FOREWORD

APFNet (Asia Pacific Forest Network) and ERISC (Environmental Research Information and Study Center) joint funded project named as “Monitoring Forest Cover Change in Mongolia with Participatory Approach [Project ID:2015P5-MN]” and Executing Agency is ERISC.

In this project produced ups-and-downs trend of the forest of Mongolia and defined Mongolian forest steppe zone’s forest cover change in Landsat and MODIS satellite data. Define virtual forest cover change in state, province and pilot community level is truly important basic information for different forest arrangements for example forest monitoring, sustainable forest management and planning forest management plan etc. Although the traditional forest inventory methodology is expensive and time-consuming and without any satellite database in whole country is the problem of rare potential to measure forest cover change by every year. That is why in forest sector uses satellite data is mandatory. As the country which has wide area, important to define forest cover ups-and-downs in any time from the satellite data.

We are publishing our results as a book because of that “Mongolian forest cover change from Landsat data” work was a massive work, so the experts of the forest sector no need do this job again and just should check and improve the data only. This work had been schedule from defending my doctoral theme and I believe the remote sensing of the forest sector by a step forward.

We published three books separately, the result of our job which is a fifteen year change of Mongolian forest cover area are introducing the as this book and approach to calculate forested area from the satellite data as “Approach to define forest cover area from the satellite data” manual book, and usage of these data for the forest management plan as “Application of satellite data in the Forest management plan” book.

I would like to express my thankful to this project sponsor APFNet. Also I would like to appreciate project team include Undram.G and Bayanmunkh.N Doctorates, Narangerel.Kh and Erdenechimeg.E Masters, Batchimeg.B and Gunjargal.B Masters of APFNet, Ermuun.B and Altanbagan.A and Zolboo.G Bachelors, wish you have great long ways to live and all kind of success and happiness.

Also thank to Doctor Baatarbileg.N who is director of School of Life Science, NUM and Ms Tungalag.M who is head of Forest policy and regulation Department of Ministry of Environment and Tourism of Mongolia and expert of that department Otgonsuren.B, Head of Department of Environment and Tourism in Bulgan province and engineer of that department Altansukh.B they supported us by policy and activity.

Head of the ERISC *Doctor Ariunzul Yangiv*

SECTION 1

INTRODUCTION

ONE. INTRODUCTION

1.1."MONITORING FOREST COVER CHANGE IN MONGOLIA WITH PARTICIPATORY APPROACH" PROJECT GOAL AND OBJECTIVES

Our country is one of the poorest country by forest resource in the world, particularly 3 or 4 times less than world average, 8 or 7 times less than Finland, 6 or 7 times less than Sweden, 8 times less than Japan. This primary forest and its change has become a priority of sustainable forest resources in Mongolia and the changes identified in short-term defines to implement the appropriate forest management activities.

Forest inventory and forest taxation and their financing arrangements regulated on the seventh article of the Forest Law enacted in 17th of May 2012. This law declares "Public organization responsible with environment to do the forest inventory in every five years and renew the forest fund status. Forest taxation work has completed in every 10 years, then update forest application and protection and methodology of rehabilitation."

A Forest area performance database created in 2014 for the first time organized by National Forest Inventory hired 500 people during the three years, forest inventory determinate by Law of Forest in 2012. Before that Mongolian forest fund information had been united from the 15 to 18 years forest taxation data. But still forest taxation yearly data has not been completed by the whole country in Mongolia. The advantage of the forest cover area production year by year and calculates and increasing and decreasing trend is valuable base of the forest sustainable management plan and forest policy.

As Mongolia vast areas covered, Mongolian forest not possible to measure by every year in situ measurement, but using satellite data in this process is making a significant period of economic and time. Currently 1062 forest pilot community includes 21000 members and 2310663 hectare forest area in Mongolia. Although those forest communities have not ability to define their community forest area from the free satellite data. However, the developed countries of the world have become used to daily use of satellite data of land cover classification and define forest cover area.

Yearly forest taxation data is important for valuable effective forest management plan for community and soum, province, state level. In that reason, our project planned to produce the forest cover area from the Landsat data.

1.1.1 Goal and Objectives

In order to facilitate Mongolian decision makers of environmental field to make educated decisions on forest management based on scientifically proven reliable products, the project aims at producing forest cover map for entire economy with use of 30m Landsat data, and resolve existing discrepancies on forest cover estimate of Mongolia; it also aims at development of a comprehensive approach of how high accuracy outputs can be utilized in strengthening the national level forest management plan; as well use developing local forest management plans for the two selected communities. Forest type maps and forest change detection maps will inform environmental and forest related organizations of the current status of forest resources, and further study the drives of the forest change that will help decision makers in the policy and decision making process.

Main goal of the project is to assist in development of the strengthened strategic documents at the national and local levels to manage forest resources by making a quantitative assessment of forest cover in Mongolia.

The following objectives are set forth to achieve the project goal that include:

-Monitoring forest cover change from 2000 to 2015

- Determining forest cover of Mongolia of 2014, and assessing the accuracy of the result

- Forest cover/type mapping of selected two forest communities based on data of 2015

- Strengthening strategic forest management plans for pilot communities.

1.1.2 Project Implementation

A project implemented by triple agreement of MET, APFNet, ERISC funded by APFNet and ERISC from 1 March 2016 to 1 March 2017. The Environmental Research Information and Study Center NGO founded in 2014 with purpose of environmental research and study. ERISC / Environmental Research Information and Study Center / is the organization which includes around 30 young researchers and students. This project started from the ERISC researchers produced the project named as "Monitoring forest cover change in participatory approach" and gave the Asia-Pacific Region Forest Network Organization announced small grants project competition in 2014.

We have aimed to define how to calculate forest cover change and yearly difference of the forest by lower cost and acceptable result and how to use those data to forest management plan.

Although application of the satellite data for the Mongolian mountain forest of the huge landscape is extremely suitable but processing of the satellite data needs knowledge about the GIS and Remote sensing and wavelength.

Project activity has been supported from Forest policy and regulation department of MET and FRDC by policy. All data taken from the FRDC. Scientific activity has been supported by teachers and researchers of the NUM, MUST, MSUA. Field trip of the project completed by the methodology used the equipment of the Multipurpose National Forest Inventory. Also On job training and Inclass training supported by Environment and Tourism Department of the Bulgan province.

