ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

Year 2 – Field Report
CAF2015-RR14-NMY-Odeh

MONITORING GRASSLAND DEGRADATION IN NORTH/CENTRAL ASIA: DECONSTRUCTING THE IMPACTS OF CLIMATE CHANGE AND GOVERNMENT POLICIES AT DIFFERENT SPATIAL TEMPORAL SCALES USING REMOTE SENSING AND EXPERT KNOWLEDGE

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1. Introduction

Mongolian grasslands are among the largest adjoining expansion of grassland in the world which encompasses regions of considerable ecological importance both nationally and internationally. A changing climate and an increased of grazing pressure have intensified the threat of desert expansion from south Mongolia towards the western, central and northern grasslands. To assess the risk of future ecosystem change and potential solutions, the relative impacts of climate and human activities must first be understood. This project aims to determine the degree of grassland degradation in the region and to decipher the relative impacts on grassland degradation due to climate change compared to those due to human activities. The project used advanced GIS, remote sensing and expert systems in determining the degree and extent of grassland degradation as influenced by climate change. The project aims to elucidate the effectiveness of past grassland restoration programs in Mongolia since the early 2000s and to produce recommendations to inform various national government policy to reform the agenda on grassland restoration.

One of the main activities of this research project is to perform fieldwork to collect samples and data from the core areas and investigate the degradation situations. Mongolian team of the project consisting of experts and researchers from different institutes and organisations performed the fieldwork. Khovd University and Sustainable Development Institute for Western Mongolia worked as a core collaborating organisation for the Mongolian team. Meanwhile, experts and researchers from the Institute for Strategic Studies, National University of Mongolia and Institute for General and Experimental Biology, Mongolian Academy of Sciences focused on technical assistance, remote sensing data analysis and policy formulation.

2. Objectives of field survey

Our fieldwork goals included the following:

1. To investigate the situation of grassland degradation at the local and provincial level
2. To identify the local rangeland policy and legislation problems, rangeland management
3. To observe the comprehensive grassland degradation treatments or practices
4. To collect samples for grassland biomass from the different ecological region and multi-scale
5. To meet with local people and herding groups to identify local situations
6. Observatory meteorological data collection for future multi-scale analysis.

To achieve these goals, our team went on fieldwork in the half part of the west Mongolian region from 16th to 31st August 2017. Before going to fieldwork, we identified the sampling sites based on ecological zone map using the sampling method produced by the late Dr Odeh in 2015.

3. Grassland monitoring and sampling fieldwork

3.1.Research area

The central and western part of Mongolia has long been used as pastureland for the nomadic pastoral system. The grassland degradation in the western part has been mainly caused by climate change, while human impacts are the leading cause of grassland degradation in central and eastern parts. The main aim of this research was to identify the main components of grassland degradation in the selected research area.

Mongolian team repeated the field data collection in the same field areas throughout the data collection period and collected a total of 384 samples from 16 sites (Figure 1).

