# USING REMOTE SENSING DATA TO MAPPING FOREST FIRE RISK

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## ABSTRACT:

Lately we had to think many questions about the fire of forest in Mongolia. Forest fire to begin increased in 1996, but lately is too many increased fire of forest. The main goal of this research is to develop a methodology for map processing of forest fire risk using Remote Sensing and Geographical Information System. The study area is the Mandal sum in Selenge province. GIS technologies and historic fire regime model were used for the mapping analysis.

## 1. INTRODUCTION

During the last century, Mongolia lost approximately four million ha of forests, averaging 40,000 ha annually. Between 1990 and 2000, due largely to unsustainable exploitation, the rate of deforestation increased to 60,000 ha per year. (Mongolia Environmental Monitor 2003). Causes for deforestation and degradation include agricultural expansion, fires, conversion to cattle ranches, commercial logging and mining. From these, forest fire is one of the disasters causing threats to the forests and ecosystem through out of the world. Fires have adverse effects on soil, forests and humans. During the process of burning, the soil nutrients are reduced and the soil is left bare making it more susceptible to both soil and water erosion. The forest cover is drastically reduced through the death of fire intolerant tree species. Furthermore, animal populations dwindle due to their death and others migrate due to loss of their habitats. Fire also leads to an increase in green house gas emissions. Mongolia has a serious increase in forest fires. According to fire statistics, most of fires burned within the central and eastern parts of the forested areas. (Z.X. Zhang…etc) Forest fire cannot be directly measured from space yet, but remotely sensed greenness can be used as an effective surrogate for forest fire in longer time scales in regions of distinct seasonality. The overall objective of this study is to apply a model, to mapping forest fire risk.

## 2. STUDY AREA AND DATA

The study area is the Mandal sum, Selenge province of Mongolia. It is about 400 km from the capital city of Ulaanbaatar. Mandal sum’s territory has a 484,300 ha. It is located between latitude 49°54 N to 49°19 N and longitude 106°76 E to 107°77 E.

Several data sets were essential for this research. These included the topographic map covering the study area. It was acquired from the survey department of Mongolia, the Digital Elevation Model, the forest shape file. ERDAS 9.1, Arc GIS, 9.2 and ILWIS 3.3 were used in the analysis. During field work, several equipments were used to collect the required data.

## 3. METHODS

### Aspect and Slope maps

The following topographical code characteristics and Digital Elevation model -SRTM data 90m (http://srtm.csi.cgiar.org/) for 2006 year were applied for the study area.

Warm Aspect (Southeast) = 125° to 145°
Warm Aspect (South) = 145° to 165°
Warm Aspect (Southwest) = 165° to 185°
Cool Aspect = 185.1° to 124.1°
Steep Slope = > 35%
Shallow Slope = < 35%

### Vegetation mapping

The Satellite Data MOD13_EVI 2006 with resolution 250m was used for vegetation classification. Enhanced vegetation index (EVI) was developed to optimize the vegetation signal with improved sensitivity for high biomass regions and improved monitoring through de-coupling of the canopy background signal and reduction of atmospheric influences. The EVI is represented by the following equation:

$$EVI = G * \frac{NIR - Red}{NIR + C_i Red - C_i Blue} + L \qquad (1)$$

Where L is the canopy background adjustment that addresses nonlinear, differential NIR and red radiant transfer through a canopy, and C1, C2 are the coefficients of the aerosol resistance term, which uses the blue band to correct the aerosol influences of the red band. The coefficients adopted in the EVI algorithm are, L=1, C1=6, C2=7.5, and G (gain factor) =2.5 (Huete, 1997).

Main land cover classes such as tundra taiga, sub-taiga steppe were determined by supervised classification. The classification results were compared with ground truth data and reference maps from the "Forestry Structure Map" produced by Russian Mongolian Complex Expedition 1:1500000 scale in 1983.

- Tundra
    - Tundra (non-forest/xeric)
    - Tundra (lowforest/LASI)
    - Tundra (high forest/LASI)
    - Tundra (non-forest/mesic)
- Taiga
    - Taiga (non-forest/xeric)
    - Taiga (low forest/LASI)
    - Taiga (high forest/LASI)
    - Taiga (non-forest/mesic)
- Sub-Taiga
    - Sub-Taiga (non-forest/xeric)
    - Sub-Taiga (low forest/LASI)
    - Sub-Taiga (high forest/LASI)
    - Sub-Taiga (non-forest/mesic)
- Steppe
    - Steppe (non-forest/xeric)
    - Steppe (low forest/BERO-POTR)
    - Steppe (high forest/BERO-POTR)
    - Steppe (non-forest/mesic)

## Historic Fire Regime Model

The vegetation classification code and topographical classification code and modeling code were used for the historic fire regime (Table 1).