Project produced following effective results:

1. Mongolian fifteen years forest cover change from Landsat satellite data year by year in first time at forest sector of Mongolia. Most probability data of the Mongolian forest cover by each year.
2. It is special, because it shows how changing Mongolian forest cover from 2000 to 2015.
3. Mongolian forest cover change mapped on MODIS and Landsat satellite data from 2000 to 2015.
4. Define 15 years forest cover change and compare with Landsat data.
5. The project result has importance with those data produced on the free data from internet and it has distributed every unit of the forest as a book.
6. Forest type of the Buuraldomuu and Khanbuyan forest community used KOMPSAT, Pleiades, and SPOT high-resolution satellite data.
7. Two communities those are Khanbuyan and Buuraldomuu of the Bulgan province calculated land use type by fifteen years and defined forest covered area.
8. 2 times validation completed field trip on Bugat and Khangal soum of the Bulgan province.
9. Two times On the job training completed for the community members of the Buuraldomuu and Khanbuyan communities and forest specialists of the Bulgan province.
10. One time Inclass training completed for forest specialists in Bulgan forest center.
11. Tuv and Bulgan provinces forest management plan has compared and assessed.
12. Improved forest management plan approach processed and published as a book.

13. 30 minutes TV program broadcasted by project result.
14. Inception and Progress and Promotion workshop completed.
15. Progress report and audit report reported.

1.2 DEFINITION OF THE MONGOLIAN FOREST FUND

1.2.1 Geographic location of Mongolia

Mongolia locates center of the Asia, it spans latitudes from 41^0 35' N to 52^0 06' N and longitudes 87^0 47' E to 119^0 57' E. Mongolia bordered 3543 km with Russia from the north and 4709.6 km with China from the south. The length from west to east is 2392 km and north to south is 1259 km, total Mongolia covers 1564.1 thousand square km area. Mongolia places 17th by the area from the top in the world [8].

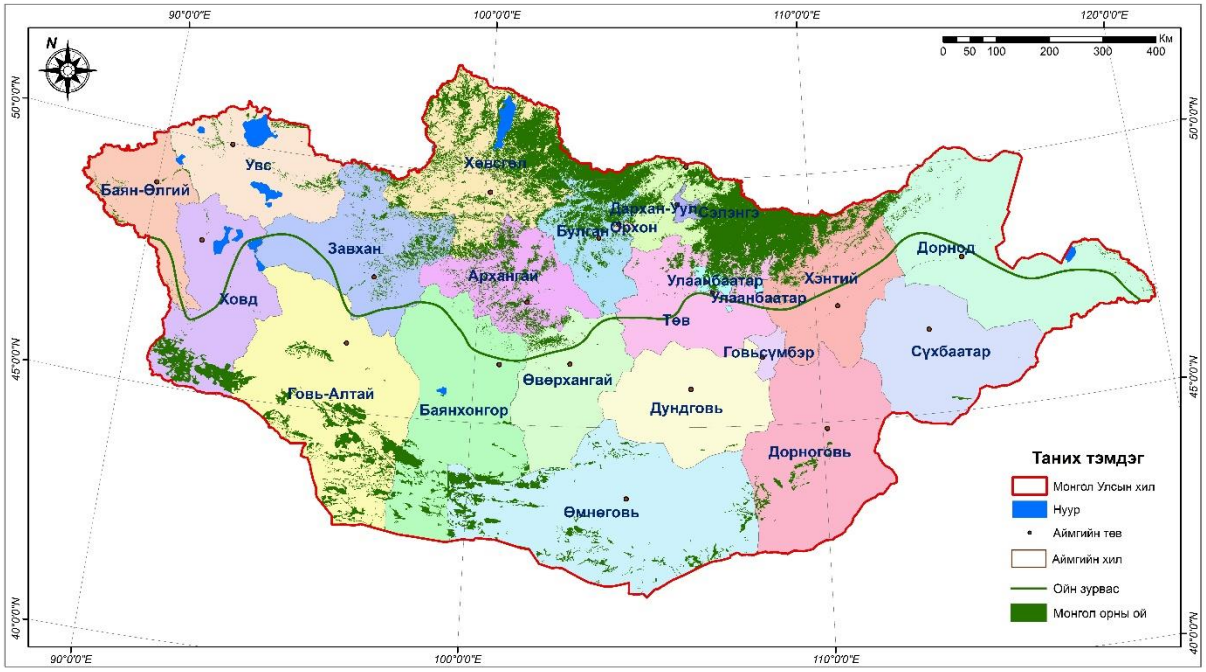
Picture 1. Mongolian location map

1.2.2. Mongolian State Administrative Region

Mongolia has 21 administrative divisions it includes capital and provinces; provinces divided into soum, soum divided into bag; capital city divided into district, districts divided into khoroo [21].

Зэрэг	Засаг захиргааны нэгж нутгийн тоо		Тоон нийлбэр
Нэгдүгээр	аймаг — 21	нийслэл — 1	22
Хоёрдугаар	сум — 330	дүүрэг — 9	339
Гуравдугаар	баг — 1568	хороо — 152	1720
Нийлбэр	Гурван түвшний зургаан зүйлийн 2081 нутаг		

Picture 2. Mongolian administrative divisions



Picture 3. The location of the provinces and distribution of the forest

1.2.3. Climate in Mongolia

The Continental position of the Mongolia, far from the influences of the oceans, the center of the Eurasian mainland that surrounded by high mountains and at least 1500 m above the sea level, determines its climate and the reason of the four seasonal high differences. It has an extreme continental climate with long, cold winters and short summers, during which most precipitation falls. Short dry summer (from June to August), long cold winter (from September to April) and fall, spring fluctuate so much. This influence Mongolian forest component and their growth. The forest is most important part for to soften extreme weather and absorption of the greenhouse gases. Most windy period is April and May. January is the coldest month and July is the warmest month.

1.2.4. Temperatures

The winter average temperature is -15^0 to -30^0, for summer 10^0 to 26.7^0 Celsius temperatures. The average temperature of the year is lower than -4^0 in Altai, Khangai, Khentii, Khuvsgul mountain area, including a depression in the landscape and a major river valleys temperatures are from -6^0 to -8^0 cold, desert steppe area warmer than 2^0 and south gobi area warmer than 60^0 [8].

The average air temperature of zero degrees line is under desert steppe / desert / regional borders average latitude of Mongolian passes 46 degrees north. Permafrost soil distributes area that has lower than -2^0 temperature [8].