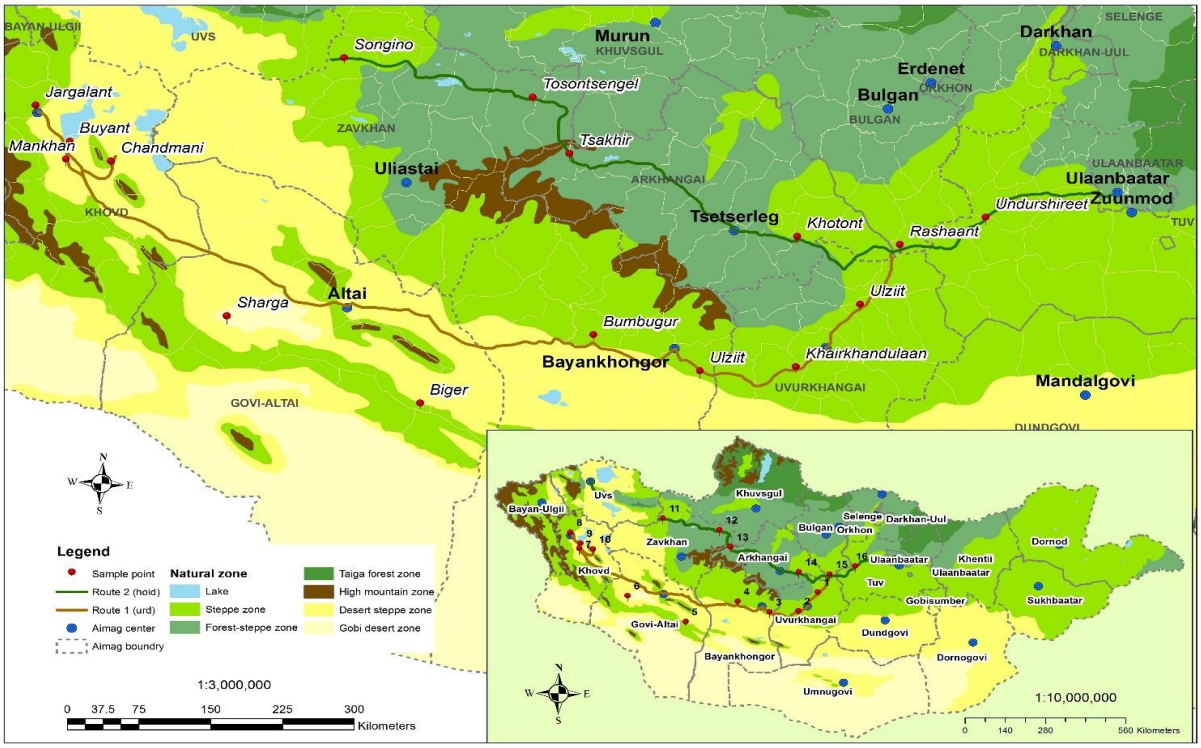


Figure 1. Fieldwork geospatial range, ecological zones and sampling sites, 2017

3.2. Sampling methodology and data analysis

Modis data: Mongolia is a territorially vast country that we needed big data for dynamic change investigation. We used MODIS TERRA data with 186 x 267m spatial resolution and WGS84 metric projection at North 450-480 latitude zone from 2000 to 2017. We analysed the vegetation dynamics of NDVI by using eMODIS data with temporal resolution of an average of second 10 days in August from 2000 to 2017.

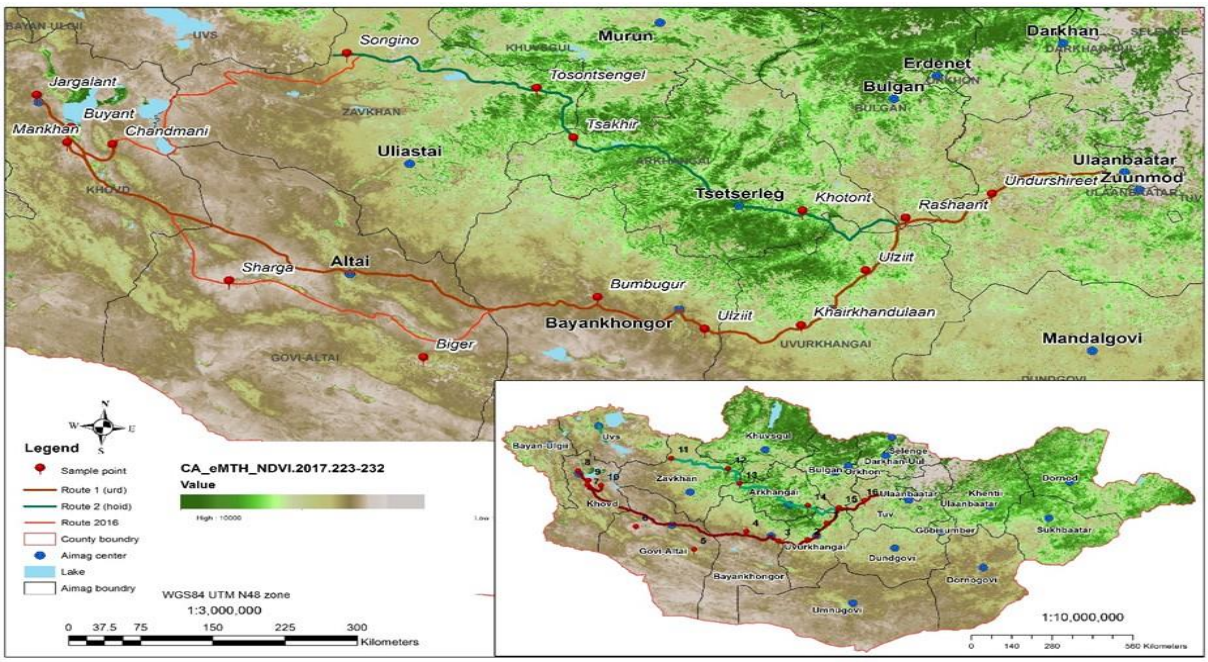


Figure 2. Vegetation in second 10 days in August 2017 by using eMODIS

We used data sets with a different spatial resolution for the grassland degradation analysis. In this section, we used Landsat satellite data with 30 x 30 m pixel size, and WGS84 UTM N46-48 projection for all sampling sites. The temporal range for the Landsat is the second 10 days of August 2016 and 2017. The vegetation NDVIs were calculated using Landsat8 OLI satellite data at 16 sampling sites. Total of 9 scenes was chosen with the minimum clouds dated between 1st July and 30th September 2017.

