for all data however final product converted to UTM-48N projection with WGS 84.

2.1 SATELLITE DATA

NOAA Data

Green leaves have characteristic reflectance properties relating to their function in photosynthesis. Photosynthetically active radiation (PAR; 0.4-0.7μm) is largely absorbed while near infrared (0.7-0.5 μm) is scattered and reflected. These reflectance characteristics have enabled the development of a number of vegetation indices which is the remotely sensed information. One of the most common vegetation indices is the normalized vegetation difference index (NDVI) which is the quotient of the difference and sum of the near infrared (NIR) and red reflectance, where

$$\mathbf{NDVI = (RED - NIR) / (RED + NIR)} \quad \mathbf{(1)}$$

RED – channel 2 of NOAA/AVHRR data, in visible red band
NIR – channel 1 of NOAA/AVHRR data, in near infrared band

Near infra-red (NIR) is strongly reflected due to the structural properties of leaves and resulting high degree of scattering in the plant canopy (Tucker 1979). As leaf cover increases, chlorophyll absorbs an increasing fraction of red light. NIR is near-infra-red reflected energy (0.725-1.10 μm) and RED refers to red reflected energy (0.58-068μm). Calculation of the NDVI results in pixels with a theoretical index value between -1.0 and + 1.0. Vegetated areas will generally yield high index values, water will yield negative values, and bare soil will result in values near zero. Temporal summation of NDVI through the growing season can be used to estimate gross primary production.

For land cover mapping purpose we have used 10 daily composite of NDVI data from 1992 and 2002 for whole territory of Mongolia.

MODIS Data

We used MODIS/NDVI datasets of 2006 from the NASA archives and real time datasets of 2008. These are 16-day composites for May to October which is a growing season in Mongolia. While the primary MODIS/NDVI data used for the classification but the individual bands were used for classification of water bodies. (Example of NDVI image is showing on Figure 1)

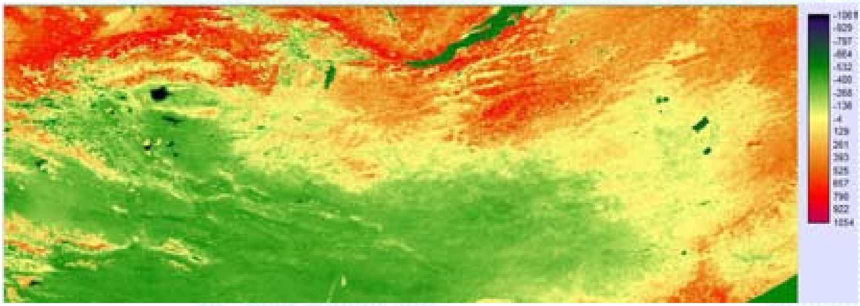

Figure 1. MODIS/NDVI image over Mongolia

LANDSAT and ASTER data

Complete coverage of Landsat scenes of 1990s and up to 2010 with 30 m spatial resolution were used for identification of water body, glaciers and croplands and also used for land cover validation. For glacier area estimation used most recent 15 m ASTER satellite data.

2.2 ANCILLARY DATA

SRTM Digital Elevation Model (DEM) Data

DEM data are important for identifying land cover types and stratifying seasonal regions representing two or more disparate vegetation types. We used extensively Google Earth.

Map Data

Maps of vegetation and forest were used in the interpretation and served as reference data to guide class labeling. Those maps are in

1:1000000 scales and had produced in late 1970's. We used those maps only in limited cases.

Basic methodology of land cover characterization is described in the document "Global land cover characteristics data base", which is in USGS EROS Data Center website.

2.3 METHODOLOGY

Time series analysis and unsupervised/supervised classification

The initial 16 day composites of the 6-month NDVI images were used for time series analysis (TSA) with Idrisi Andes software. We have applied the principal component analysis (PCA) for 12 images. Resulting image of TSA is performed into seasonal greenness classes using unsupervised clustering.

Classification approach

Concerning the topic land cover mapping initial analysis came to the result that a part of the mapping can be carried out by supervised classification. Specific classes and issues have to be mapped/refined by a following interpretation of the data. Based on the available data (in a first step data of 1989 covering the whole basin were used) a general work approach has been worked out which is replicable for 2000 data sets, re-using training areas, adapted techniques and applications.