Picture 4. The average temperature of 2014

1.2.5. Precipitation

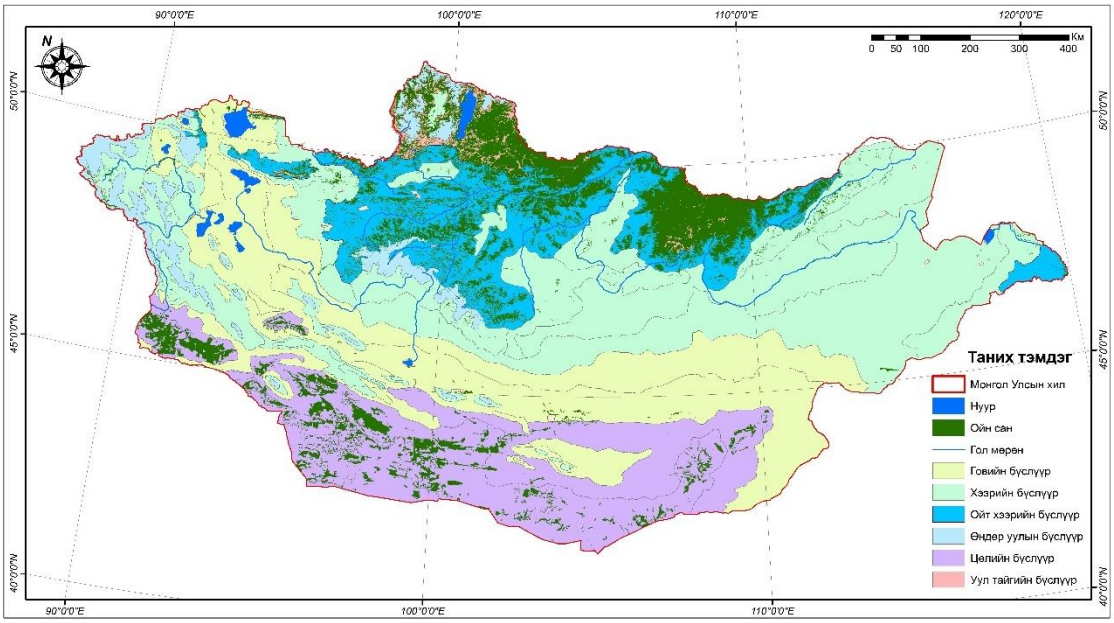
The average annual precipitation of Mongolia is low. The average precipitation of Khangai, Khentii and Khuvsgul mountain area is 300 mm to 400 mm. Mongol Altai and forest steppe zone has 250 mm to 300 mm, steppe zone has 150-250 mm, gobi desert zone 50-100 mm precipitation. Precipitation decrease from north to south and from west to east influence with landscape relief. Cumulative rainfall is much lower than the potential evaporation. Potential evaporation in the mountainous region is 500 mm, in the forest steppe region 550-700 mm, in the steppe zone has 650-750 mm, gobi desert zone 800-1000 mm. 85 percent of the precipitation occurs from April to September, from that 50 percent of that occurs in July and August.

1.2.6. Natural zone

Mongolia is a mountainous country. The Mongolian Altai and Gobi Altai mountain ranges extend across nearly two-thirds of the nation's breadth. In the center of the country, the Khangai Mountains divide Asia's continental watershed, lie the rugged and uninhabited Khentii Mountains.

In the far western Altai, Khuiten Peak in the Tavan Bogd Mountains reaches 4653 meters, the highest point in the country. (The lowest point, in the Khokh Lake depression, at 532 meters, is far out on the eastern steppe.)

Climate in the high mountain zone is extreme, with high winds, extreme cold, and a short growing season. Relatively few species are adapted to these harsh conditions. Located above tree line, the zone has characterized by tundra, alpine-sedge meadows, highland swamps, and lichen-covered boulder fields.



Picture 5. Natural zone and forest distribution

1.2.7. Surface water

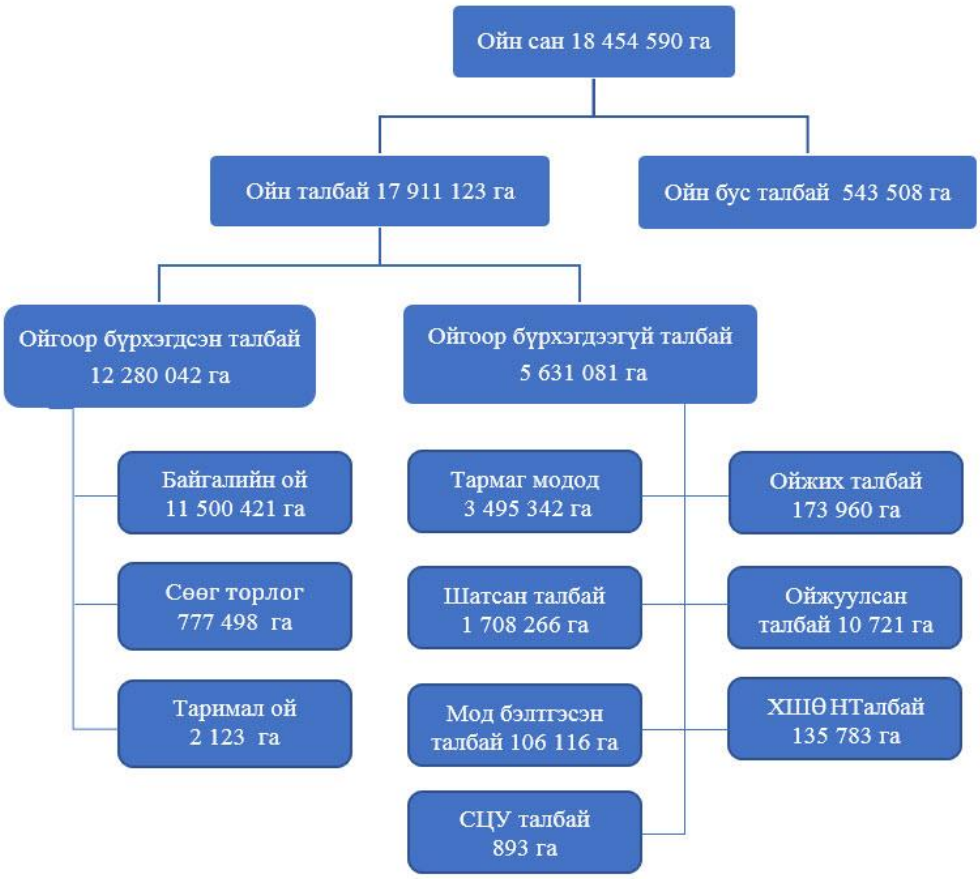
Mongolian rivers take their origin from the high mountains of Central Asia such as Mongol Altai, Khangai-Khuvsgul, Khentii and belong to the three main basins, depending on its drainage system: Arctic Ocean Basin, Pacific Ocean Basin, and Internal Drainage Basin of Central Asia. Mongolian forest has ability to purify and protect those three water-basin's river and lakes.

The source of the biggest rivers such as Kherlen, Onon, Tuul, orkhon, Selenge are small brooks and rivers that has forested area not taken source from the Pacific Ocean and Atlantic Ocean.

