REGIONAL WORKSHOP ON UNDERSTANDING THE OPERATIONAL ASPECTS OF THE DROUGHT OBSERVATION SYSTEM IN MONGOLIA

DroughtWatch system operation in Mongolia

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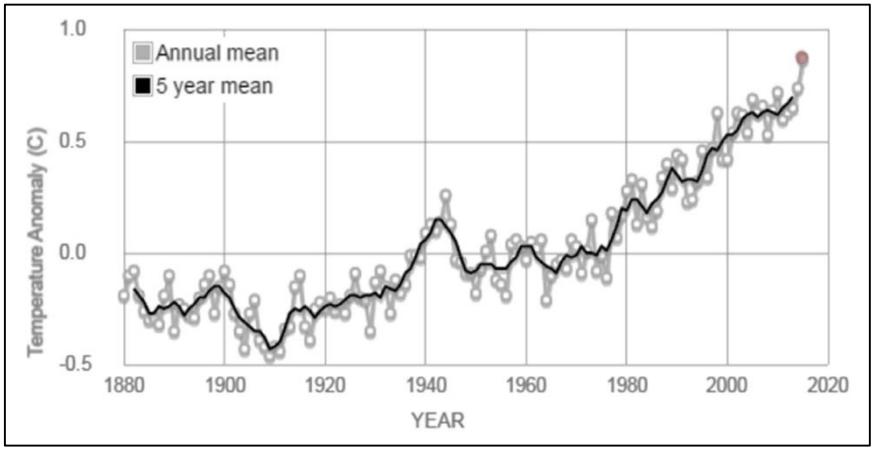
Outline

- Definition of drought
- Drought & Dzud study in Mongolia
- Dzud – harsh winter condition
- Remote sensing and meteorological indices
- Study area: land cover and vegetation
- Objectives
- Data used & methodology
- The DroughtWatch system operation, 2018
- Comparison analysis of RS sensing indices and ground measurement, 2016–2018
- Summary

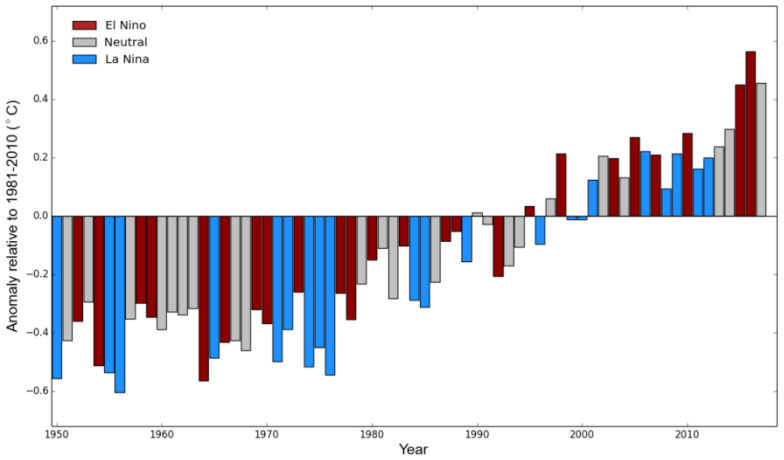
What is the Drought?

- Drought is a recurrent climate process, but occurs with uneven temporal and spatial characteristics over a broad area and over an extended period of time.
- A period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area.
- Drought must be considered as region specific since the atmospheric condition that results in deficiencies of precipitation are highly variable from region to region (Keyantash and Dracup, 2002).

Global Land-Ocean Temperature Index, 1880–2015



The long-term average temperature



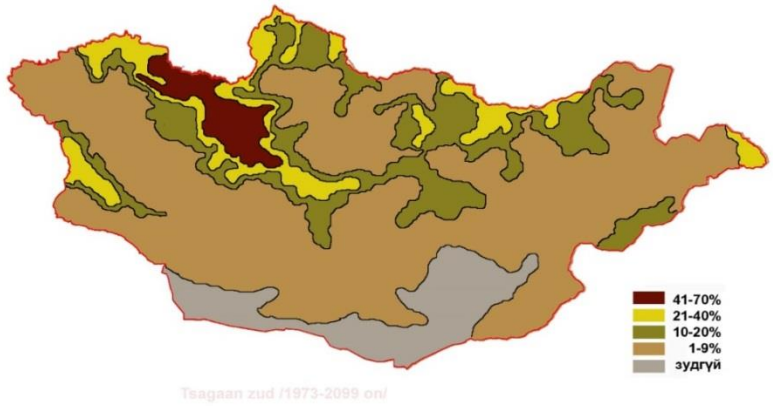
Source: NASA's Goddard Institute for Space (GISS), "Global Temperature," NASA website, http://climate.nasa.gov/vitalsigns/global-temperature/

Drought & Dzud study in Mongolia

These drought and dzud frequency maps are based on observation data of drought from 1973 to 2009 (Natsagdorj, 2009; Natsagdorj et al, 2017).

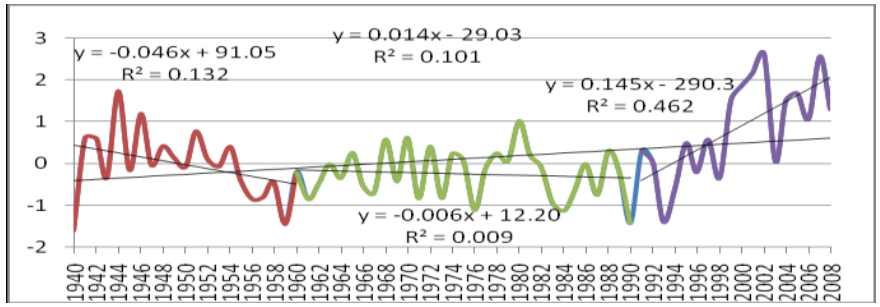
Drought frequency map, %

White dzud frequency map, %

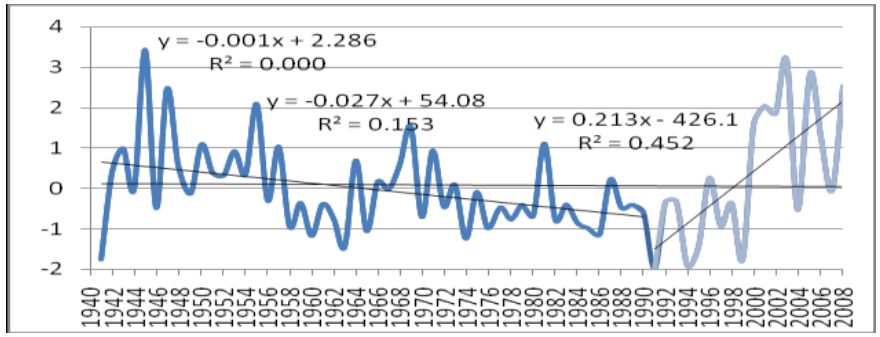


Source: Л.Нацагдорж, 2009. "Ган, Зуд". Улаанбаатар, ISBN 978-99929-77-85-X.

