ENVIRONMENTAL MONITORING IN MONGOLIA SUPPORTED WITH MODIS AND FY-2C SATELLITE DATA

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ABSTRACT:

Mongolia is a country which relies on exploitation of its natural resources. The productivity of the agricultural sector, which plays and important role to the Mongolian economy, is sensitive to droughts and severe winters as well as land degradation.
The application of the remote sensing data shall have improvement with implementation of the program supported by the Dutch Fund. Dutch Government funded and the Mongolian Ministry of Nature and Environment implemented program "National Geoinformation center for Natural Resources Management (NGIC)" that has commenced in December 2006 aims at macro level environmental decision and policy making. The following objectives have been formulated for the project working group:
1. To develop and implement a monitoring system for drought/desertification, dzud, fire and dust based on MODIS and FY2-C satellite imagery;
2. To develop a web-based environment to distribute the disaster monitoring products to aimag environmental offices;
Within one of the components' frame work of NGIC project the receivers from MODIS and FY-2C geostationary satellites were installed and operationalised.

1. INTRODUCTION

The government of Mongolia develops and implements policy on rational utilization of its natural resources. Up-to-date information on the state of the environment would be ideal to support adequate planning and policy formulation.

The use of satellite data will be efficient in management and planning to prevent from natural disasters; in problem identification, monitoring and policy formulation, policy implementation and evaluation for further strengthening of natural resources management.

FY-2C receiving station manufactured at ShineTek, China was installed in May 2007 and the data processing software such as Energy Water balances monitoring system (EWBMS) provided by EARS company of the Netherlands is implemented and producing some basic and application products.

The MODIS receiving station provided by eOsphere, UK was installed in November 2007 and MODIS data are intended to be applied for monitoring of drought/desertification process, fire occurrence and snow/dzud monitoring and forecasting, detecting changes of the natural resources such as, forest and surface water.

Moreover, this suggest the development of application of the above data in conducting science based extensive research for monitoring and management of natural resources and prevention from natural disasters.

The products derived with employment of the satellite data will be distributed to the end-users including local decision makers at aimag (provincial) level via existing VSAT and ftp network and high speed internet.

2. NEW SATELLITES FOR ENVIRONMENTAL MONITORING

2.1 MODIS Applications

MODIS products focusing on land cover types, forest and water. Since this is not very specific, but considering the potential application areas and several products will be generated from the MODIS data, such as,

1. a 10 daily composite of Normalized Difference Vegetation Index (NDVI) at 250 meter resolution and Enhanced Vegetation Index (EVI) at 1 kilometer resolution
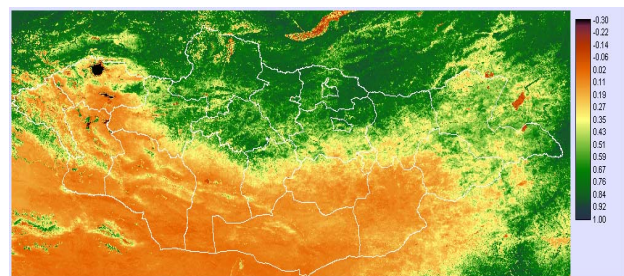

Figure 1. NDVI map of Mongolia

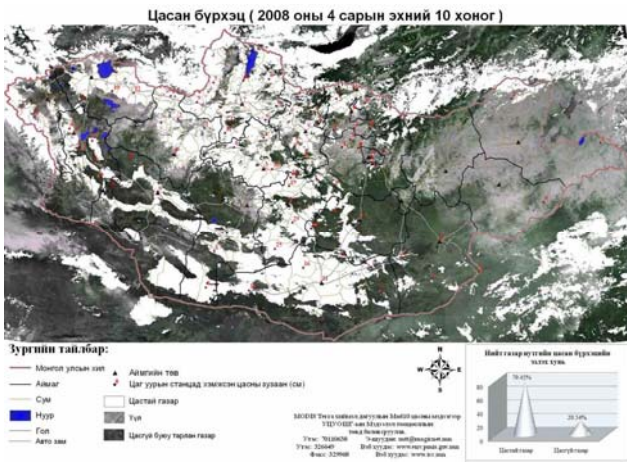2. a dzud (severe winter) condition estimation based on snow/ice products

