Investigation the dynamics of land use and land cover changes using Remote Sensing/GIS in some parts of Mongolia

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Contents

- Introduction
- Regional Network activities
- Application of Remote Sensing and GIS in Mongolia
The Capital City Ulaanbaatar

With the world’s lowest population density, huge landscape, minimal infrastructure varied ecosystems and abundant wildlife
Nomads civilization

Mongolia is the only one of the ancient nomad states to retain the tenets of its original nomadic civilization, including the classic migration of livestock and closeness to nature.
Mongolia has a big territory, remote sensing offers a unique access to primary data about the research of land surfaces.

Economically beneficial

Accessible unreachable places

Natural Disaster vulnerable
Remote Sensing Society/GIS Laboratory
National University of Mongolia

DESERTIFICATION

DROUGHT

Deforestation

PASTURE LAND DEGRADATION

FORESTRY AND FOREST STEPPE FIRE

AIR POLLUTION

GLACIER

Land Cover/Use Change

SEVERE WINTER CONDITION (ZUD)
Land degradation has been identified as one the priority concerns. Causes of land degradation can be divided into two categories natural and human induced.

**Natural cause:**
- Climate changes
- Dust and sand storms

**Human induced:**
- Mining
- Pasture Degradation
  /Overgrazing/
Many lakes have been disappeared
NOAA/NDVI dynamics, August 1982-2006

Long term dynamics of NDVI, August 1982 - 2006
Over whole Mongolia

\[ y = -0.4902x + 169.44 \]
Dust and Sand Storm

APPROACH

\[ \text{Band \_ difference} = \text{ch4-ch5} \]
by AVHRR/NOAA (1)

\[ \text{Band \_ difference} = \text{ch32-ch31} \]
by MODIS/TERRA (2)

Where:
- Ch4 : AVHRR-4 (10.3 \text{\mu m} \sim 11.3 \text{\mu m})
- Ch5 : AVHRR-5 (11.5 \text{\mu m} \sim 12.5 \text{\mu m})
- Ch31 : MODIS-31 (10.780 \text{\mu m} \sim 11.280 \text{\mu m})
- Ch32 : MODIS-32 (11.770 \text{\mu m} \sim 12.270 \text{\mu m})

Each year from March to May, it is observed that the dust and sand storm, which occurred in the Gobi desert of Mongolia
Dust and Sand Storm

2002.03.18 – 03.21

Wind speed
> 16m/s: 217 soum
> 28m/s: 31 soum

Maximum Duration: 68 hours

Losses:
3 person
53000 livestock
2.1 billion tugrigs

Dust and Sand storm studies using MODIS/TERRA emissive bands
Dust and Sand Storm

Pre-processing Satellite data → Visual Interpretation

Band difference

Meteorological data into GIS

Overlaying layers

Dust storm images

a) March.6, 2006 by AVHRR/NOAA

b) March.6, 2006 by MODIS/TERRA

c) March.9, 2006 by AVHRR/NOAA

d) March.9, 2006 by MODIS/TERRA
Fire Monitoring (National Remote Sensing Center)

98.5 percent of forests are classified as high fire risk areas.
Цасан бүхээцийн зураг. 2007 оны 3-р сарын 3-р 10 хоног

Тайлбар:
- Аймгийн хил: Замын хил
- Аймгийн төв: Цас бага туюу тарлган газар
- Сумын хил: Цас
- Нуурны хил: Уул
- Голны хил: Цаг уурын станцид хэмжээн цасны зузаан (см)

NOAA 17 хиймэл дагуулын "NDVI" сувгийн мэдээлэл "NERC"-ын Мэдээллэй төрөөллөөн тэвл болох суурдуулл.