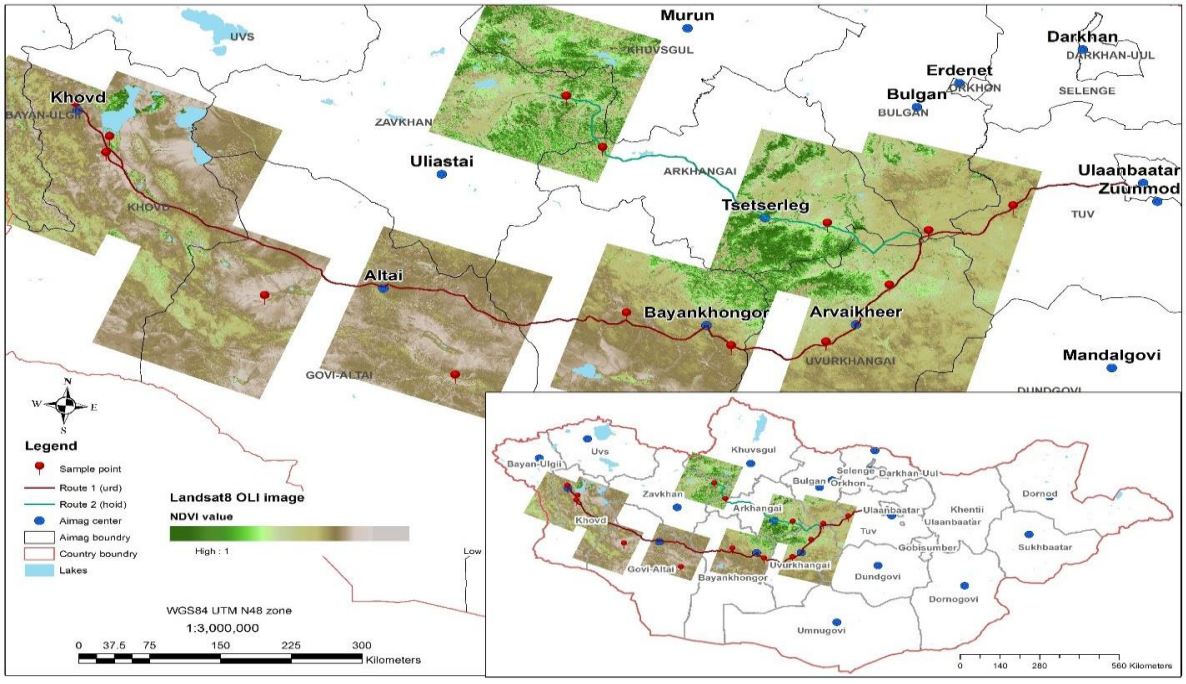


Figure 3. NDVIs calculated at sample points, by Landsat data in August 2017

Landsat data: We used data sets with a different spatial resolution for the grassland degradation analysis. In this section, we used Landsat satellite data with 30 x 30 m pixel size and WGS84 UTM N46-48 projection for all sampling sites. The temporal range for the Landsat is the second 10 days of August 2016 and 2017. The NDVI analysis using Landsat data at 16 sampling sites was compared with the results of MODIS data analysis. In this case, we used data from early July to late September and then normalised them into same time range.

The Landsat data analysis was also used for field measurement. We compared the NDVI value at MODIS cells and Landsat cells at the same pixel or same ecoregion to identify the difference and replace the high-resolution datasets with the low-resolution datasets.

3.3. Field data sampling method

The hierarchical sampling scheme based on the procedure of Wilson et al. (2011) was used for the sampling. Sampling plots and points were selected based on the eMODIS (250m) and LANDSAT (30m) satellite cells. 250 x 250 m, 10-day interval eMODIS image was used as a layout for the fieldwork sampling. Within each of the selected MODIS cells, 3-4 (depending on local variability) randomly selected 2 m × 2 m (4 m2) quadrats, each with a grid of 4 subquadrat points, was used for sampling. The plot size was determined by the size of the homogeneous area. The plots were selected based on the grassland ecological zones with relatively homogeneous vegetation structure and community composition and were mapped with a GPS, differentially corrected to improve accuracy.