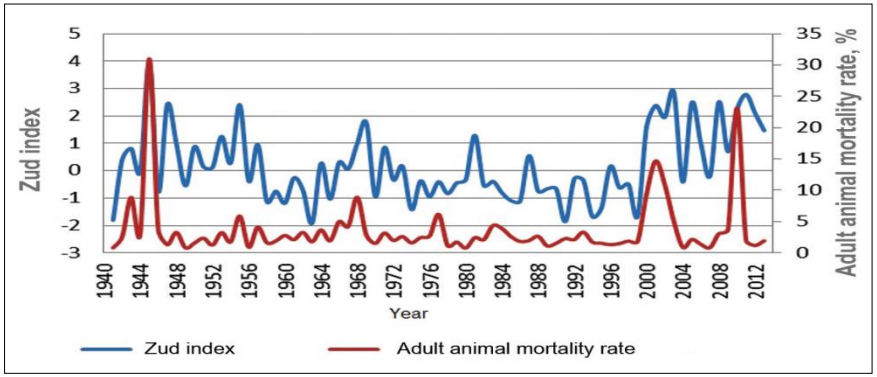
Drought index changes



Dzud index changes



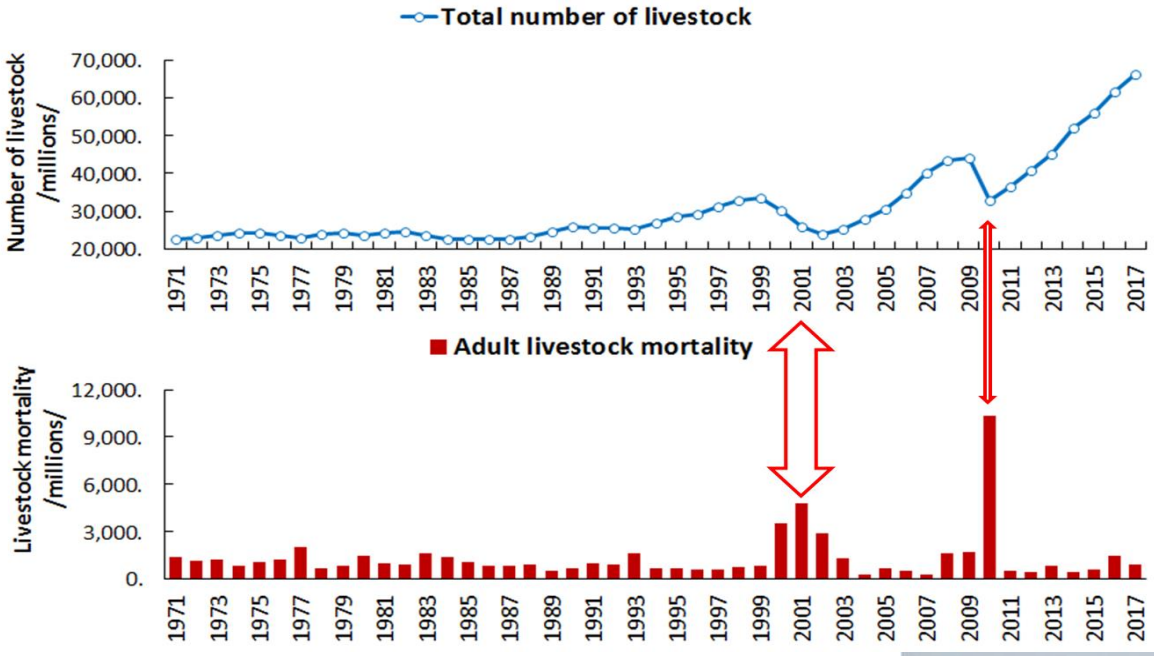
Relationship between annual dzud index and the adult animal mortality rate, %



Source: MARCC 2014

Dzud – Harsh winter condition

Number of livestock, 1971-2017



Source: http://ekhoron21.mn/aimag.php/a/15/r/3990

Remote sensing (RS) and meteorological indices

Remote sensing drought indices:

Normalized difference vegetation index (NDDI)

$$NDDI = (NDVI - NDWI)/(NDVI + NDWI)$$

Vegetation condition index (VCI; Kogan 1995; Yan Nana, 2005)

$$VCI = \frac{NDVI_i - NDVI\ min}{NDVI\ _{max} - NDVI_{min}}\ x\ 100$$

Temperature Condition index (TCI; Kogan 1995; Yan Nana, 2005)

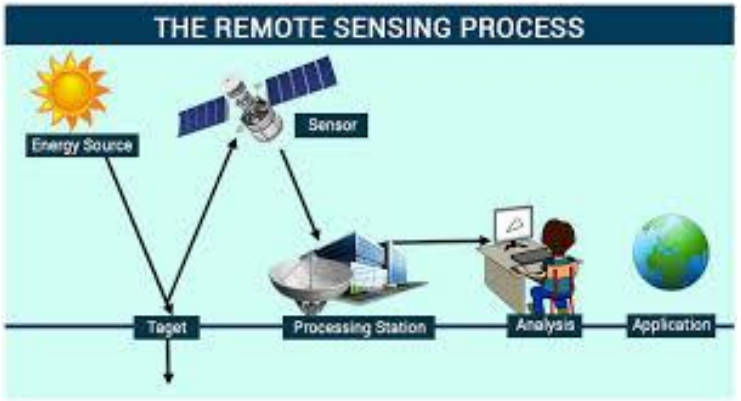
$$TCI = (LSTmax - LSTi)/(LSTmax - LSTmin) \times 100$$

Vegetation health index (VHI; Kogan, 1995; Kogan *et al.*, 2004*)*

$$VHI = 0.5VCI + 0.5TCI$$

Normalized difference water index (NDWI; Gao, 1996)

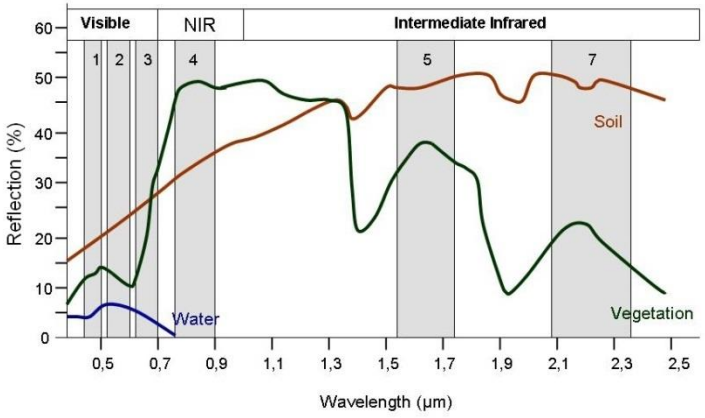
$$NDWI = (NIR - SWIR)/(NIR + SWIR)$$



Meteorological drought indices:

SPI – Standard Precipitation Index (McKee *et al.*, 1993)

AI – Aridity Index - De Martonne in 1926 (Livada and Assimakopoulos 2007)

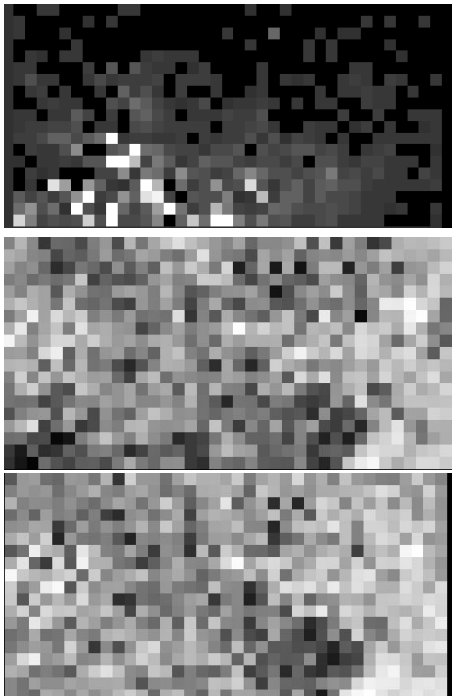


Source: Introduction to Remote Sensing

Remote sensing (RS) and meteorological indices in study area

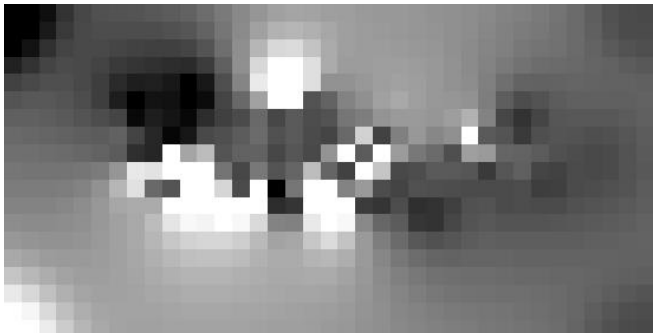
Comparison of RS and meteorological indices of MODIS,
August of 2000–2013