Утас: 329984. 3-шууд: mt@magicnet.mn.
Факс: 329968. Вэб хууд: www.iic.mn.
In Mongolia, that word is Zud—a combination of blizzard and bitter cold, preceded by drought. Heavy snow falls caused adverse grazing conditions for livestock. Pasture land is used for winter season. The ground can become frozen so hard that animals cannot graze and water cannot be easily extracted.
LAND COVER MAP by MODIS Terra

- 1390.11 (ha)
- 1397.92 (ha)
- 127.38 ha
- 1535.6 ha
Glacier changes in Western mountain

Landsat data
## Classification results of Glaciers

<table>
<thead>
<tr>
<th>Mountains</th>
<th>Area, ha</th>
<th>Changes, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990</td>
<td>2002</td>
</tr>
<tr>
<td>1 Tsambagarav</td>
<td>112.0</td>
<td>88.1</td>
</tr>
<tr>
<td>2 Kharkhiraa</td>
<td>70.6</td>
<td>38.5</td>
</tr>
<tr>
<td>3 Turgen</td>
<td>93.8</td>
<td>41.6</td>
</tr>
<tr>
<td>4 Sutai</td>
<td>24.3</td>
<td>16.2</td>
</tr>
<tr>
<td>5 Sair</td>
<td>14.2</td>
<td>8.1</td>
</tr>
<tr>
<td>6 Munkhkhairkhân</td>
<td>51.2</td>
<td>29.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>366.1</strong></td>
<td><strong>222.3</strong></td>
</tr>
</tbody>
</table>
Change forest biomass of the study area between years 2003 - 2007

N52°, E98°

2003  N48°, E102°  2004  2005

2006  2007

0 tonnes/ha
70 tonnes/ha
140 tonnes/ha
210 tonnes/ha
280 tonnes/ha
350 tonnes/ha
Outline of Methodology

Technique to apply linear mixture models

\[ r_i = \sum_{j=1}^{n} a_{ij} x_j + e_i \quad i = 1, 2, \ldots, m \]

\[ \sum_{j=1}^{n} x_j = 1, \quad x_{ij} \geq 0 \]

\[ m = n \]

- \( r_i \): Measured satellite sensor response for a pixel in spectral band \( i \)
- \( a_{ij} \): Spectral response of mixture component, \( j \), for spectral band \( i \)
- \( x_j \): Proportion of mixture component, \( j \), for a pixel
- \( e_i \): The error term for spectral band \( i \)
Overgrazing in the dry region, degraded pasture exists primarily as a result of livestock concentration around the water sources and settlement areas.

Nearly 30 million livestock graze 117 million hectare of pasture, approximately 75% of the territory. The economic hardships resulting increased a pressure on a grazing land.

Overgrazing can occur under continuous grazing. It can be caused by having too many animals by not properly controlling their grazing activity.
The Ongi river starts from Khangai Range then acrossed 3 kinds of areas which are Mountain & Wooded area, steering plain area, gobi desert area.

Onggi river basin

The length is 437km, site is 175 square km

Geographical location:
47°10'N - 44°00'N
101°20'E - 105°00'E
During Mongolia’s transition to a free market, socio-economic factors such as poverty and profit-seeking mining exploitation of the environment have contributed to its deterioration, and consequently, the loss in regional biodiversity, land degradation and vulnerability.

Approximately 60 thousand people and over one million livestock who one living around Ongi river one getting defective of drink water and pasture because of Ongi river and Ulaan lake’s evaporation.
Hand level mining contributes to land degradation,

Increased small to large-scale mining, as well as illicit activity resulting in exploitation of the country’s mineral resources.
Mining activity comprises 55% of total industrial output.

### Mining Activity by Commodity

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Gold (kg)</th>
<th>Silver (tons)</th>
<th>Coal (ton)</th>
<th>Construction Material</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990 Mining Number</td>
<td>3</td>
<td></td>
<td>5</td>
<td>*</td>
<td>4</td>
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<tr>
<td>2000 License Number</td>
<td>127</td>
<td>1</td>
<td>15</td>
<td>*</td>
<td>2</td>
</tr>
</tbody>
</table>

### Graph

The graph shows the trend of gold, silver, and coal production from 1990 to 2002. Gold and silver production increased steadily, while coal production remained relatively stable.
Mining

Landsat, August 1989

Landsat, August 2003
Onggi river & Ulaan lake, Landsat Image
Air pollution in Ulaanbaatar city

Ulaanbaatar city 1990
Ger area 1990
Ger area 2007

Ulaanbaatar city 2007
Data base
Land use change

Legend
- Undeveloped land
- Developed land
- Land use change
Between 1990 and 2005, 60,000 ha of forest have been lost. The main causes include:

- Recent rapid deforestation is primarily due to fire, improper commercial and illegal logging, inadequate enforcement of forest rules and regulations.
- Grazing and browsing of young trees by livestock, and insect infestations.