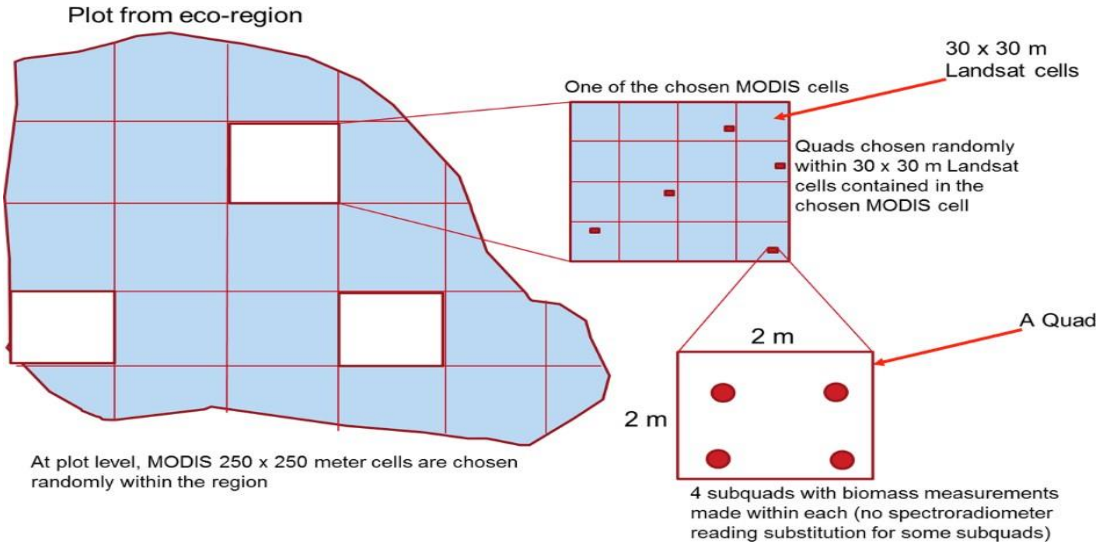


Figure 4. Schematic of hierarchical sampling framework (Adapted from Wilson et al., 2011)

Field sampling involved determining aboveground biomass by cutting a proportion of total standing biomass within each sub-quadrat for each plot. Due to lack of necessary equipment such as spectrometer, we could not measure the photosynthetically active radiation intercepted by the canopy (iPAR) and hyperspectral reflectance.

Taking into consideration the extent of the study region and limited time for fieldwork, sampling unit plots were selected according to the following criteria.

- 2 plots for each main grassland ecological zone in Mongolia. Within the same ecological zone, one plot should have significantly different NDVI value than the NDVI average in August for 2000-2016, another one should have NDVI that is almost unchanged.
- Plots to be within 5 km radius from the main road to ensure less or no direct human effects.

3.4. Field work activities

August 16-22, 2017

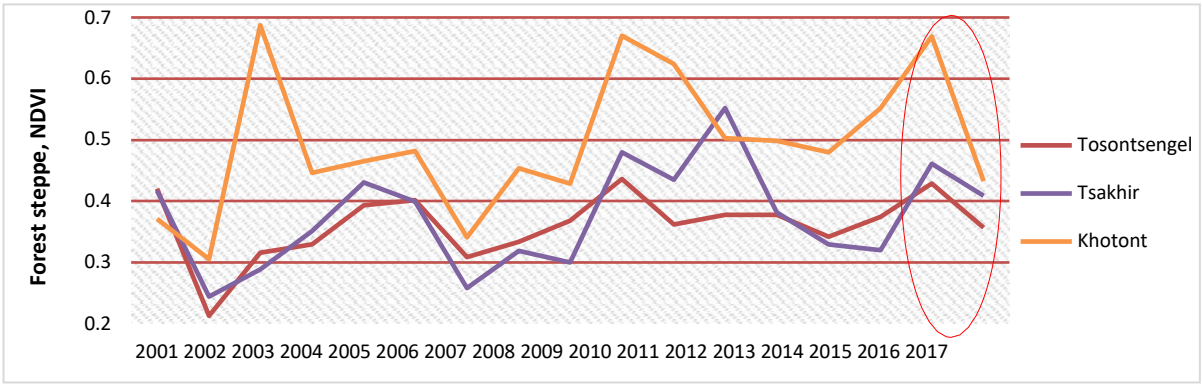
This year Mongolian team performed field sampling and monitoring activities in two separate groups: Group 1 went on the south-west route (**Route 1**), while Group 2 went on the north-west route (**Route 2**). Group 1 started its fieldwork in Ulziit soum, Uvurkhangai province, located 430 km southwest of Ulaanbaatar city on 16th August. There are 9 sampling points in Route 1. Group 1 finished its fieldwork activities on 22 August.