RS indices



VS

Meteorological indices



Correlation between RS and meteorological indices

Indices	NDDI	TCI	VCI	VHI	VSWI	VTCI	VSDI	NMDI
SPI	0.71	0.64	0.43	0.56	0.55	0.57	0.3	0.42
AI	0.29	0.53	0.35	0.29	0.51	0.53	0.3	0.31
Soil moisture (SM)	0.68	0.58	0.48	0.61	0.43	0.49	0.31	0.46

Bulgan *et al.*, 2014

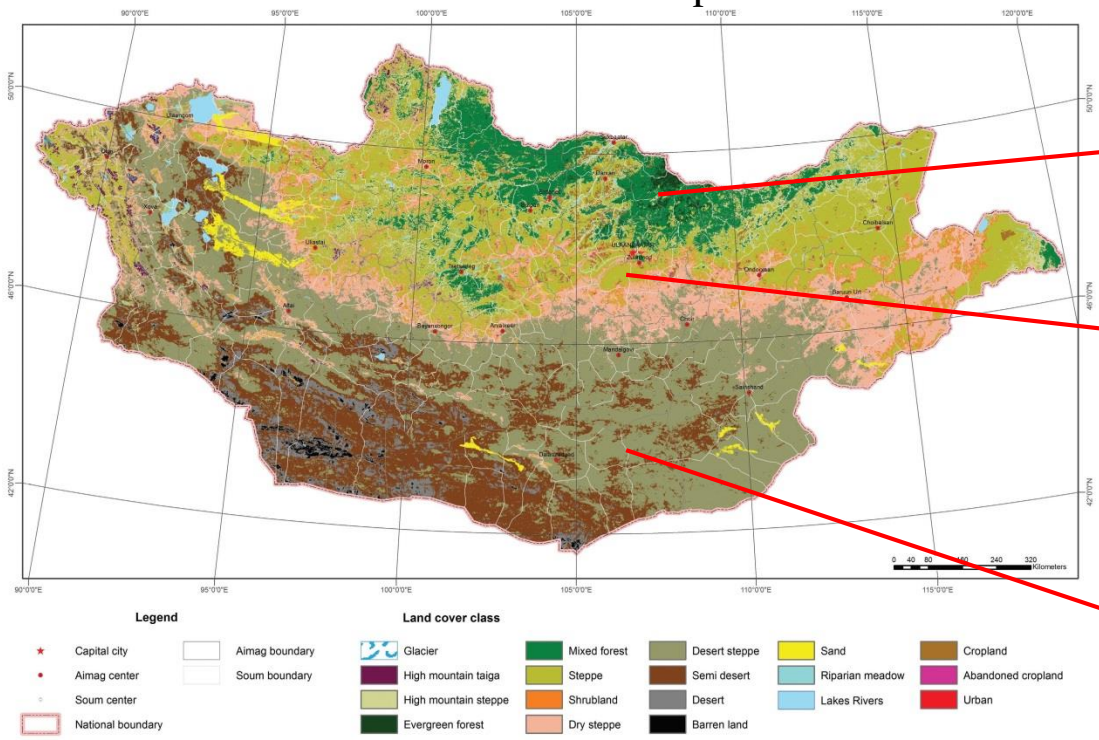
Objectives

The main objectives of this project are to contribute and serve drought monitoring information using MODIS data to decision makers and users.

- Main product of drought map is based on MODIS/NDWI, VCI and VHI indices. Drought map is classified by 5 classes.
- Drought maps can be produced for 10 days during summer season (Jun–Sep). The spatial resolution is 1 kilometer.
- Drought map can provide the report of drought affected area by study area and province level in summer season.

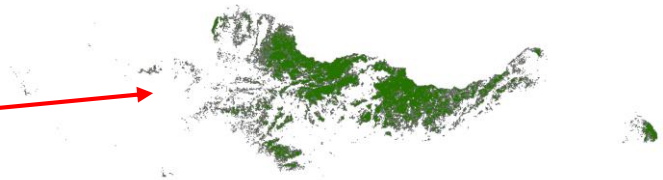
Study area: Land cover & vegetation

Land cover map

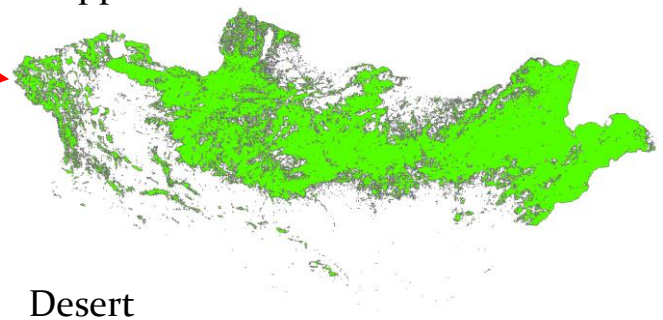


Source: Bulgan *et al.*, 2014

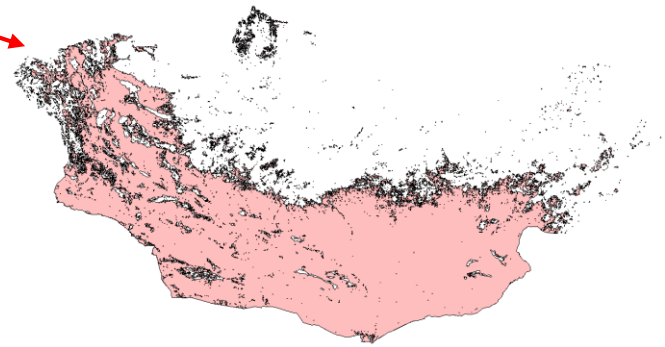
Forest



Steppe



Desert



- Most of the north and the central parts are covered by mixed forest and woodland with some grass vegetation in the valleys during the growing season.
- Towards south and southwest, the vegetation becomes denser and some grassland can be found as well as some barren land (Munkhzul *et al.*, 2017).

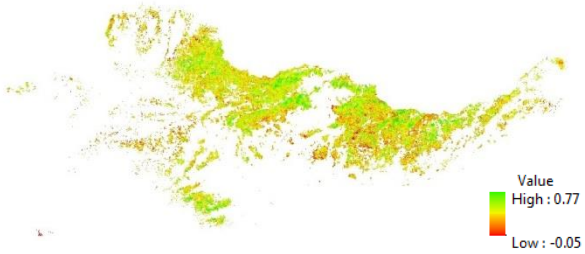
- Three main vegetation zones were selected for this analysis.
  - Forest
  - Steppe
  - Desert

Used data & Methodology

Normalized Difference Water Index (NDWI)