Figure 2. Snow cover map of Mongolia

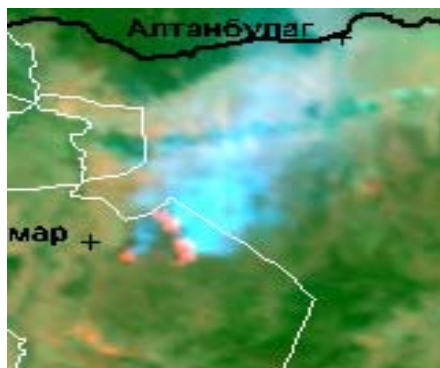3.   a fire occurrence and spreading risk and burnt area maps

Figure 3. Fire map, Terra/MODIS, 17 May 2007

4.   a bi-annual map of land cover at 500 meter resolution of the entire country which can support analysis of land cover change, analysis of hotspots of land cover (forest and surface water) change, climate change modeling, and the analysis of ecological structures supportive of maintaining biodiversity, with particular reference to migratory birds. It will also be useful in refining MODIS product generation, where land cover characteristics are used in the generation.
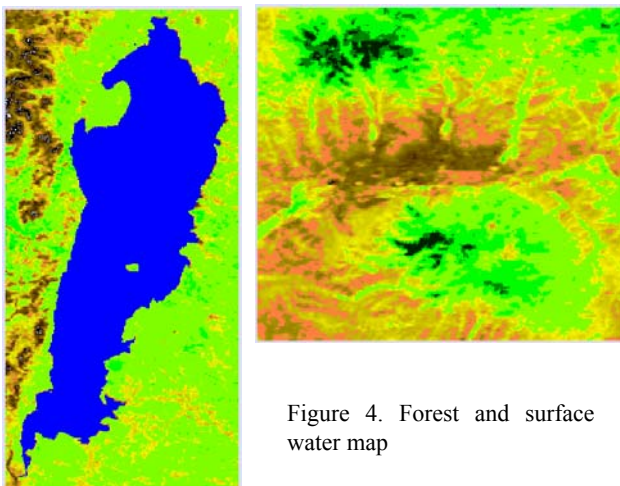

Figure 4. Forest and surface water map

2.2 FY-2C Applications

The Energy, Water Balances Monitoring System (EWBMS) consists of a set of software programs that comprises three steps, which have to be followed sequentially to obtain information on winter grazing conditions, drought indices and pasture yield forecast. The EWBMS software needs two primary input products: specially prepared FY-2C satellite images and GTS (Global Telecommunication System) rainfall data.

The EWBMS provides hourly cloud duration, rainfall, radiation, sensible heat flux and actual evapotranspiration data for whole Mongolia at 5 km spatial resolution and using those basic products running Drought monitoring system, Pasture monitoring system and Winter grazing condition monitoring system to monitor both summer and winter condition in order to prevent the natural disasters such as, drought and dzud.
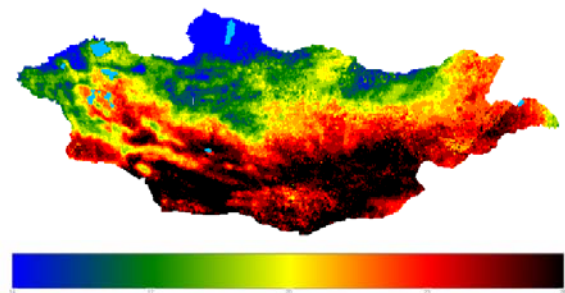

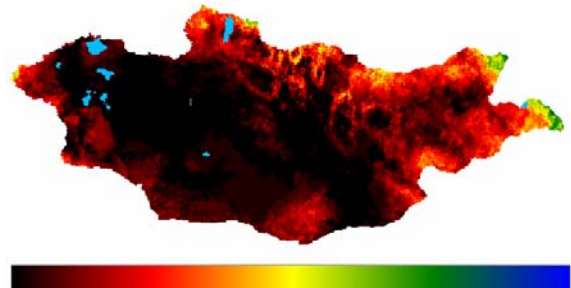Figure 5. Air temperature map,
1st decade of July, 2007