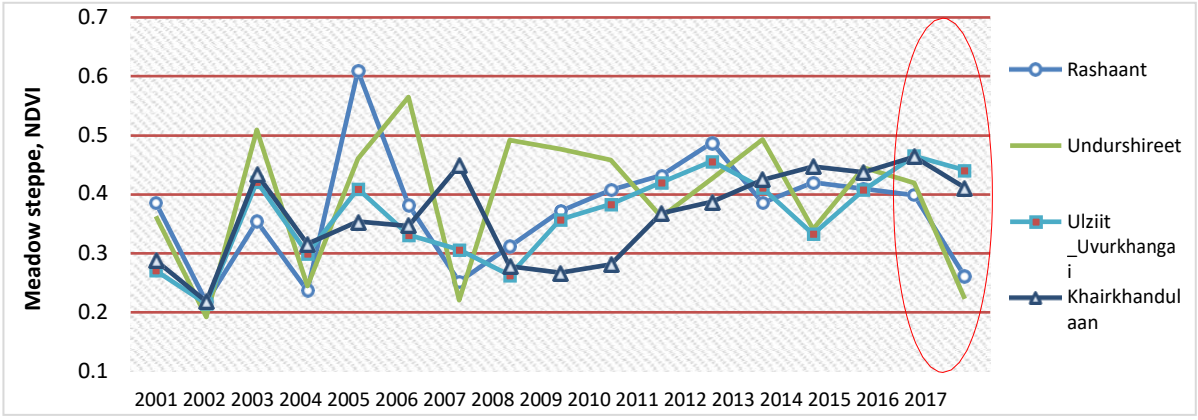
August 23-30, 2017

Group 2 started its fieldwork on 23 August, 2017. There are 7 sampling points in Route 2. This group ended their fieldwork activities on 30th August 2017.

Fieldwork analysis

The fieldwork conducted in 2017 revealed the fact that Mongolia as a whole did not have enough precipitation throughout the summer of 2017 (See Appendix 1). Spatial data clearly showed a difference in precipitation in the research areas between 2016 and 2017. The warmest months, June and July, did not have sufficient precipitation, while late August had more precipitation during the time that fieldwork took place. Therefore, vegetation coverage in 16 study plots during the fieldwork ranged from almost none to more 60 per cent depending on ecological zones. Forest steppe, meadow steppe, and dry steppe sites located in the central and northerly parts were covered with more vegetation than dry steppe sites in the southern and western part of the study region. Gobi Desert had less vegetation coverage. Likewise, forest-steppe had higher aboveground dry biomass. For meadow steppe and dry steppe sites, vegetation coverage was not consistent with aboveground dry biomass. The teams realised especially in the sites (forest, meadow steppes and some dry steppes) near central region; vegetation coverage was higher and greener. However, there were evident signs of grassland degradation at the sites, with dominating undesirable plant species, bare ground and encroaching sand.