The Orhon River is 1124 km long and is navigable for shallow-draft vessels only in July and August. The river has a drainage area of some 133,000 square km. However, Kherlen is the longest river that is 1200 km include Chinese stream. Selenge River is richest water. The annual average flow is 300 m^3 per second. The biggest glacier of the Mongolia is Potanian glacier with length around 20 km in the Altai Tavan Bogd. Shishged River and Tengis River drain into the Russia from the west of the Khuvsgul. Khangai Mountain Rivers drain into Orkhon River, Orkhon River and other Tuul, Kharaa and Yoroo River drain into Selenge River, and further Selenge River drains into Baigali Ocean and Angar River and its compound Yenissey River and Northern Arctic River Basin. The Onon River from the Burkhan Khaldun mountain east piracy with the Baljir and Amgalan River drains into the Russia. The Kherlen and Khalkh River from the Burkhan Khaldun mountain west drains into Pacific Ocean. Some rivers from the Khangai Mountain dont drain into Orkhon River flows into the Arag, Boontsagaan and Taats Lake of the Gobi. That is internally threaded drainage.

The Mongolian forest is the source that organize water regime of those drainage. The deepest lake of the Mongolia is the Khuvsgul depth with 262.4 meter and it places second in the world after the Baikal River.

Schema 1. Basic performance of the Mongolian forest fund



Forest unit fundamental described as forest taxation. Mongolian forest first mapped in topographic map by Russian experts on 1956-1958.

In 1974-1975 Mongolian and Russian cooperation experts studied from aerial mapping and in situ research of forest for application of the tree resource up to 1990 in whole Mongolia and they improved 1956 forest distribution map and forest statistic data.

In 1976-1988, studied from aerial mapping and in situ research of forest for application of the tree resource of 16 enterprises and they defined forest density, resource and age and also improved forest fund performance.

From the 1989 forest taxation started to make by province. From 1990 started to use satellite data. From the 2006 started to make re-taxation in each province. We have shown forest taxation chronology in following table.

Table 1. Forest taxation data chronology

№	Province name	Taxation year	Re-taxation year	Forest fund area /thousand hectare/	Forest covered area /thousand/			
					Natural forest	Shrubs	Nursing forest	Result
1	Arkhangai	1995, 1996	2008	1008.6	799.4	8.8		808.2
2	Bayan-Ulgii	1985	2008	68.1	42.3	9.8		52.1
3	Bayankhongor	1991, 2006	2015	33.5	29.8	0.1		29.8
4	Bulgan	1997-1999	2010	1917.7	1315.0	67.1	0.04	1382.1
5	Gobi-Altai		2005	9.4	9.1			9.1
6	Dornod	2003	2012	243.9	75.4	15.5	0.06	91.0
7	Zavkhan	2006	2013	732.0	456.8	43.5		500.2
8	Uvurkhangai	1997	2008	171.7	134.6	0.4		135.0
9	Umnugobi		2011	0.14	0.1			0.1
10	Sukhbaatar		2011	15.7	0.6	1.6		2.2
11	Selenge	1992-1994	2008, 2009	1931.2	1397.4	42.1	1.53	1441.0
12	Tuv	2007	2013	1388.2	957.2	137.9	0.14	1095.2
13	Uvs	1990	2011	236.6	197.3	3.6	0.03	200.9
14	Khovd		2011	16.0	12.4			12.4
15	Khuvsgul	2000-2003	2012	4011.8	3152.5	123.4	0.02	3275.9
16	Khentii	2004, 2005	2013	1754.7	989.7	186.2	0.16	1176.1
17	Darkhan	2006	2013	82.0	64.8	1.3	0.08	66.2
18	Ulaanbaatar	1998	2008	116.0	87.1	6.5	0.02	93.6
19	Orkhon	2001	2010	17.8	15.6			15.6
20	Dornogobi	1990, 2007	2015		0.012			0.012
Forest area				13755.1	9737.3	647.5	2.1	10386.9
1	Bayankhongor	1990, 2006	2015	787.2	509.5	3.1		512.6
2	Gobi-Altai	1990	2011	1664.3	461.7	91.3		553.0
3	Dornogobi	1990, 2007	2015	116.6	54.7	1.1		55.8
4	Dundgobi	1990, 2007	2015	32.8	16.8		0.043	16.9
5	Uvurkhangai	1990	2011	125.5	68.5	9.7		78.2
6	Umnugobi	1990	2011	1189.1	604.6	13.5		618.1
7	Khovd	1990	2011	783.8	47.3	11.3		58.6
Saxual forest area				4699.5		130.0	0.043	1893.3
Total state size				***18454.6***	***11500.4***	***777.5***	***2.1***	***12280***