Figure 6. Precipitation map,
1st decade of July, 2007

The basic products validation work have been started using meteorological

2.2.1 The Drought Monitoring System: is capable of calculating three desertification indices as, the climatic moisture index (CMI) indicates a climatic condition, the soil moisture index (SMI) characterizes the actual drought or desertification status the Evapotranspiration Drought Index (EDI) defines the agricultural drought and on a pixel by pixel basis.
CMI-Climatic Drought Indicator (1 YEAR)

$$CMI=P/LE_{pot} \tag{1}$$

where,

P: precipitation
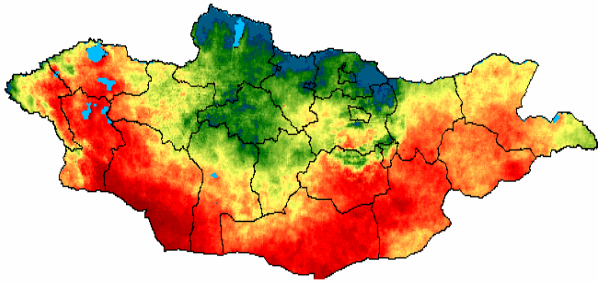LE_{pot} : potential evapotranspiration

Figure 7. CMI map of Mongolia, 2007

The CMI was adopted by UNCCD (1994) as an index defining climatic drought condition and process drought itself defined by the UNCCD that, "*Drought is the regional stable precipitation deficite that cause hydrological inbalance due to long duration of abnormal dry weather*".

The UNCCD also defined and adopted the aridity area classes by following criteria,

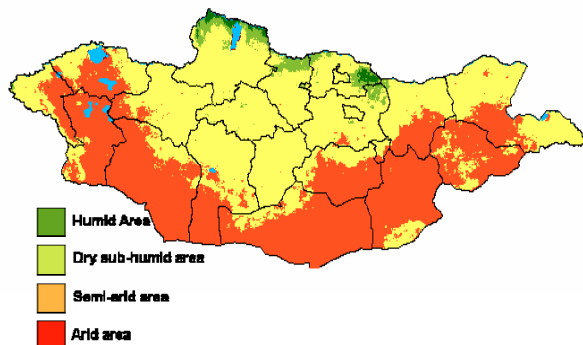| extremely arid area	<0.05
arid area	0.05-0.20
semi-arid area	0.21-0.50
dry sub-humid area	0.51-0.65
humid area	>0.65

Figure 8. Aridity zone map of Mongolia, 2007

SMI- Ecological Drought Indicator (1 YEAR)

$$SMI = LE/LE_{pot} \qquad (2)$$

where,

  LE :   evapotranspiration
  LE_{pot} : potential evapotranspiration

The amount of water that is available to the vegetation is also quantified in terms of plant available water (PAW in mm), here defined as soil moisture (SM) minus wilting level (WP):

$$PAW = SM - WP \qquad (3)$$

The wilting point or wilting level is the amount of water left in the soil that cannot be taken up by the roots of vegetation due to strong capillary forces of the soil matrix. We assume the soil moisture content never exceeds field capacity.
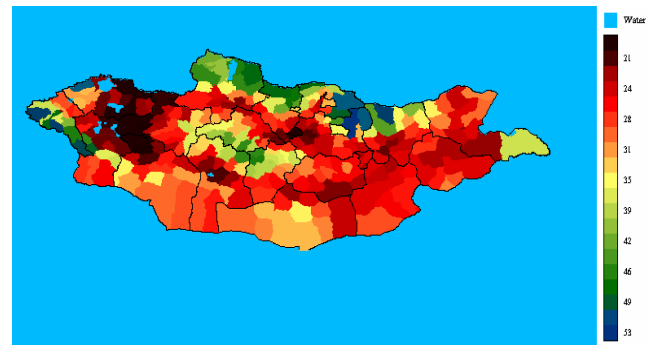