The main working steps are as follows:

- Geocoding of satellite data
- Preparation of material for ground survey and execution (carried out for Selenge)
- Develop land cover classification and interpretation keys
- Supervised classification using existing information and ground survey results
- Post-processing and filtering of systematic errors
- Interpretation and refinement of classification results
- Generalize land cover classes into big classes
- Generate land cover change map

Classification of clusters into land covers classes

We calculated profiles (spectral curves) for greenness classes (clusters). Analysis of profiles together with ancillary data such as forest and vegetation maps, Landsat scenes gave possibility of initial labeling of basic classes like forest, water, grassland and barren land. After that we made the second stage of classification determining more detailed classes of forest and grassland types. During this stage we reduced number of clusters merging similar clusters based on statistics and graphs of each cluster.

3. CLASSIFICATION RESULTS

3.1. NOAA/NDVI based Land cover maps

We have classified the land cover types (Figure 2) using 10 daily, 1 km spatial resolution NOAA/NDVI data and estimated their changes (Table 1). The results were estimated land cover types changes in worse direction as, decrease of areas of dry steppe, permanent snow and ice and water body in 28-36 per cents and increase of areas of sand, barren land and desert steppe in 46-64 per cents. The forested area decreased in 8 per cents. The land cover types areas and their changes are giving in Table 1.

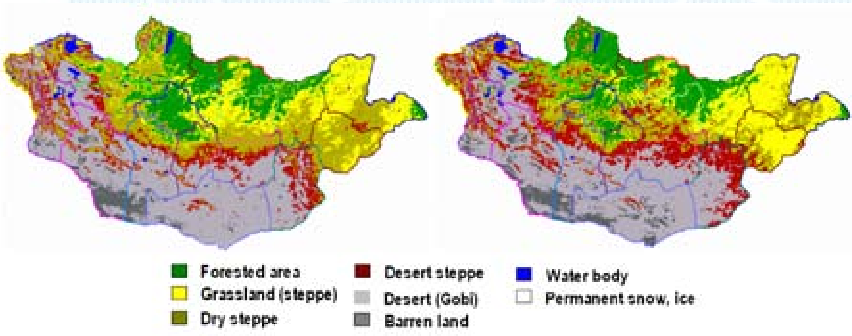

Figure 2. Land cover maps of Mongolia for 1992 and 2002

Table 1. Land cover types and their changes

Land classes	1992	2002	Change (%)
Water body	17470	11131	**-36**
Sand, barren land	52593	76700	**46**
Desert	522938	525259	**0**
Desert steppe	155126	253936	**64**
Dry steppe	334360	240397	**-28**
Grassland, steppe	251261	250672	**0**
Forested area	223904	205534	**-8**
Permanent snow, ice	296	204	**-31**
Total (sq.km)		1557948	

3.2. MODIS/NDVI based Land cover map

We used IGBP land cover classification as base model but with modification to Mongolian condition. This scheme can be converted to other schemes for example to the FAO GLC scheme.

The result of classification is a separation of classes, which has different land cover types. We described “snow and ice”, “high mountain rock”, “Urban and Built-Up”, and “Meadow with trees”. For the determination of “Cropland/Natural Vegetation Mosaic” class we used threshold classification method on NDVI images. The land cover type’s areas were calculated and showed in Table 2.