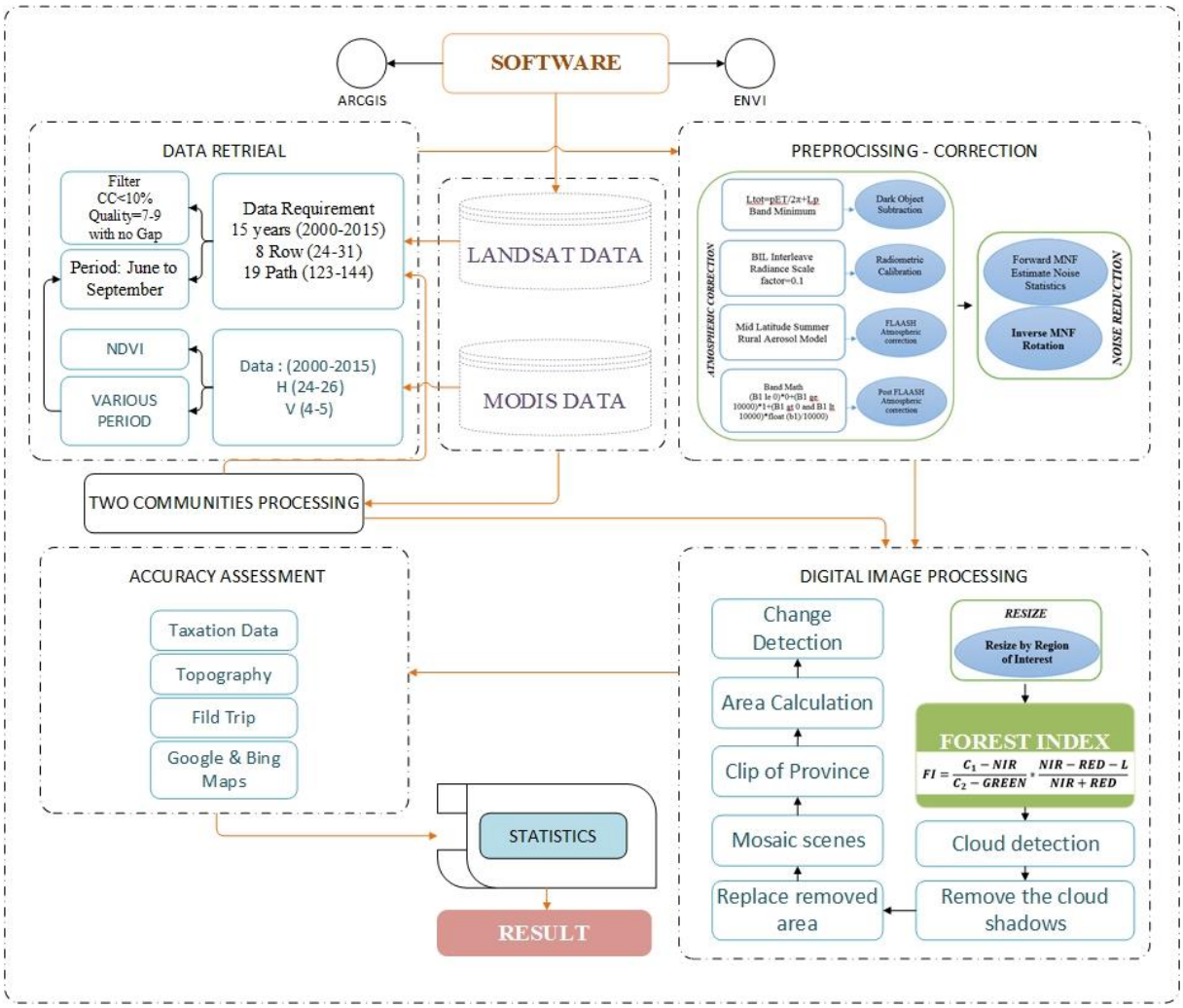
SECTION 2

“THE ASSESSMENT RESULT OF THE MONGOLIAN FOREST COVER CHANGE USING SATELLITE DATA”

2.1. Methodology

The first step of processing the methodology for defining Mongolian forest cover change using satellite data has started when we were writing project summary and it improved during the project implementation period. Following schema shows methodology step by step.

Schema 2. Methodology schema for define forest cover



We used Remote sensing methodology for the high resolution and middle-resolution satellite data. Assessment processed with the layer of the data such as Forest taxation data of the FRDC, 200000 Topographic maps of Mongolia, Google Earth Pro and Bing map used GIS softwares. We used vegetation indexes and forest index for the Landsat and MODIS satellite data when we define forest cover area of Mongolia.

Results validated by field trip.

2.2. Procedure

Preparation work:

- 1st level of activity */Data retrieval/*:
  - ✓ Collect all databases of Mongolian forest fund and forest distribution.
  - ✓ Collect all data related to satellite data such as path-row and nomenclature and about the Satellite.
  - ✓ Create MODIS and Landsat database for full Mongolia.

Correction work:

- 2nd level of activity /Data correction /:
  - ✓ Make radiometric and atmospheric correction for Satellite raw data to processing.

Forest cover mapping – Digital Image Processing

- 3rd level of activity:
  - ✓ Forest cover-calculation work on the pilot community areas validation completed by field trip.
  - ✓ Calculate forest cover from the corrected data.
  - ✓ Mongolian forest cover map completed by each province.

Forest cover change detection

- 4th level of activity:
  - ✓ Calculate forest cover change by area

Forest inventory data collection, validation

- 5th level of activity:
  - ✓ Assess forest cover data with forest taxation data, topographic map, and Google Earth Pro map.

Fieldwork:

- Validate by fieldwork. Here: measure longitude and latitude an elevation, navigation land class and type, forest type, number of the trees in one pixel, value of the Forest Index,

forest age, component, average height, average diameter, canopy diameter of the each sample point.

Document processing work:

- Report the output.
    - ✓ Report, Basic performance of Mongolian forest
    - ✓ Produce maps. Produce a Mongolian forest distribution map of the forest steppe. Make those maps with grid, scale and legend as a standard.
    - ✓ Basic performance of the community forest fund.
    - ✓ Produce maps. Forest distribution map of communities. Make forest classification map which classified by NELDA research project land type. Forest type map from the high-resolution satellite data. Make those maps with grid, scale and legend as a standard.

2.3. FIRST ACTIVITY

/DATA RETRIEVAL/

Estimation the Mongolian forest covered area used Landsat with 30-meter resolution, MODIS 250-meter resolution satellite data.

2.3.1. Description of the Landsat

Speeding around the Earth at 16,800 mph (27,000 kph), two Landsat satellites are expertly watching and recording changes in the Earth's lands from space. Landsat provides images of Earth at a resolution of 30 m; the temporal resolution is 16 days. Each Landsat scene is about 185 kilometers long and 185 kilometers wide.

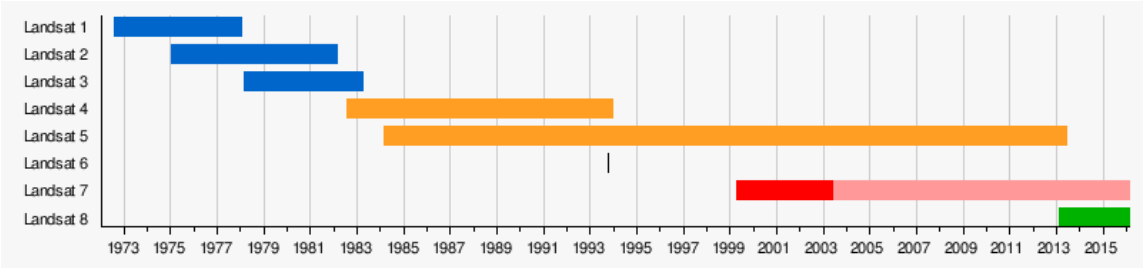
The Landsat program is the longest-running enterprise for acquisition of satellite imagery of Earth. On July 23 1972, the Earth Resources Technology Satellite had been launched. This eventually renamed to Landsat. Download the Landsat data from http://glovis.usgs.gov website.