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$$

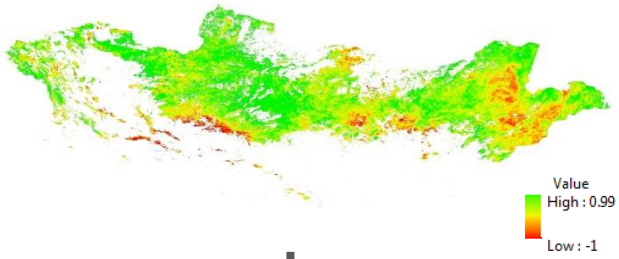
NDWI – Forest



Vegetation Condition Index (VCI)

$$VCI = \frac{NDVI_j - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

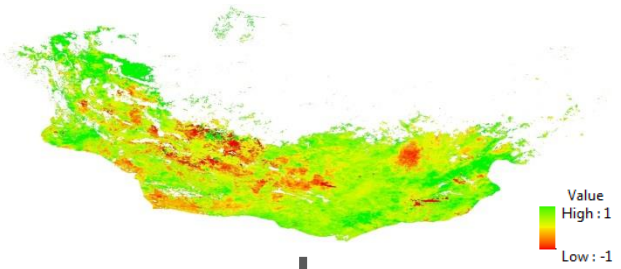
VCI – Steppe



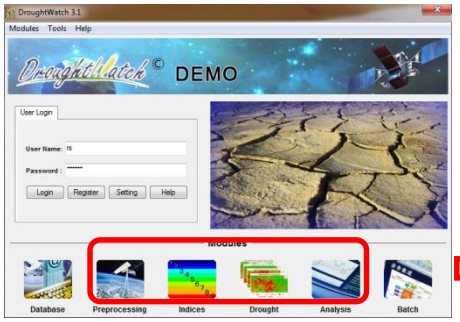
Vegetation Health Index (VHI)