**Table 1. Historic Fire Regime Prediction Model**

| Historic Fire Regime | Vegetation Classification Code | Topographical Classification Code | Comments |
|---|---|---|---|
| 1 - No fire | Tundra (Non-forest/xeric) | All aspects: I, II, III,IV, V | High alpine ecosystems of |
| 2 – Frequent (<10 years), stand replacement | Steppe (non-forest/xeric)<br>Sub-Taiga (non-forest/xeric) | All aspects: I, II, III, IV, V | Warm and cool aspects/slopes of grass/forb/shrub |
| 3 – Frequent (<10 years), mixed-severity | Steppe (low forest/BERO-POTR)<br>Steppe (highforest/BERO-POTR)<br>Sub-Taiga (low-forest/LASI)<br>Sub-Taiga (high-forest/LASI) | Warm aspects: II, III, IV | Warm aspect forests of LASI, PISY, and BERO/POTR mixed with grass |
| 4 – Frequent (<30 years), mixed-severity | Steppe (non-forest/mesic)<br>Sub-Taiga (low-forest/LASI)<br>Sub-Taiga (high-forest/LASI)<br>Sub-Taiga (non-forest/mesic)<br>Taiga (non-forest/xeric)<br>Taiga (low-forest/LASI)<br>Taiga (high-forest/LASI) | Cool/low-elevation riparian +<br>Warm/mid-elevation +<br>Warm subalpine | Cool, low elevation riparian zones, plus mid-elevation warm aspect forests of LASI, PISY, and BERO/POTR mixed with grass, and warm aspect subalpine (Taiga) forests of LASI |
| 5 – Frequent (<50 years), mixed-severity | Taiga (non-forest/mesic)<br>Taiga (low-forest/LASI)<br>Taiga (high-forest/LASI) | Cool/mid-elevation riparian +<br>Cool/subalpine | Cool, mid-elevation riparian zones, plus cool aspect subalpine (Taiga) forests of LASI, PISI, ABSI, PISI and forbs |
| 6 – Infrequent (>100 years), mixed-severity | Tundra (low-forest/LASI-PISI)<br>Tundra (high-forest/LASI)<br>Tundra (non-forest/mesic) | All aspects: I, II, III, IV, V | High-elevation forests and meadows that contain continuous to discontinuous fuels |

**Modeling code:**

HFR1 = Tundra (non-forest/xeric) + Topographical Codes: I, II, III, IV, and V

HFR2 = Steppe (non-forest/xeric) + Sub-Taiga (non-forest/xeric) + Topographical Codes: I, II, III, IV, and V

HFR3 = Steppe (low-forest/BERO-POTR) + Steppe (high-forest/BERO-POTR) + Topographical Codes: I, II, III, IV, and V; Sub-Taiga (low-forest/LASI) + Sub-Taiga (high-forest/LASI) + Topographical Codes: II, III, and IV

HFR4 = Steppe (non-forest/mesic) + Sub-Taiga (non-forest/mesic) + Topographical Code: V; Sub-Taiga (low-forest/LASI) + Sub-Taiga (high-forest/LASI) + Topographical Codes: I; Taiga (non-forest/xeric) + Taiga (low-forest/LASI) + Taiga (high-forest/LASI) + Topographical Codes: II, III, and IV

HFR5 = Taiga (non-forest/mesic) + Taiga (low-forest/LASI) + Taiga (high-forest/LASI)

+ Topographical Codes: I and V

HFR6 = Tundra (low-forest/LASI-PISI) + Tundra (high-forest/LASI) + Tundra (nonforest/mesic) + Topographical Codes: I, II, III, IV and V

## 4. ANALYSES

First we overlaid Aspect (Fig.1) and Slope (Fig.2) maps. After that we combined that maps and overlaid Aspect and Slope map combination (Fig.3). Finally we combined all these maps with vegetation map and overlaid Historic fire regime map (Fig.5).