Table 2. LANDSAT 7 ETM+a Satellite Sensor Specifications

Launch Dates / Status:	15 April 1999, at Vandenberg Air Force Base in California
Operators	NASA (National Aeronautics and Space Administration)
Orbit Height	705 km
Orbit Type	Sun-synchronous circular
Repeat Cycle	16 days
Resolution	30 meters
Radiometric resolution	8bit

LANDSAT 8 Operational Land Imager (OLI) Satellite Sensor Specifications

Launch Dates / Status:	15 April 1999, at Vandenberg Air Force Base in California
Operators	NASA (National Aeronautics and Space Administration)
Orbit Height	705 km
Orbit Type	Sun-synchronous circular
Repeat Cycle	16 days
Resolution	30 meters
Processing:	Level-1T - Terrain Corrected
Radiometric resolution	16bit
Spatial Resolution	15 to 90 meters
Pixel Size:	OLI multispectral bands 1-7,9: 30-meters OLI panchromatic band 8: 15-meters TIRS bands 10-11: collected at 100 meters but resampled to 30 meters to match OLI multispectral bands

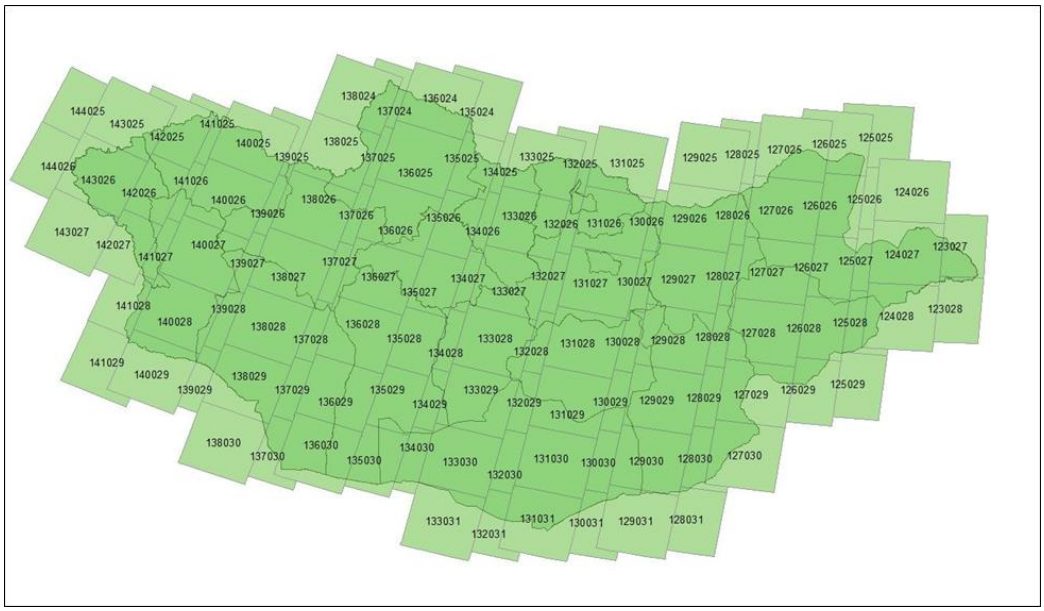


Picture 6. Chronology of Landsat satellite

2.3.2. Download Landsat data

Firstly, we defined scene amount of Mongolian full cover for Landsat satellite data by path/row with WRS-2. The Landsat 1-3 WRS-1 notation assigns sequential path numbered from east to west to 251 nominal satellite orbital tracks, starting with number 001 for the first track that crosses the equator at 65.48 degrees west longitude. A specific orbital track can vary due to drift and other factors; thus, a path line is only approximate. The orbit periodically adjusted after a specified amount of drift has occurred in order to bring the satellite back to an orbit that is nearly coincident with the initial orbit. Total with 233 path. Total row number 248 scenes per complete orbit (descending and ascending) selected as the standard.

Mongolia includes 131 scenes that paths from 123 of Dornod province to 144 of Bayan-Ulgii province and row from 24 of Khuvsgul province to 31 of Umnugobi province.

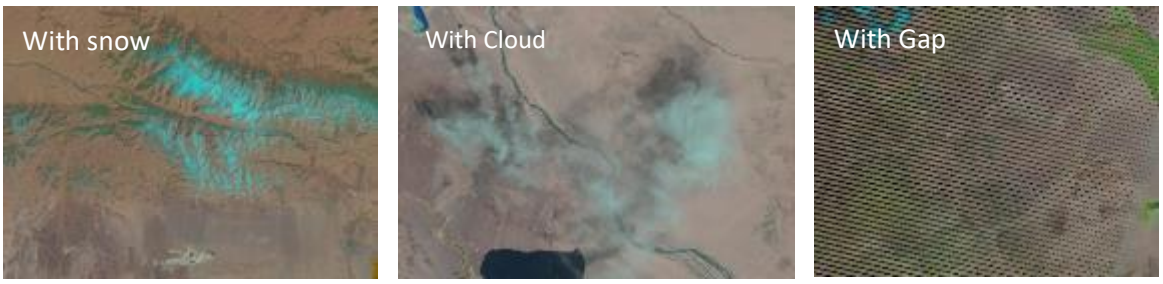


Picture 7. WRS-2 of Landsat satellite data /Mongolia/

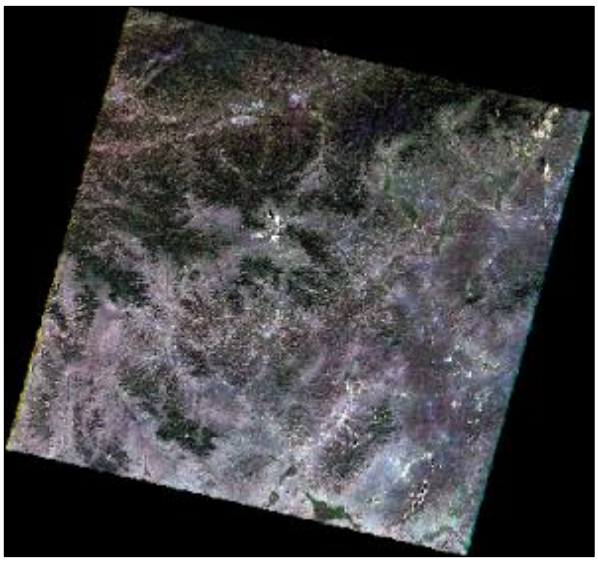
Following database created during the project. Here:

- Total 1965 scenes of 15-year data downloaded from the http://glovis.usgs.gov website [25].
- All those datas checked by manually and 165 datas subtracted because of cloud and gap. In addition, 2012 year most data has gap and cloudy so we have not include 2012 year's data.
- Total 1800 scenes from 2000 to 2015 used for define Mongolian forest cover change. (Annex 2).
- Scenes divided into two type forested and saxual-forested area. Here, 808 scenes forested and 435 saxual forested secenes.

- Timeframe of the all data is forest growth period 15th of June to 15th of September.
- If datas not possible to download in this timeframe, we used data from 5th of June to 20th of Sptember.