$$VHI = 0.5 \times VCI + 0.5 \times TCI$$

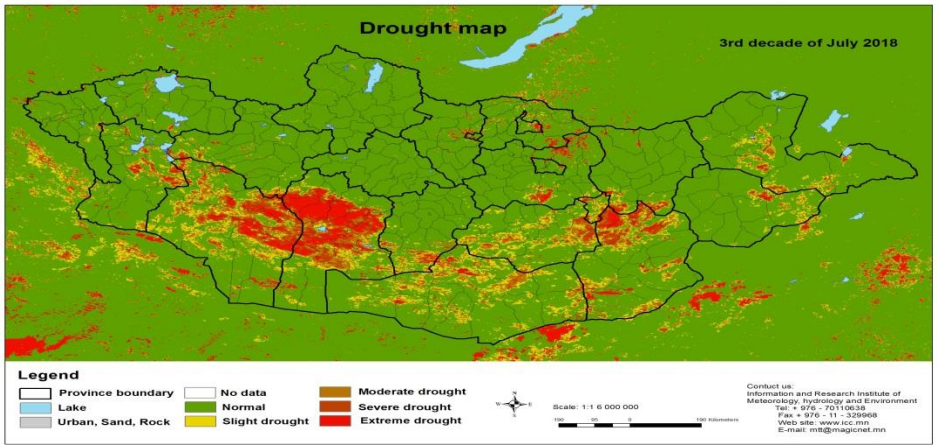
VHI – Desert

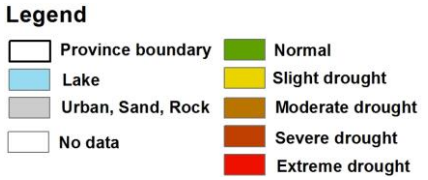


DroughtWatch system



Extracting, Setting the threshold value & Classifying

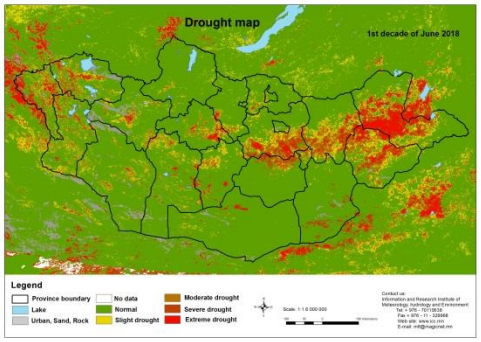




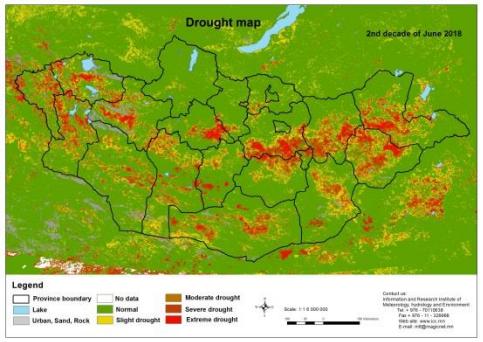
The DroughtWatch system operation, 2018

Drought map from DroughtWatch system

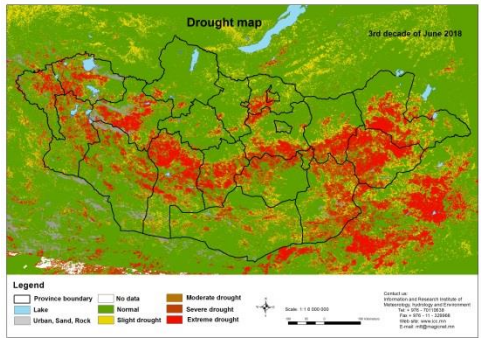
Drought map of MODIS, 2018



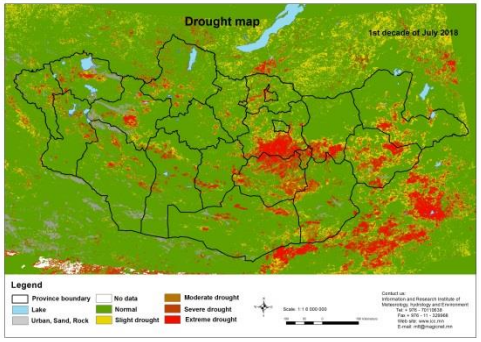
1st decade of June



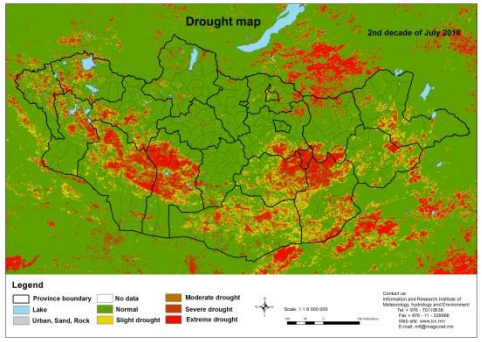
2nd decade of June



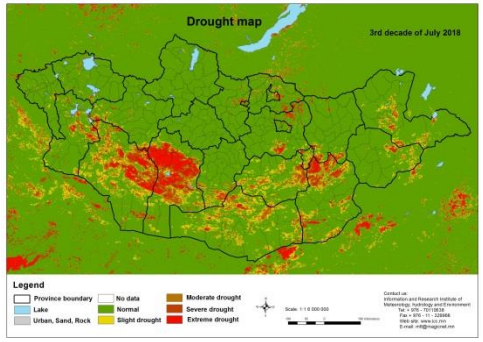
3rd decade of June



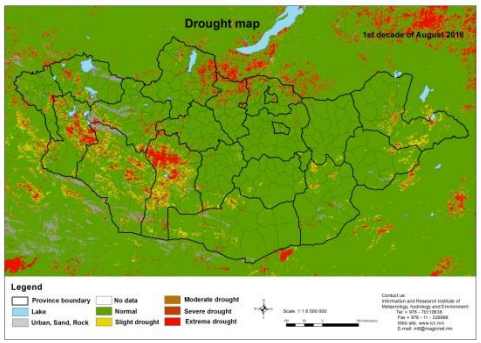
1st decade of July



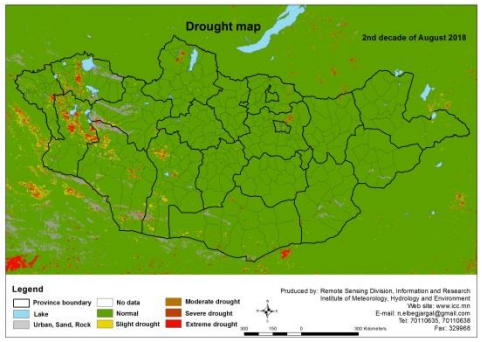
2nd decade of July



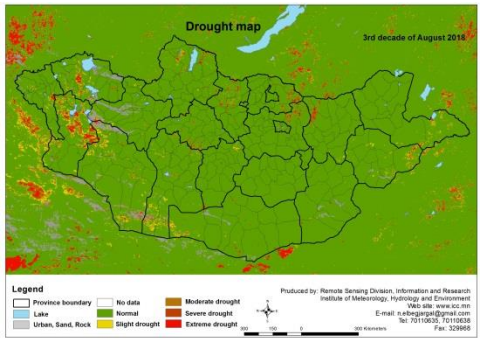
3rd decade of July



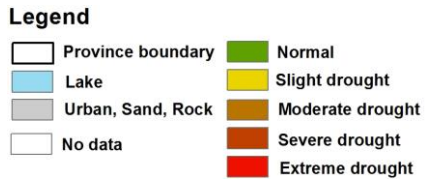
1st decade of August



2nd decade of August



3rd decade of August



Output drought map

Drought map can provide the percentage of drought affected area by study area and province level.

1. Percentage of drought classification of the total area by Graph

Percentage of drought classification is calculated as below:

$$P = \frac{S_{each\ class\ area}}{S_{total\ area}} \times 100$$

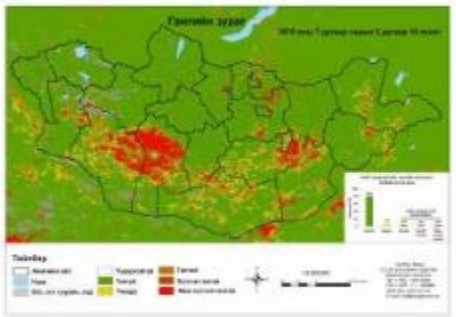
where; P – percentage of drought classification, %

$S_{each\ class\ area}$ – the area of each class of drought

$S_{total\ area}$ – the total area of drought

2. Percentage of drought affected area in province level by Table

www.icc.mn

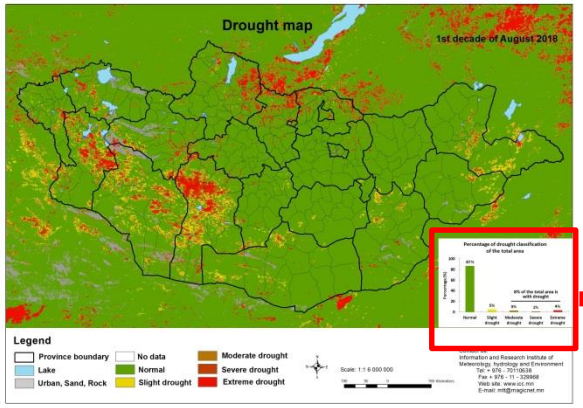


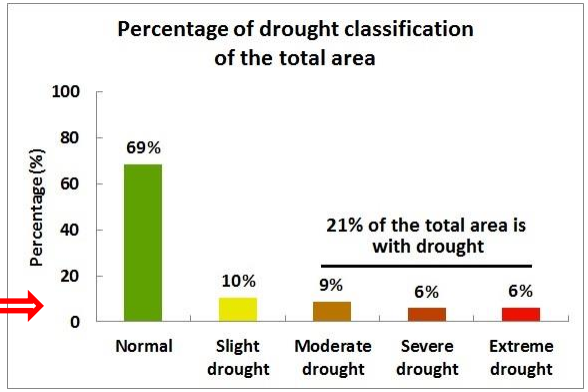
2018/7/21 - 2018/7/31

2018/7/20 - 2018/7/31

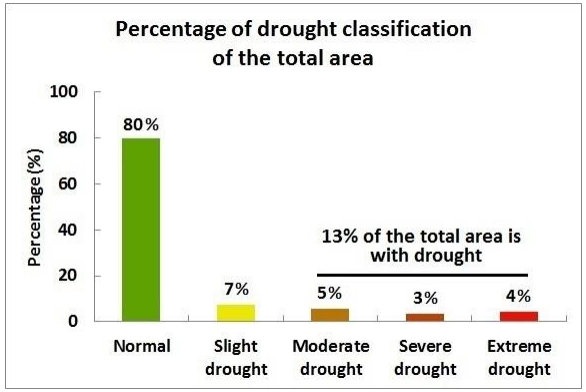
Each class of drought by percent in 2018

Percentage of drought classification of the total area, 2018

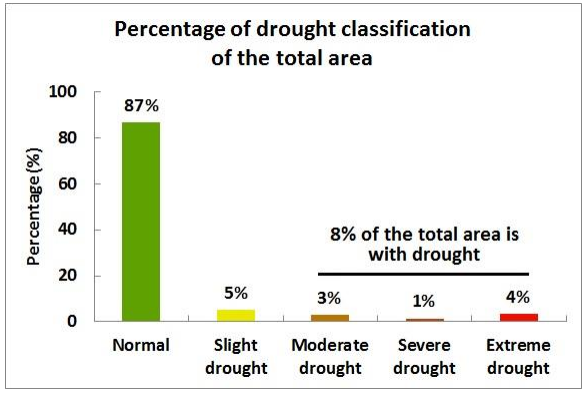




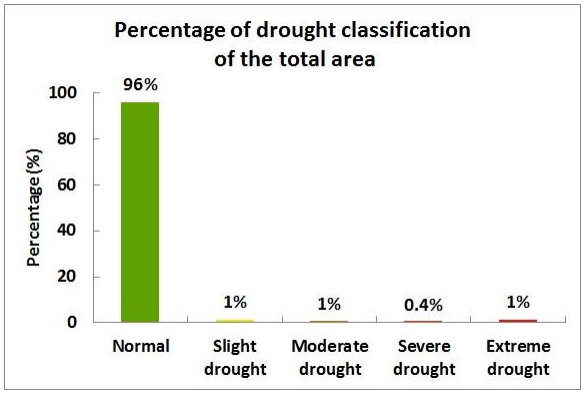
2nd decade of July



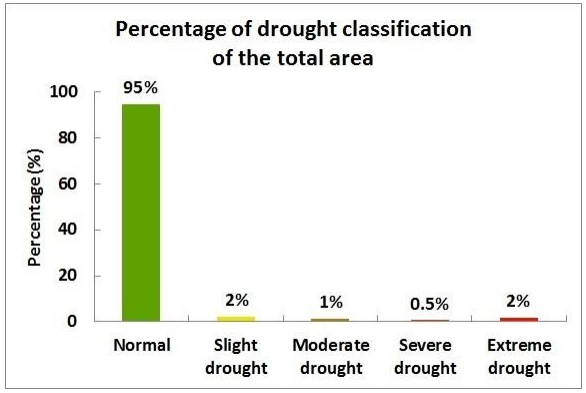
3rd decade of July



1st decade of August



2nd decade of August



3rd decade of August

Output drought reports in province level in 2018

Drought map can provide the drought affected area by province level and each class of drought over selected period.