Figure 9. SMI map of Mongolia, 2007

EDI-Agricultural Drought Indicator (2 months)

$$EDI = \Sigma \ (LE/LE_{pot})/ \ n \qquad (4)$$

where,

  LE :   evapotranspiration
  LEpot : potential evapotranspiration
  n : time period (2 months)

Informs on the actual drought at the surface:
- information on water availability for crops and vegetation
- strongly related to soil moisture and actual drought conditions of the ground

The agricultural drought is evaluated over a two months period:
- Suitable time period to evaluate the growth conditions of pasture (growing season)
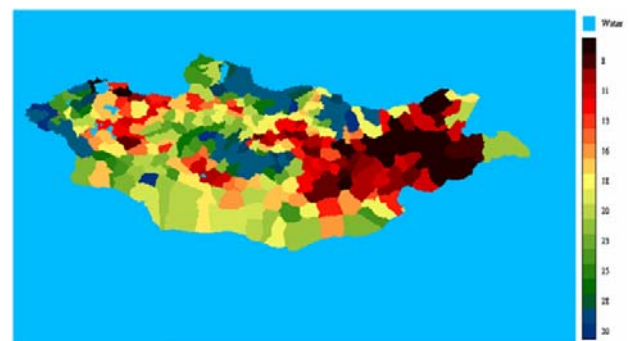

Figure 10. EDI map, July – August 2007

2.2.2 The Pasture Monitoring System: calculates actual aboveground green biomass, biomass available for daily grazing and pasture carrying capacity of entire country and at aimag, soum levels in order to support pasture management, prevent overgrazing.

The Pasture Monitoring System simulates pasture growth with radiation, temperature and relative evapotranspiration data from the Energy Balance Mapping module. The model calculates light use efficiency and takes into account the conversion

efficiency of solar energy to biomass, daily respiration losses and relative yield decrease due to drought or freezing conditions.

Four different output products can be generated with the Pasture Monitoring System which show the geographical distribution of:
Actual biomass: the pasture absolute yield (kg/ha) as the amount of aboveground green biomass in dry matter.
Relative biomass: the pasture relative yield (%) or the actual biomass relative to the aboveground green biomass of pasture that would be attained without water limitations to the plant.
Biomass available for grazing: the daily optimum amount of biomass (kg/ha) that is available for grazing.
Pasture carrying capacity: the number of cattle (0.1 Sheep Units/ha) that the pasture can support based on the information in the Biomass available for grazing files.

Actual and relative pasture biomass data can be generated with this model for grazed conditions and ungrazed conditions. Biomass for grazing and pasture carrying capacity are only generated under grazed conditions.
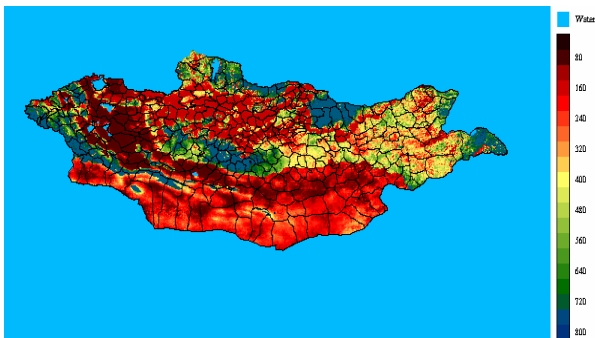

Figure 11. The actual pasture biomass map of
2nd decade Aug 2007, [kg/ha]