Picture 8. Non-compliance data



Picture 9. Compliance data

Table 3. Database of the Landsat

Province name	*Scene number*	*Row*	*Path*	*Total data*	*Province name*	*Scene number*	*Row*	*Path*	*Total data*	*Data*
Arkhangai	9	26	134	135	*Khovd*	10	26	140	150	
			135					141		
			136				27	139		
			137					140		
		27	133					141		
			134					142		
			135				28	139		
			136					140		
			137					141		
Bayankhongor	8	27	134	120			29	139		
			135					140		
			136		*Khuvsgul*	15	24	135	225	
			137					136		
		28	134					137		
			135					138		
			136				25	134		
			137					135		
Bayan-Ulgii	8	26	142	120				136		
			143					137		
			144					138		
		27	141				26	134		
			142					135		
			143					136		
		28	140					137		
			141					138		
Bulgan, Orkhon	10	25	133	150			27	135		
			134		*Uvurkhangai*	7	27	132	105	
			135					133		
		26	132					134		
			133					135		
			134				28	133		

			135					134	
		27	132					135	
			133		*Tuv, Ulaanbaatar*	10	27	129	150
			134					130	
Selenge, Darkhan-Уул	8	25	131	120				131	
			132					132	
			133					133	
			134				26	129	
		26	130					130	
			131					131	
			132					132	
			133					133	
Dornod	5	25	127	75	*Uvs*	8	25	139	120
			128					140	
		26	127					141	
			128					142	
		27	123				26	139	
Khentii	12	26	127	180				140	
			128					141	
			129					142	
			130		*Zavkhan*	10	25	138	150
			131					139	
		27	127				26	136	
			128					137	
			129					138	
			130					139	
		28	128				27	136	
			129					137	
								138	
								139	
Total								*1800*	

2.3.3. Description of MODIS satellite data

The moderate-resolution imaging spectroradiometer (MODIS) is a payload scientific instrument built by Santa Barbara Remote Sensing that was launched into Earth orbit by NASA in 1999 on board the Terra (EOS AM) Satellite, and in 2002 on board the Aqua (EOS PM) satellite. The instruments capture data in 36 spectral bands ranging in wavelength from 0.4 μm to 14.4 μm and at varying spatial resolutions (2 bands at 250 m, 5 bands at 500 m and 29 bands at 1 km). Together the instruments image the entire Earth every 1 to 2 days.

The system has 36 separate spectral bands and a field of view ±55° off-nadir which gives it the ability to have very large swath widths of 2,330 km. The bands most applicable for rangeland studies would be bands 1-7 which gather data in the visible and infrared range at a spatial resolution of 250 meters and 500 meters. MODIS is in a sun-synchronous orbit meaning it crosses over any given latitude at the same time each day. It flies at an altitude of 705 km and covers the entire Earth in 1-2 days. It has a swath width of 2,330 km and 12-bit radiometric_resolution meaning it can distinguish radiation in 4096 different levels for each band.

They are designed to provide measurements in large-scale global dynamics, including changes in Earth's cloud cover, radiation budget and processes occurring in the oceans, on land, and in the lower atmosphere. MODIS utilizes four on-board calibrators in addition to the space view in order to provide in-flight calibration: solar diffuser (SD), solar diffuser stability monitor (SDSM), spectral radiometric calibration assembly (SRCA), and a v-groove black body.[2] MODIS has used the marine optical buoy for vicarious calibration. MODIS is succeeded by the VIIRS instrument on board the Suomi NPP satellite launched in 2011 and future Joint Polar Satellite System (JPSS) satellites.

Download MODIS satellite data fron (https://lpdaac.usgs.gov/) website. Mongolia locates MODIS satellite data on “Sinusoidal grid tiling system” vertical from 24 to 26 and horizontal from four to five.

Table 4. Specifications of MODIS

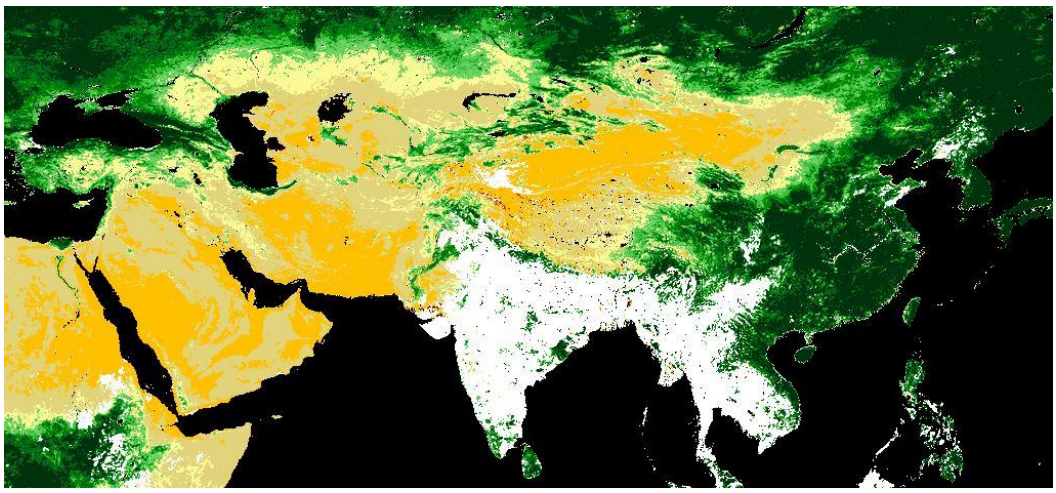
Launch Dates / Status:	Terra:18 December 1999-operating nominally in 2015 Aqua: 4 May 2002-operating nominally in 2015
Operators:	NASA (National Aeronautics and Space Administration)
Orbit:	705 km
	Sun-synchronous circular
Repeat Cycle:	16 days
Resolution:	250 m, 500 m, 1 km
Swath:	2330 km
Spatial Resolution:	500 m (bands 3-7), 1000 m (bands 8-36)
Design life:	6 years

2.3.4. Download MODIS data

Following data prepared during the project. Here:

- We used MODIS 16-day repeat cycle with the spatial resolution of 500m for channel 3 to 7 (0.4µm - 2.1µm) NDVI data.
  - MODIS 15 years satellite data that is 15 scenes downloaded from the (http://glovis.usgs.gov) website [25].
  - Timeframe of the MODIS NDVI is 16th of August of each year.
  - Also comparison purpose, 17th data of different month in winter and fall.
  - Define forested area.

MODIS NDVI threshold taken from doctoral thesis study of Define NDVI index threshold for Mongolian forest cover of Doctor Ariunzul.Ya [2].