Causes:
- Incorrect policies
- Infrastructure support for sustainable logging regimes
- Increasing domestic demand for fuel wood and timber
NDVI changes for over years 1982-2008 in Mongolia
NOAA AVHRR 8km

1982-1990

1991-1999

2000-2008
Moisture index map of Mongolia

2000 CRU data
TREND OF VEGETATION IN KHANGAI RANGE

( July August, 1982-2008 )
NELDA-APN regional activities “Human impact on Land Cover changes in the Heart of Asia”

Participation in the training course in Oregon University October, 2009

Third Annual International Workshop on Geoinformation application in Mongolia June, 2009
Study area

The Darkhan province is located in the northern part of the country, between 47°-49°N and 104°-107°E.

Tuv province is in steppe zone of Mongolia, between 46°-48°N and 105°-108°E.
Ground truth data collection

Location of ground truth collection
## Data

### MODIS data

Moderate Resolution Imaging Spectroradiometer (MODIS) 250 m Enhanced Vegetation Index (EVI) products were used for the analysis vegetation over years 2001-2006

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Date</th>
<th>Path Row</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM</td>
<td>8/21/1989</td>
<td>P132 R26</td>
</tr>
<tr>
<td>ETM+</td>
<td>9/21/2000</td>
<td>P132 R26</td>
</tr>
<tr>
<td>ETM+</td>
<td>9/10/2002</td>
<td>P132 R26</td>
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<tr>
<td>ETM+</td>
<td>8/31/2001</td>
<td>P131 R27</td>
</tr>
<tr>
<td>ETM+</td>
<td>8/26/2005</td>
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</tr>
<tr>
<td>TM</td>
<td>8/5/2006</td>
<td>P131 R27</td>
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</table>
Radiance conversion

**TM Radiance:**

$$L_{sat} = \text{bias} + \text{gain} \times DN$$

**ETM+ Radiance:**

$$L_{sat} = \left(\frac{(L_{MAX,\lambda} - L_{MIN,\lambda})}{(QCALMAX - QCALMIN)}\right) \times (QCAL - QCALMIN) + L_{MIN,\lambda}$$

Input data are contained in the metadata files of the Landsat TM (gain and bias for each band) or ETM+ (LMAX, LMIN, QCALMAX, QCALMIN) images.
Atmospheric Correction of the study area
(Path 131 Row 27)
Land cover classification
Class Definitions

Tree Dominated:
• Needle leaved Deciduous Closed
• Needle leaved Deciduous Open
• Broadleaved Deciduous Closed
• Broadleaved Deciduous Open

Shrub Dominated:
• Mix

Herbaceous Dominated:
• Herbaceous Vegetation Closed
• Herbaceous Vegetation Open

Bare Land and Sparse Vegetation:

Water:
Land cover classification of Darkhan province (LANDSAT Image, Path 132 Row 26, 21 August 1989)

Land cover classification of Darkhan province (LANDSAT Image, Path 132 Row 26, 21 September 2000)
Land cover classification of Darkhan province with mining area (LANDSAT Image, Path 132 Row 26, 10 September 2002)

Land cover classification of Tuv province (LANDSAT Image, Path 131 Row 27, 31 August 2001)
Land cover classification of Tuv province (LANDSAT Image, Path 131 Row 27, 26 August 2005)

Land cover classification of Tuv province (LANDSAT Image, Path 131 Row 27, 5 August 2006)
### Full Classification Accuracy Assessment
(Darkhan Province, Path 132 Row 26)