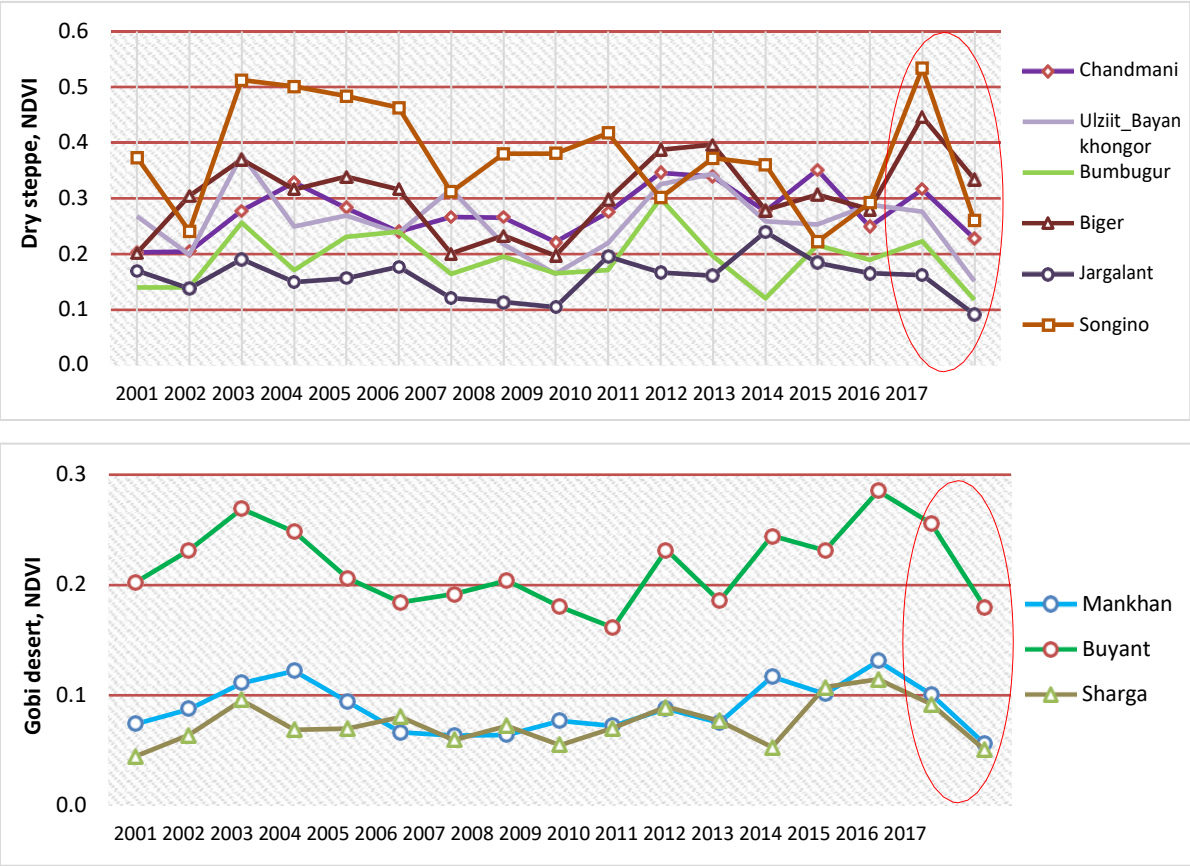


Figure 5 (a-d). Vegetation dynamics expressed in NDVI for 16 plots differentiated by natural zones

The research group had several meetings with local herders. Herders said that rangeland condition was much worse than 20 years ago. Herders in Khotont soum, Arkhangai province and Biger soum, Gobi-Altai province, noted about increases in undesirable plant species, declines in species richness, and the disappearance or decreasing abundance of specific desirable plant species. Herders commonly related the cause of grassland degradation to heavy grazing, climate change in particular reduced or altered precipitation, warming temperatures, desertification and livestock types grazed. Herders in central provinces (forest-steppe and meadow steppe) cited overstocking as the main cause of grassland degradation, whereas herders in western dry steppe sites attributed climate change as the cause of grassland degradation. This is in line with the previous studies in the study areas (Bruegger et al., 2014, Altanbagana et al., 2015).

4. Outputs

Under the support of APN and collaborating with 2 international organisations such as University of Sydney, Australia and Nanjing University, China and several local organisations in Mongolia such as Sustainable development Institute for the western region of Mongolia, Khovd state university, Institute of general and Experimental biology under Mongolian Academy of Science, Institute of strategic studies under security council of Mongolia, and sustainable development institute, National University of Mongolia, we have accomplished:

1. Organised 2 times field survey on pasture and grassland degradation in Western and Central part of Mongolia (2016 and 2017);
2. Trained 6 young researchers through grassland degradation study during field survey and laboratory analysis;
3. Organised 1 training workshop on Geospatial technology for environmental and energy security study, 11-14 September 2016, Ulaanbaatar, Mongolia;
4. Trained 16 young scientists through training workshop;
5. Established a strong mixed research team from diversified local and international institutes;
6. Presented research results 3 times at national level and 2 times at international level workshops;
7. Published 2 papers at national scientific journal proceedings;

5. References

Altanbagana, M., Suvdantsetseg, B., Nominbolor, K., Tuvshinbat, D., Kherlenbayar, B. (2015). *Policy recommendation based on vulnerability assessment of five provinces (Khovd, Arkhangai, Bulgan, Uvurkhangai and Khentii) prioritising green development.* Ulaanbaatar: National Development Institute.

Bruegger, R.A., Jigjsuren, O., Fernandez-Gimenez, M.E. (2014). Herders observations of rangeland change in Mongolia: Indicators, causes and application to community-based management. *Rangeland Ecol Manage, 67*(2), 119-131.

Inakwu.Odeh. (2015). *Monitoring grassland degradation in North/Central Asia: Deconstructing the impacts of climate change and government policies at different spatial-temporal scales using remote sensing and expert knowledge.* Sydney: APN.

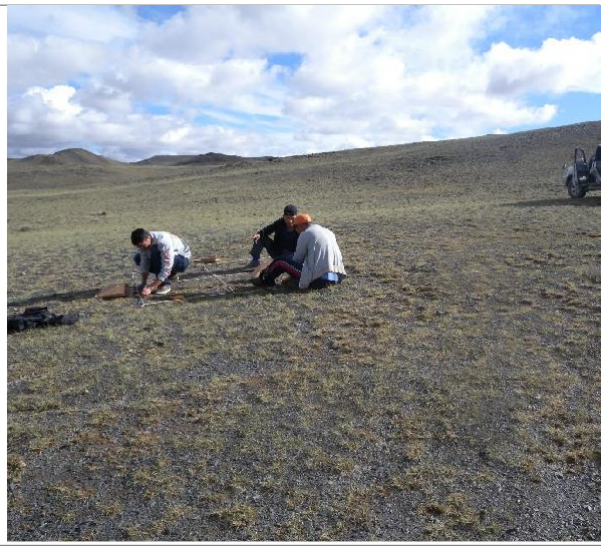
Wilson, A., Silander, J., Gelfand, A., Glenn, J. (2011). Scaling up: linking field data and remote sensing with a hierarchical model. *International Journal of Geographical Information Science, 25*(3), 509-521.