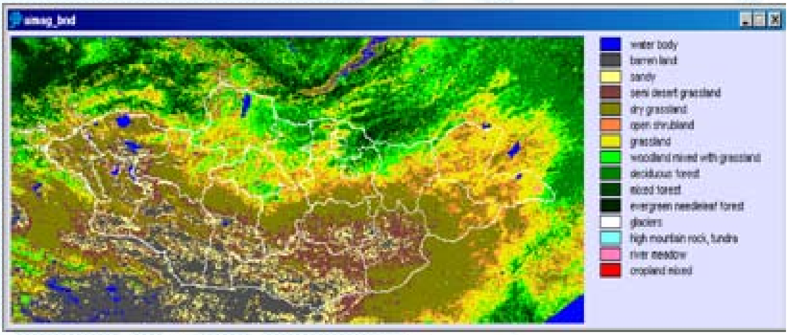

Figure 3. Land cover map of Mongolia, 2006

Table 2. Land covers types and area

	Class name	Area (sq.km)
1	Water body	13069.96
2	Barren or Sparsely Vegetated	149761.95
3	Desert grassland	396903.85
4	Dry grassland	438067.81
5	Open Shrubland/grassland	109186.02
6	Grassland	277341.90
7	Needle leaf forest (larch, pine)	99657.69
8	Needle leaf, broadleaf mixed forest	45837.42
9	Deciduous, evergreen mixed forest	3451.76
10	Evergreen needle leaf forest	3230.46
11	Snow and ice	1377.61
12	High mountain rock, tundra	3482.12
13	Meadow with trees	12115.40
14	Cropland mixed with natural vegetation	4318.88
15	Urban and Built-Up	310.54
	Total	1558113.4

3.3. LANDSAT based land cover maps

Selenge – Tuv regions

The interpretation key helps to organize the information available in the image data for a specific topic, like land cover classification and to correct/identify unknown feature classes during the further work. It is recommended to describe the appearance of each class by the standard characteristics of image interpretation and to give examples. As any image analysis, regardless interpretation or automatic technique is in the end an individual process, it is important to ensure as much as possible a systematic and consistent identification.

Based on official land cover class system we made the following land cover classes, which are possible to classify from Landsat satellite imagery.

Table 3. Land Cover classes over Selenge river basin

No.	Class
1.	**Pasture and Grassland**
2.	**Arable land**
2.1	Cropped/vegetation cover
2.1.1	High density crop land
2.1.2	Medium/low density crop land
2.2	Fallow, abandoned
3.	**Forest**
3.1	Coniferous forest
3.2	Deciduous forest
4.	**Riverine**
5.	**Burnt areas**
4.1	Burnt forest
4.2	Burnt pasture/grassland
6.	**Bare soil/eroded area**
7.	**Wetland**
8.	**Water bodies**
9.	**Infrastructure**

While supervised classification it was very useful for distinguishing land cover features, specially forest types and pasture. For land cover classification study we created GIS database, which consists of the following dataset:

1. Main geographic features like administrative boundaries, lakes, roads, rivers, and relief (scale 1:500,000)
2. Land use map of Selenge aimag (scale 1:500,000)
3. Ecosystem map of Selenge region (scale 1:500,000)

4. Fire map, which produced from NOAA AVHRR data of 2000

After test classification we have done accuracy checking and it gave with result more than 90%. Once classification procedure tested we could use it for whole images and generated land cover maps of 1989 and 2000 (Figure 4).

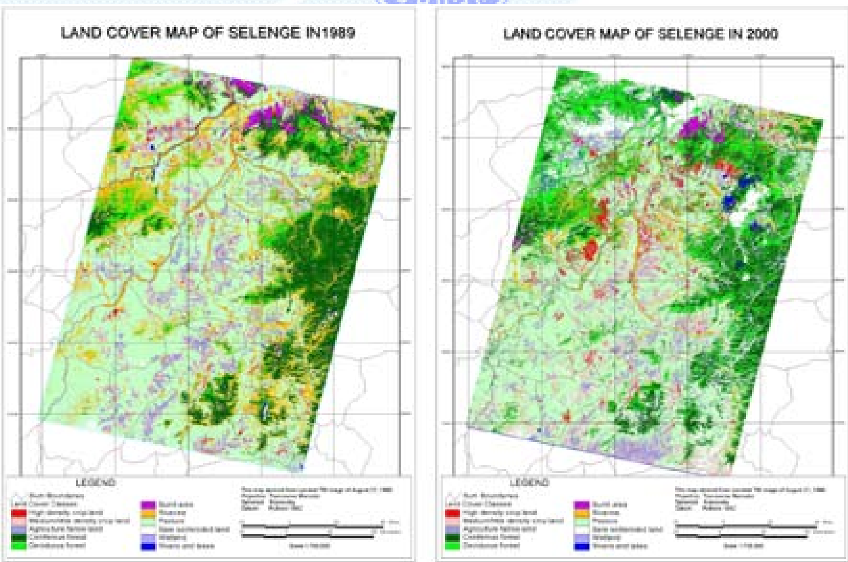

Figure 4. Land cover classification result

To be generate land cover change map we needed to generalize land cover classes into 6 big classes like, Crop land, Forest, Bare soil/ eroded land, Pasture, Wetland and Water bodies.