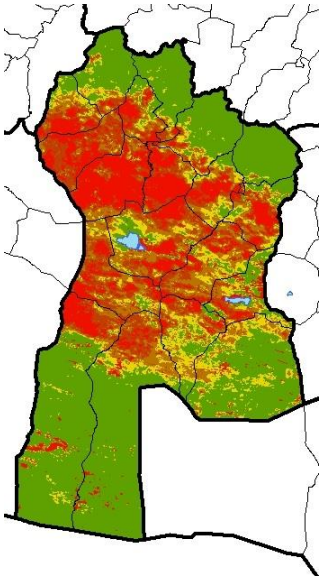
Percentage of the drought classification in province level, second decade of July 2018

Province name		Arkhangai	Bayan-Ulgii	Bayankhongor	Bulgan	Dornogobi	Dornod	Dundgobi	Gobi-Altai	Gobisumber	Zavkhan
Percentage of the drought classification,	Normal	98	69	47	98	40	81	43	56	1	72
	Slight drought	1	12	11	1	18	9	19	12	2	10
	Moderate drought	0.4	10	14	0.3	18	6	20	13	8	9
	Severe drought	0.2	5	13	0.2	15	3	12	10	37	5
	Extreme drought	1	4	16	1	9	1	6	10	52	4

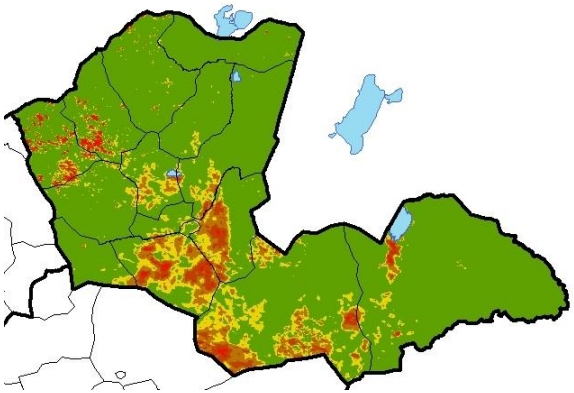
Province name		Uvurkhangai	Umnugobi	Khovd	Khuvsgul	Khentii	Selenge	Sukhbaatar	Tuv	Uvs	Average
Percentage of the drought classification,	Normal	90	61	70	91	75	86	74	79	69	69
	Slight drought	4	19	9	3	6	5	13	8	8	10
	Moderate drought	2	11	9	2	6	3	8	6	7	9
	Severe drought	1	4	6	1	5	1	3	4	4	6
	Extreme drought	3	4	6	4	8	5	2	4	12	6

Drought map in each province, 2nd decade of July 2018

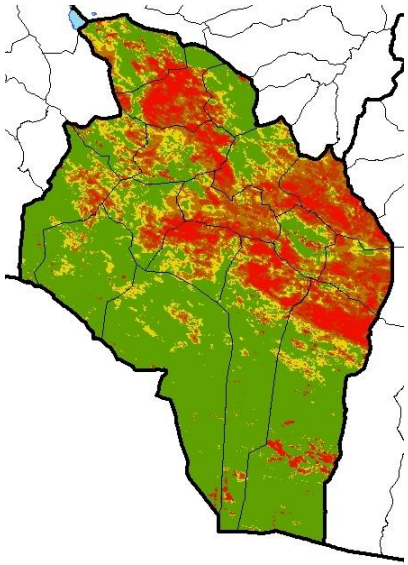
Bayankhongor



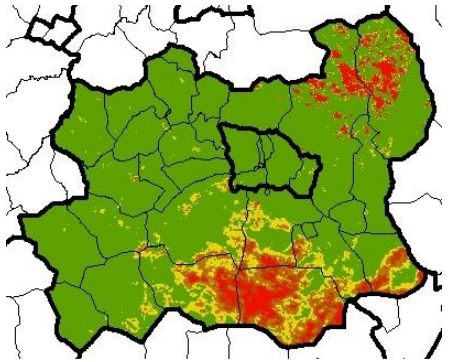
Dornod



Gobi-Altai



Tuv



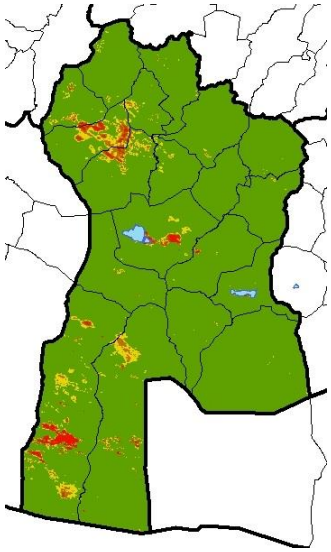
Output drought reports in province level in 2018

Percentage of the drought classification in province level,
second decade of August 2018

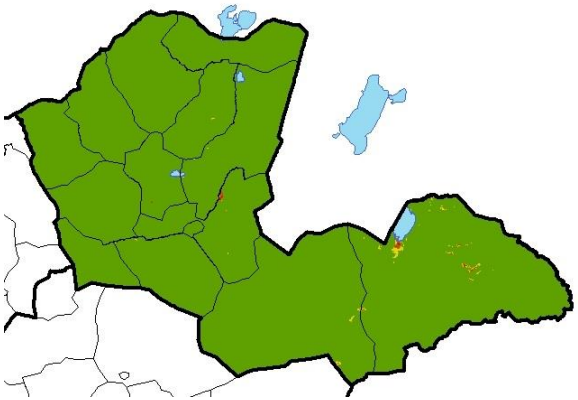
Province name		Arkhangai	Bayan-Ulgii	Bayankhongor	Bulgan	Dornogobi	Dornod	Dundgobi	Gobi-Altai	Gobisumber	Zavkhan
Percentage of the drought classification,	Normal	99.8	93	94	99.7	99.7	99	99.9	91	99.7	97
	Slight drought	0.1	3	3	0.1	0.1	0.2	0.1	4	0.1	2
	Moderate drought	0.1	1	1	0.1	0.05	0.1	0.03	2	0.1	1
	Severe drought	0.01	1	0.5	0.04	0.03	0.05	0.01	1	0.04	0.3
	Extreme drought	0.004	2	1	0.04	0.1	0.3	0.05	2	0.12	1
Province name		**Uvurkhangai**	**Umnugobi**	**Khovd**	**Khuvsgul**	**Khentii**	**Selenge**	**Sukhbaatar**	**Tuv**	**Uvs**	**Average**
Percentage of the drought classification,	Normal	99.6	99	79	97	99.7	99	99.99	99	85	96
	Slight drought	0.3	1	8	1	0.1	1	0.01	0.3	3	1
	Moderate drought	0.1	0.3	6	0.4	0.1	0.3	-	0.2	2	1
	Severe drought	0.03	0.2	3	0.3	0.04	0.2	-	0.1	1	0.4
	Extreme drought	0.1	0.3	4	2	0.1	0.2	0.005	0.5	8	1

Drought map in each province, 2nd decade of August 2018

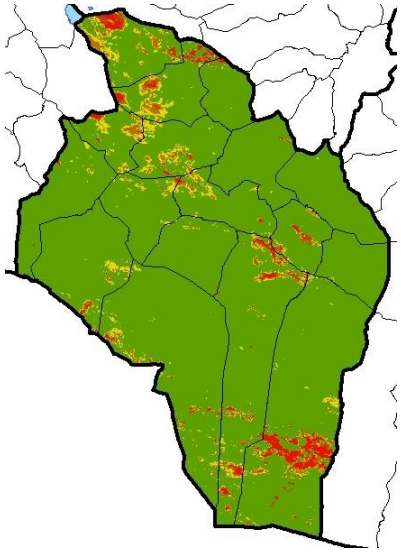
Bayankhongor



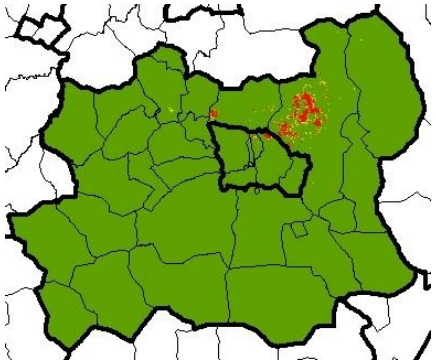
Dornod



Gobi-Altai



Tuv



Comparison analysis of RS indices and ground measurement, 2016–2018

Temporal variation of RS indices in zones

Normalized Difference Water Index (NDWI: Gao, 1996)