**Overall Accuracy** = 78.07 %

**Kappa Coefficient** = 0.77

<table>
<thead>
<tr>
<th>Classes derived from satellite</th>
<th>B</th>
<th>BS</th>
<th>HC</th>
<th>HO</th>
<th>SC</th>
<th>SO</th>
<th>TDBC</th>
<th>TDBO</th>
<th>TDNC</th>
<th>TDNO</th>
<th>TMC</th>
<th>TMO</th>
<th>W</th>
<th>Sum</th>
<th>Comission %</th>
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<td>1</td>
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<td>43</td>
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<td>1</td>
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<td>0</td>
<td>44</td>
<td>20.45</td>
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</tr>
</tbody>
</table>

| Sum                           | 20| 48 | 55 | 51 | 41 | 40 | 27   | 59   | 45   | 45   | 47 | 48 | 35| 561 |

| Omission %                    | 5.00| 22.92 | 18.18 | 19.61 | 4.88 | 25.00 | 29.63 | 23.73 | 33.33 | 42.22 | 25.53 | 12.50 | 0.00 |   |

B = Bare
BS = Bare sparse
HC = Herbaceous closed
HO = Herbaceous open
SC = Shrub closed
SO = Shrub open
TDBC = Tree Deciduous Broadleaf Closed
TDBO = Tree Deciduous Broadleaf Open
TDNC = Tree Deciduous Needle leaf Closed
TDNO = Tree Deciduous Needle leaf Open
TMC = Tree Mixed Closed
TMO = Tree Mixed Open
W = Water
Full Classification Accuracy Assessment  
(Tuv Province, Path 131 Row 27)  
**Overall Accuracy** = 88.42%  
**Kappa Coefficient** = 0.87
Land cover change

Land cover change in Tuv province

<table>
<thead>
<tr>
<th>Path 131 Row 27</th>
<th>Aug, 2001 (area, km²)</th>
<th>Aug, 2005 (area, km²)</th>
<th>Aug, 2006 (area, km²)</th>
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<tr>
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<td>1887</td>
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<td>Herbaceous</td>
<td>17075</td>
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</tr>
<tr>
<td>Shrubs</td>
<td>3802</td>
<td>2653</td>
<td>2903</td>
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<td>Trees</td>
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<td>11336</td>
<td>10885</td>
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<td>Water</td>
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<tr>
<td>sum</td>
<td>34301</td>
<td></td>
<td></td>
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</tbody>
</table>

Land cover change in Darkhan province

<table>
<thead>
<tr>
<th>Path 132 Row 26</th>
<th>Aug, 1989 (area, km²)</th>
<th>Sep, 2000 (area, km²)</th>
<th>Sep, 2002 (area, km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baren</td>
<td>10669</td>
<td>8229</td>
<td>347</td>
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<tr>
<td>Herbaceous</td>
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<td>27820</td>
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<td>Shrubs</td>
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<tr>
<td>sum</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Change Detection for bare sparse in the study areas
a) Bare sparse in Darkhan province, b) Bare sparse in Tuv province
MODIS EVI vegetation change

\[
EV = \frac{\text{NIR} - \text{Re} d}{\text{NIR} + C_1 \text{Re} d - C_2 \text{Blue} + L}
\]

Enhanced Vegetation Index change over years 2001-2006
Change of climate and socio economic data in Darkhan province

Change of climate and socio economic data in Tuv province
The relationships between vegetation, climate and socio economic data, where is the a) temperature, b) precipitation, c) population, and d) livestock (Darkhan province)
The relationships between vegetation, climate and socio economic data, where is the a) temperature, b) precipitation, c) population, and d) livestock (Tuv province)
Conclusions and Recommendations

- The objective also directly addresses the goals of the Northern Eurasia Regional Information Network (NERIN).

- The project provides a dataset with ground truth data in association with Remote Sensing/GIS data for the analyses of land cover change in the two selected provinces of Mongolia.

- Land cover change assessment found that changes were largely attributed to urban expansion and bare land.

- The most prevalent human activity in the study areas is animal husbandry, characterized by livestock grazing, mining and urban expansion.

- We are also seeking more opportunities for building and distributing integrated geospatial data sets in other regions of Mongolia.
Thank you