6. Appendices

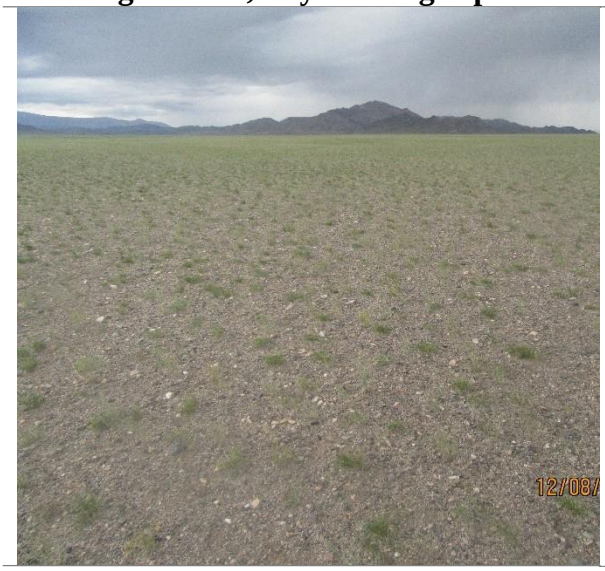
Appendix 1. Fieldwork survey, 2016 and 2017

2016	2017
	
Ulziit soum, Uvurkhangai province	
	
Khairkhandulaan soum, Uvurkhangai province	

Ulziit soum, Bayankhongor province



Bumbugur soum, Bayankhongor province



Mankhan soum, Khovd province

Khovd soum, Khovd province

Great Lakes Depression, Khovd province

Tsakhir soum, Arkhangai province


Tosontsengel soum, Zavkhan province


Khotont soum, Arkhangai province


Rashaant soum, Bulgan province

Undurshireet soum, Tuv province

Appendix 2 Training and workshop agenda

PROGRAM OF THE TRAINING WORKSHOP ON ENVIRONMENTAL AND ENERGY SECURITY STUDIES

Scope

The workshop will focus on the issues of environmental security such as pasture degradation, ecosystem loss, water resource shortage, urban pollutions, biodiversity loss and climate change-related extreme impacts and energy security as such mineral supply and renewable energy resource, ageing of established infrastructure, power adjustment station and electric generating capacity for Mongolia with specific emphasis on the current status of the development in the region, and future prospect for cooperation among other countries in the region. It will provide invaluable information where the representatives of different countries will share their knowledge and experiences in environmental and energy security at multi-scale levels of communities.

This technical workshop gathers experts and users from public and private sectors to share knowledge and experience on environmental and energy security issues in Mongolia and Asia. The workshop also hopes participants can learn the latest techniques to accelerate the utilisation of the advanced geospatial technologies in various sectors of environmental studies especially in pasture monitoring in Mongolia to meet with the demand of the national development strategies.

Date: 11-14 September 2016, Ulaanbaatar, Mongolia
Venue: Conference room at the Institute for Strategic studies
Local Organiser: Institute for strategic studies, Sustainable development Institute for western region of Mongolia
International Organizer: Keio University, Japan and University of Sydney, Australia
Sponsor organisations: Khovd University, Environmental research information and study center

Detailed program

Day 1 Workshop on environmental and energy security

12 September 2016 (Monday)		
8:30-09:00	**Registration**	
Moderator: Dr. Balt SUVDANTSETSEG, Khovd university, Sustainable development Institute for western region of Mongolia		
09:00-09:10	**Opening Remarks**	Ganbat.D PhD, Director of Institute for Strategic Studies, National Security Council of Mongolia Prof. Wanglin YAN, Head of International Program for Environmental Innovators / Director of Research Center for Climate Change Adaptation, Keio University, Japan
09:10-09:20	**Introduction**	Introduce participants