**Aspect map**

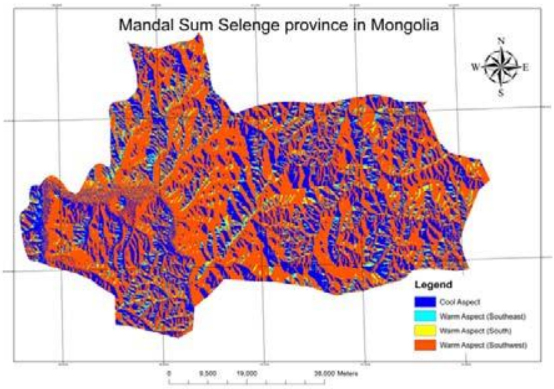

*Fig.1 Mandal Sum Selenge province Aspect Map*

**Slope map**

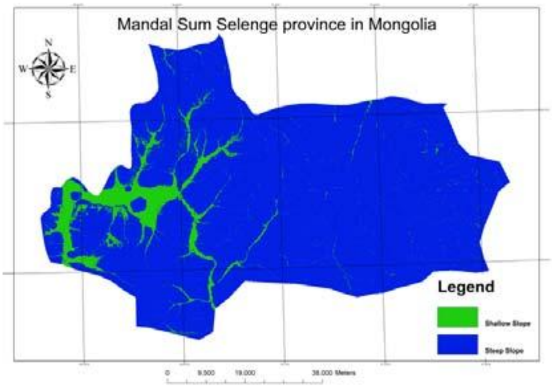

*Fig.2Mandal Sum Selenge province Slope Map*

**Aspect Slope Combination Maps**

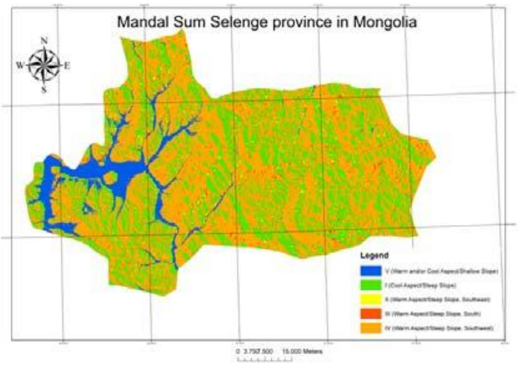

*Fig.3 Mandal Sum Selenge province Aspect Slope Combination Map*

**Vegetation Type Maps**

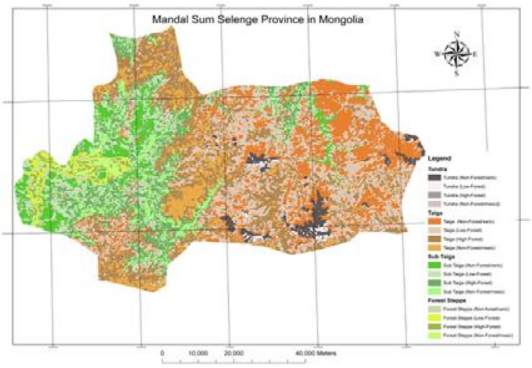

*Fig.4 Mandal Sum Selenge province Vegetation Type Map*

## Historic Fire Regime Maps

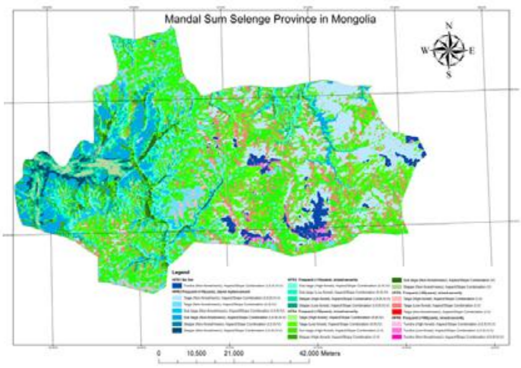

*Fig.5 Mandal Sum Selenge province*
*Historic Fire Regime map*

## 5. RESULTS

The fires were said to be prevalent in the summer season when both air and soil temperatures were high. This is from April to June. The distribution of the average monthly air and soil temperatures in Mongolia are higher in the months of April to June. This is the reason why fires are prevalent around this time because of the increased air and soil temperatures. Wind is influential in the way the fire behaves. An increased wind speed in the summer season (April to June) confirms that fires are frequent during this time due to the effect of wind that makes the fire spread faster. Using Historic fire regime map we can determine multiyear forest fire.

## REFERENCES

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Studies on Mongolian Environmental Issues Using Remote Sensing and Geographical Information System

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