The pasture carrying capacity can be estimated by varying the amount of consumed biomass in the model and monitor the response of the pasture biomass. An example for this relationship in the Steppe zone is given in Fig 10. The biomass consumed by the cattle was varied from 0 to 3 kg/ha.day and the response on the pasture biomass (kg/ha) plotted. The figure shows that biomass consumptions from 0 to 2 kg/ha have only a very limited influence on the Steppe pasture biomass (decrease of 67 kg/ha). However, the pasture biomass shows a steep decrease at a consumption rate of 2.1 kg/ha.day. This point determines the pasture carrying capacity for this natural zone during summer period.
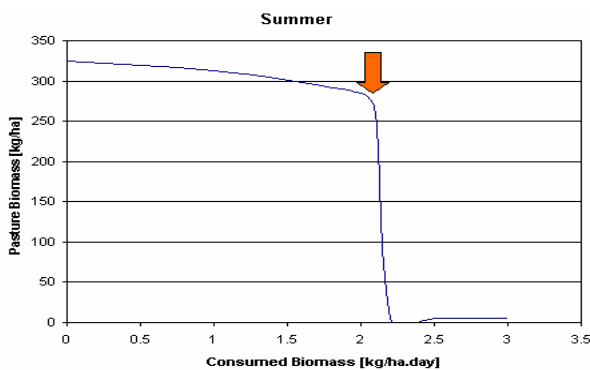

Figure 12. Determination of the carrying capacity (2.1 kg/ha)
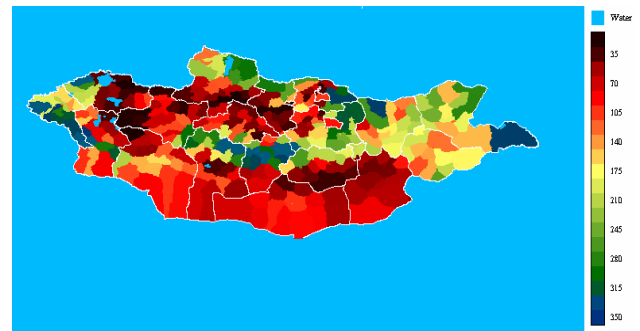for Steppe zone calibrated model

Figure 13. Pasture carrying capacity map, 2007 (at soum level),
[SU/ha]

Pasture carrying capacity being 0.3-1.0 SU/ha (sheep unit per hectare) in Western and Gobi-Desert region of Mongolia. In the Gobi-Desert region is low biomass but bigger pastureland area and cattle numbers relatively few.

The figure shows that pasture carrying capacity is around 1.4-2.1 SU/ha in Eastern region, so this year there is with low biomass. Other years, the carrying capacity was being higher since the summer conditions were not so dry before.

2.2.3 The Winter Grazing condition monitoring system: generates snow cover represents number of days with snow, snow height showing amount of snow present at the surface in water equivalent, amount of snow melt and presence of ice crust at the ground surface
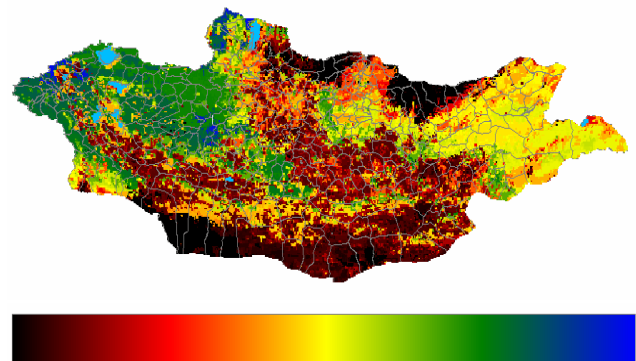

Figure 14. Snow cover map,
3rd decade of January 2008

The EWBMS software is supplemented with utility software tools to quickly evaluate the results and display the output products for remote users at aimag level.

3. CONCLUSIONS

1. MODIS data can be used natural disaster monitoring in regular based servicing like, daily dust and fire maps, 10 daily snow and vegetation maps
2. With natural resources mapping purpose we will map the Land cover types in each 2 years in order to get necessary information for decision making for natural resource management
3. The MODIS based Land cover classes can be identified by field survey then the Land cover changes can be detected

4. The satellite data can be sent to all aimag's centers and processed at the local level to provide the satellite based products to the decision makers
5. For these reasons we need to validate both basic and application products from EWBMS by ground measurement data.
6. The outputs of the EWBMS system will be used for development of a decision support system for pastureland management

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