After generalizing land cover classes there were generated land cover 2 maps of 1989 and 2000 (Figure 5) in order to detect land cover changes.

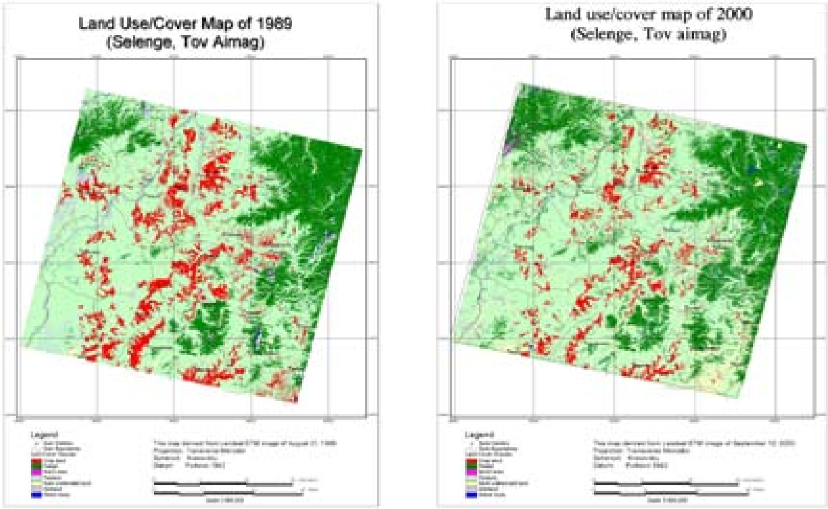

Figure 5. Generalized land cover maps

After generalizing land cover maps intersected these maps and generated land cover change map. In Figure 6 red color corresponds to the crop land changes over study area.

Numerical values of land cover changes in 1989 and 2000 show, there are noticeable changes in some classes, such as crop land, forest and eroded area. In other words, the land cover change analyses were determined that from 14 to 53 percentages of land cover classes have been changed to any other classes. For example, the area of arable land reduced by 152000 hectare, bare soil or eroded area increased by 7300 hectare and forest area decreased by 120000 hectare from 1989 to 2000.

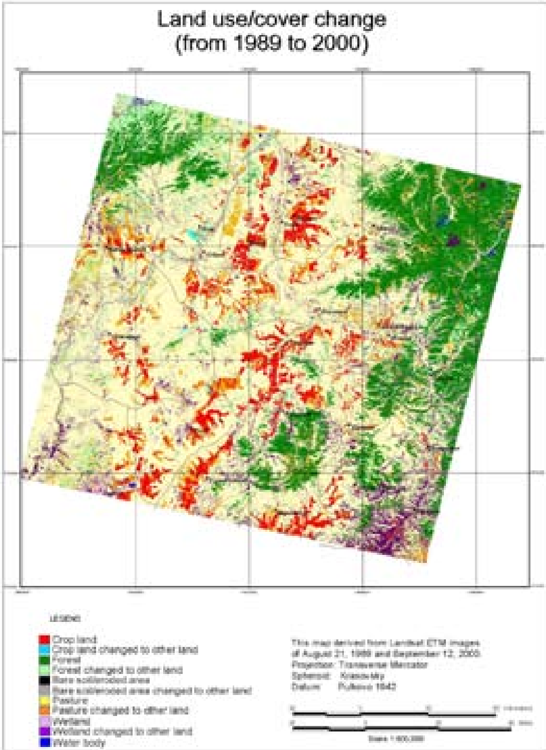

Figure 6. Land cover change map of Selenge – Tuv aimags

Glacier mapping

The glaciers were mapped as land cover type based on 250 m spatial resolution MODIS/NDVI map. In next step, to identify the glaciers areas and their change detection the ICC staff processed 10 years difference (1990s and 2000s) Landsat satellite data of Sair, Turgen, Altai Tavan Bogd and Hoid Buurugt mountains of Bayan-Ulgii aimag and classified the glaciers. Due to spatial resolution and acquisition time period of Landsat we tried to use latest and higher spatial resolution satellite data to estimate recent area of glaciers. So, in last step we have used most recent 15 m resolution ASTER satellite imagery from 2007 and 2009 to check the area of those glaciers and compared with previous areas.