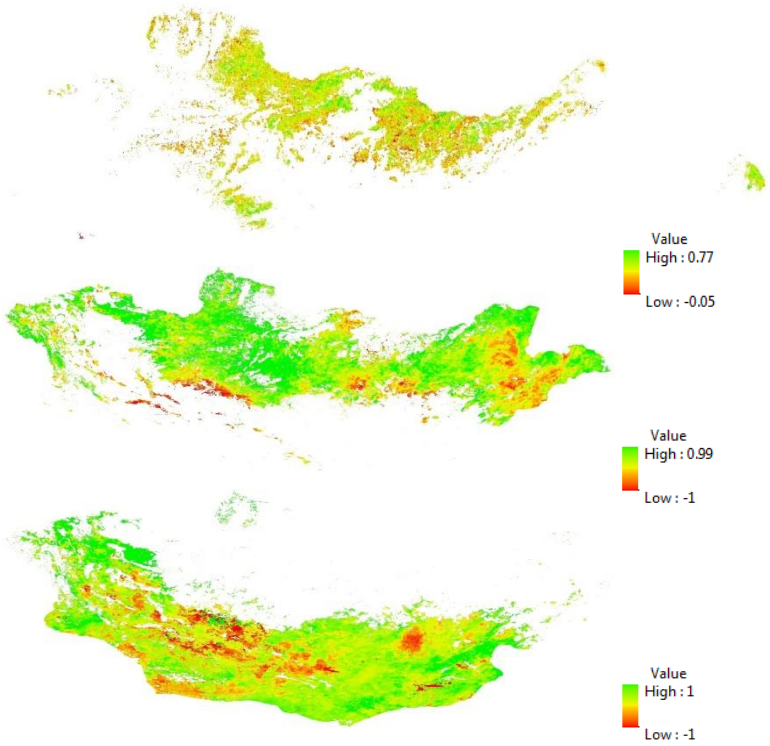
$$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$$

Vegetation Condition Index (VCI: Kogan, 1995)

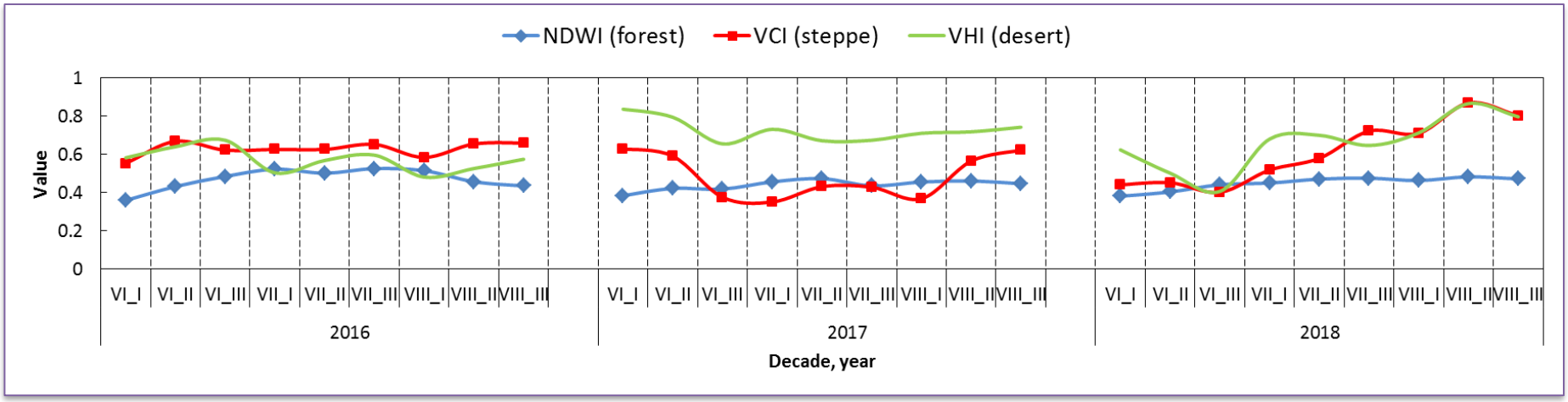
$$VCI = \frac{NDVI_j - NDVI_{min}}{NDVI_{max} - NDVI_{min}} \times 100$$

Vegetation Health Index (VHI: Kogan, 1995)