09:20-09:40	**Keynote Speech**	*"Japan's Green Innovation: adapting to an environmentally vulnerable world"* Prof. Kobayashi HIKARU, Graduate school of Media and Governance, Keio University, Japan
09:40-10:00	**Keynote Speech**	*"Sustainable Management of Australian Grasslands to Contain Land Degradation"* Prof. Inakwu Odeh, Faculty of Agriculture, Food and Natural Resources, University of Sydney, Australia
10:00-10:20	Coffee break	
Moderator: Prof. Inakwu ODEH, Faculty of Agriculture, Food and Natural Resources, University of Sydney, Australia		
Session I: Ecological security		
10:20-10:40	**Speaker**	*Ecological security challenges in Mongolia* Kh.Nominbolor, Institute for Strategic Studies
10:40-11:00	**Speaker**	*"Climate change scenario in Mongolia"* P.Gomboludev, PhD, Information and research institute of meteorology, hydrology and environment
11:00-11:20	**Speaker**	*National water security assessment* P.Batima, PhD, Mongolia water forum
11:20-11:40	**Speaker**	*"Innovative Adaptation technologies for Mongolian ecological security"* Prof. Wanglin YAN, Director of Research Center for Climate Change Adaptation, Keio University, Japan Mr. Ahmad Muzaffar Bin Baharudin, Keio University, Japan
11:40-12:00	**Local guest Speaker**	*"Surface water quality and its impact on environmental change in the valley of Ikh nuuruud, western Mongolia"* Prof. Z.Burmaa, N.Jargalsuren, School of Natural science and Technology, Khovd University
12:00-13:00	**Lunch**	
Moderator: Prof. Wanglin YAN, Keio University, Japan		
Session II: Grassland degradation		
13:00-13:20	**Speaker**	*"Mongolia pastureland health report"* D.Bulgamaa, PhD, Applied research component leader, Green gold project, Swiss Development Agency Mongolia

13:20-13:40	**Speaker**	*"Program of tree-planting in Ulaanbaatar by Japanese companies"* Makoto Fukuda, Professor, Nagaoka Industrial School and Advisor of Somethings, Ltd., Japan
13:40-14:00	**Speaker**	*Current state of Mongolian rangeland ecosystem and its conservation* J. Undarmaa, PhD, Center for Ecosystem Studies, Mongolian University of Life Sciences
14:20-14:40	**Speaker**	*"Desertification in Mongolia"* N.Mandakh, Researcher, Institute of Geography & Geo-ecology, Mongolian Academy of Sciences
14:40-15:00	**Speaker**	*Pasture and forage system in Mongolia* Udval, PhD, Research institute of animal husbandry,
15:00-15:20	**Speaker**	*"Mongolian forest monitoring by using remote sensing data"* G.Undram, and Ya.Ariunzul, PhD, Researcher, Environmental research information and study center
15:20-15:40	**Tea Break**	
Moderator: Prof. Kobayashi HIKARU, Keio University, Japan		
Session III: Energy and Mining		
15:40-15:55	**Speaker**	*Energy policy and security issues of Mongolia* Sh. Ganzorig Energy Policy and Planning department, Ministry of Energy
15:55-16:10	**Speaker**	*Progress and challenges of Egiin Goliin HPP project and its potential downstream hydrological impacts* S.Oyuntuya, Environmental Assessment specialist, Egiin gol hydro power project unit
16:10-16:25	**Speaker**	Organic soil materials for adaptation Kh.Narangerel and Researcher, Environmental research information and study center
16:25-16:40	**Speaker**	*International practice on building large scale dams on upstream* B.Boldbaatar, hydro-construction engineer, Egiin gol hydro power project unit
16:40-17:00	**Local guest Speaker**	*"Desertification and pasture restorations in Gobi-Altai province"* Mr. B.Erdenebayr, Buhuu, Head of Forest agency, Gobi-Altai province
17:00-17:50	**Discussion**	
17:50-18:00	**Closing Remarks**	

Day 2 Training workshop on Geospatial technology for environmental study

13 September 2016 (Tuesday)		
8:30-09:00	**Name**	**Title**
Remote sensing technology training workshop		
09:00-10:30	**Dr.Suvdantsetseg,** Sustainable development institute for western Mongolia, Khovd University	Application and development of Remote sensing and GIS
10:30-10:45	**Coffee break**	
10:30-12:00	**Dr.Suvdantsetseg,** Sustainable development institute for western Mongolia, Khovd University	Grassland degradation monitoring in Mongolia using long term remote sensing data
12:00-13:00	**Lunch**	
Sampling analysis training workshop		
13:00-17:00	**Prof. Inakwu Odeh** University of Sydney	Sampling design analysis, calibration of remote sensing data with different spatial scales and field work measurement.
17:30-20:00	Reception dinner	
14 September 2016 (Wednesday)		
Morning	**Business trip to Bulgan province**	

Training workshop participants, 12-14 Sep 2016, Ulaanbaatar, Mongolia