$$VHI = 0.5 \times VCI + 0.5 \times TCI$$

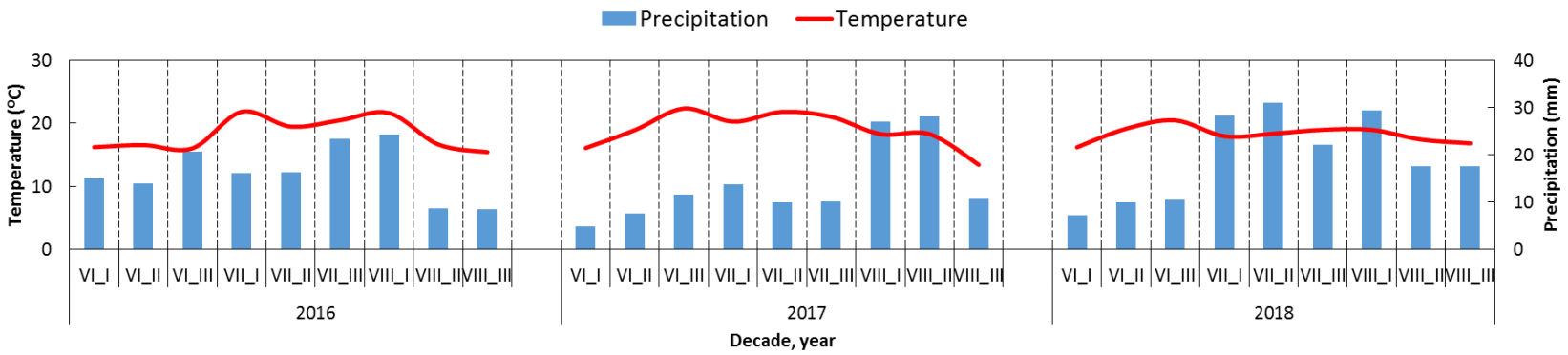


Time-series plots of RS indices, 2016–2018

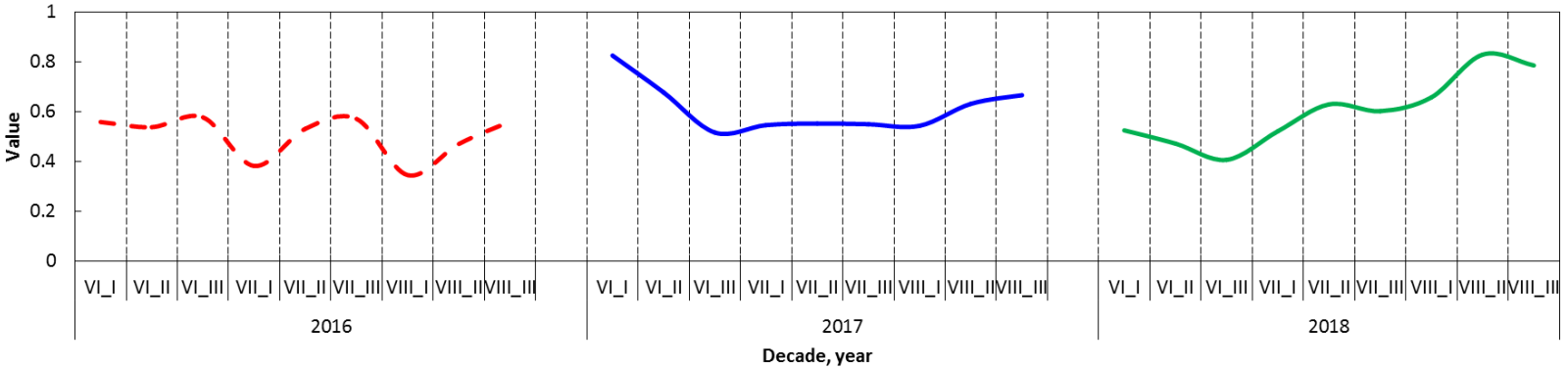


Temporal variation of drought & weather condition

Time-series plots of weather condition, 2016–2018



Time-series plots of drought, 2016–2018

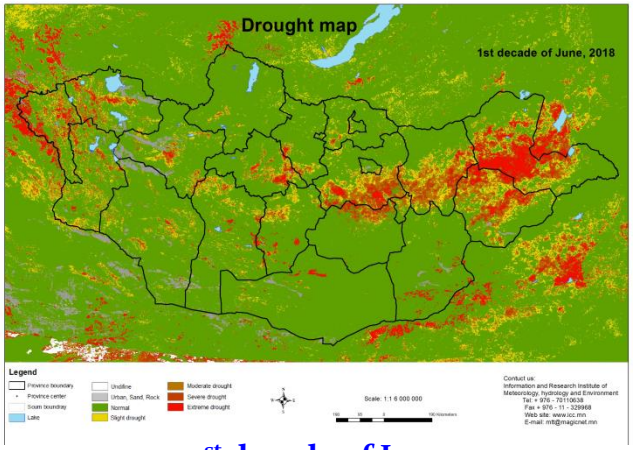


Correlation coefficient (*r*) of drought & weather conditions, 2016–2018

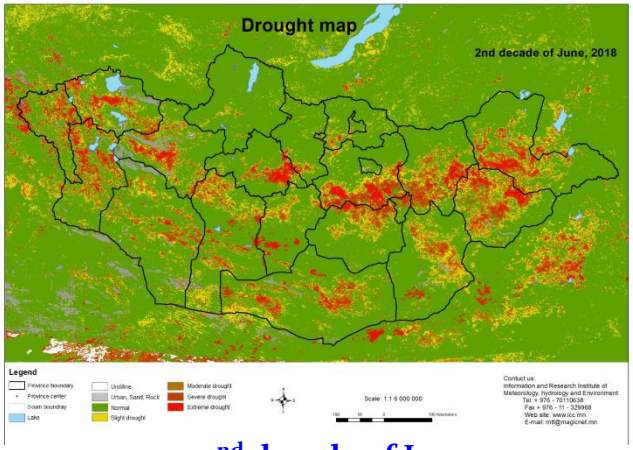
Year	2016	2017	2018
Temperature *vs*. drought	–0.69	–0.70	–0.53
Precipitation *vs*. drought	–0.20	–0.37	0.33

Output RS maps

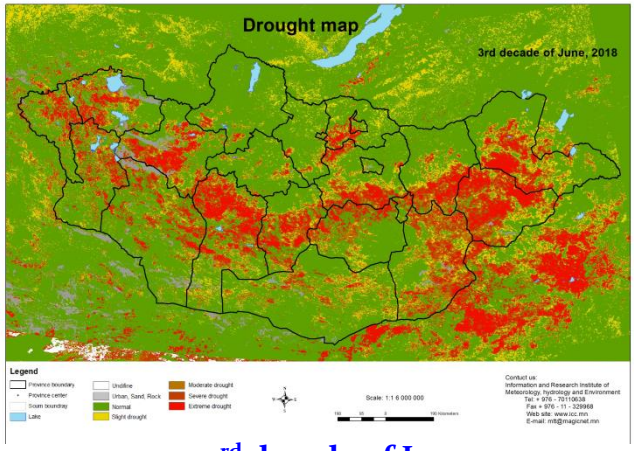
Drought map of MODIS, 2018



1st decade of June

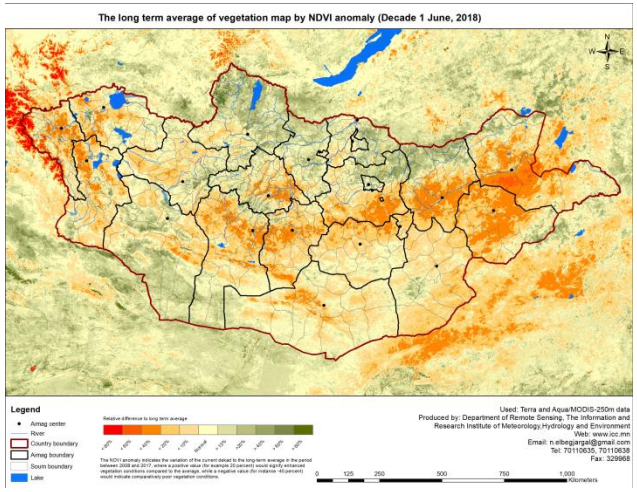


2nd decade of June

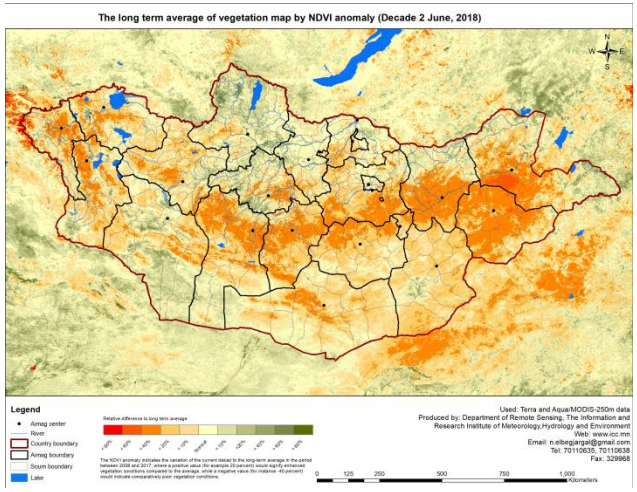


3rd decade of June

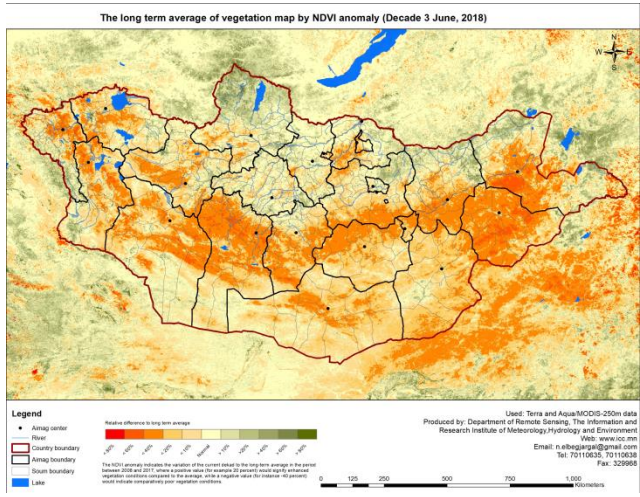
NDVI anomaly map of MODIS, 2018



1st decade of June



2nd decade of June



3rd decade of June

DroughtWatch system has been well assessed in the maps of drought gives good results, similar picture as NDVI anomaly map.

Summary

- DroughtWatch system helps to analyze and compare maps derived from different indices.
- DroughtWatch system has been well produced the drought map and gives good results, similar picture as ground measurement and NDVI anomaly map.
- Human resource capacity has improved during this project.

THANKS FOR YOUR ATTENTION