Picture 10. MODIS-NDVI data

Table 5. Used MODIS data for project

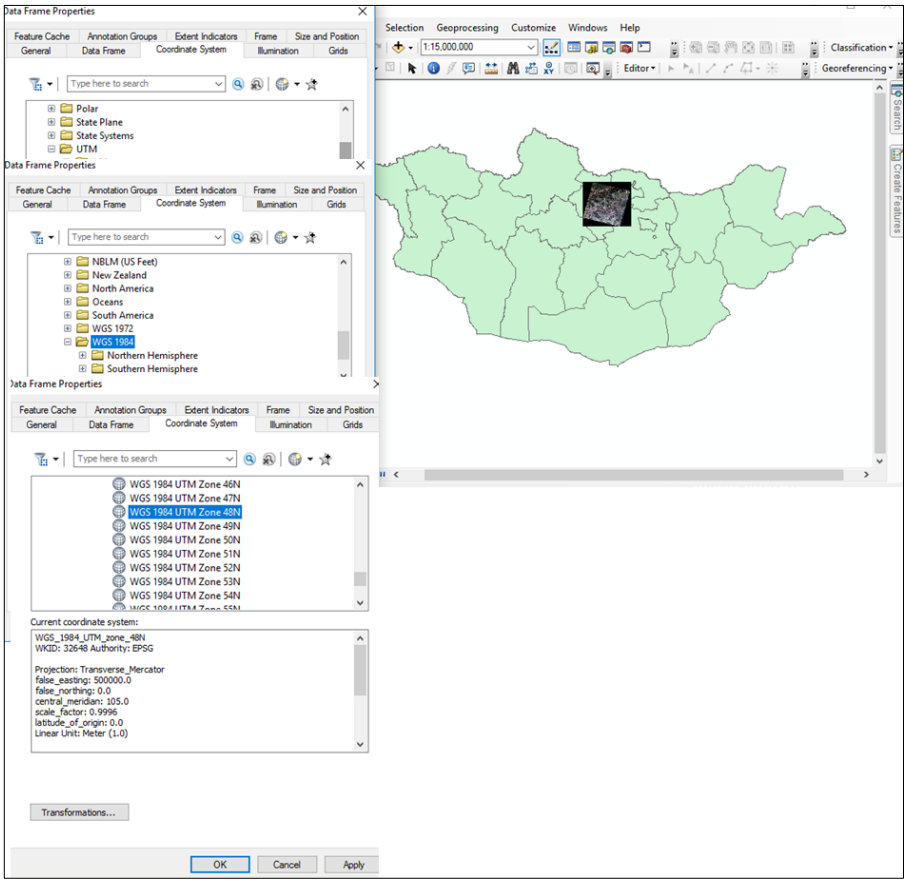
Төсөлд ашигласан МОДИС хиймэл дагуулын мэдээ			
№	*Он*	*Мэдээний нэр*	*Зурагласан өдөр*
1	2000	CA_eMTH_NDVI.2000.229-238.QKM.COMPRES.005.2011175015156	August 16, 2000
2	2001	CA_eMTH_NDVI.2001.228-237.QKM.COMPRES.005.2011168091319	August 16, 2001
3	2002	CA_eMTH_NDVI.2002.228-237.QKM.COMPRES.005.2011175045916	August 16, 2002
4	2003	CA_eMTH_NDVI.2003.228-237.QKM.COMPRES.005.2011164010028	August 16, 2003
5	2004	CA_eMTH_NDVI.2004.229-238.QKM.COMPRES.005.2011161103230	August 16, 2004
6	2005	CA_eMTH_NDVI.2005.228-237.QKM.COMPRES.005.2011157150801	August 16, 2005
7	2006	CA_eMTH_NDVI.2006.228-237.QKM.COMPRES.005.2011156141919	August 16, 2006
8	2007	CA_eMTH_NDVI.2007.223-232.QKM.COMPRES.005.2011151074340	August 16, 2007
9	2008	CA_eMTH_NDVI.2008.234-244.QKM.COMPRES.005.2011134220754	August 16, 2008
10	2009	CA_eMTH_NDVI.2009.213-222.QKM.COMPRES.005.2011124034848	August 16, 2009
11	2010	CA_eMTH_NDVI.2010.182-191.QKM.COMPRES.005.2011110141743	July 1, 2010
12	2010	CA_eMTH_NDVI.2010.213-222.QKM.COMPRES.005.2011114044657	August 1, 2010
13	2010	CA_eMTH_NDVI.2010.228-237.QKM.COMPRES.005.2011111050040	August 16, 2011
14	2011	CA_eMTH_NDVI.2011.213-222.QKM.COMPRES.005.2011229012124	August 1, 2011
15	2011	CA_eMTH_NDVI.2011.228-237.QKM.COMPRES.005.2011242212522	August 16, 2011
16	2012	CA_eMTH_NDVI.2012.214-223.QKM.COMPRES.005.2012232162750	August 16, 2012
17	2012	CA_eMTH_NDVI.2012.229-238.QKM.COMPRES.005.2012256012320 (1)	August 1, 2012
18	2013	CA_eMTH_NDVI.2013.213-222.QKM.COMPRES.005.2013226205117	August 1, 2013
19	2013	CA_eMTH_NDVI.2013.228-237.QKM.COMPRES.005.2013243012428	August 16, 2013
20	2014	CA_eMTH_NDVI.2014.228-237.QKM.COMPRES.005.2014241190732	August 16, 2013
21	2014	CA_eMTH_NDVI.2014.213-222.QKM.COMPRES.005.2014233183408	August 1, 2014
22	2015	CA_eMTH_NDVI.2015.228-237.QKM.COMPRES.005.2015245090548 (1)	August 16, 2000

2.4. SECOND LEVEL OF ACTIVITY

/PRE-PROCESSING-DATA CORRECTION/

Downloaded and prepared data are raw data and it needs atmospheric and radiometric correction for better quality and valueable digital number /DN/. We completed three types correction those are geometric, radiometric and atmospheric.

1. The geometric correction of image data is an important prerequisite, which must have performed prior to using images in geographic information systems (GIS) and other image processing programs. To process the data with other data or maps in a GIS, all of the data must have the same reference system. A geometrical correction, also called geo-referencing, is a procedure where the content of a map would be assigned a spatial coordinate system (for example, geographical latitude and longitude). All data that we used is already geometric corrected. However, state and province boundary vector file taken from the Land Administration Institutional Development in Mongolia transferred by UNREDD Mongolia. Because that boundary vector file used for all spatial data in the Mongolian territory, also Multipurpose NFI used this state and province boundary vector file. Mongolian government 28/01/2017 No-25th order declared basic coordination system use as WGS-84 and UTM Zone 48N.



Picture 11. Project Coordination system

2. As any image involves radiometric errors as well as geometric errors, these errors should be corrected. Radiometric correction is to avoid radiometric errors or distortions, while the geometric correction is to remove geometric distortion. Radiometric correction is classified into the following three types:

(1) Radiometric correction of effects due to sensor sensitivity

In the case of optical sensors, with the use of a lens, a fringe area in the corners will be darker as compared with the central area. This is called vignetting.

(2) Radiometric correction for sun angle and topography

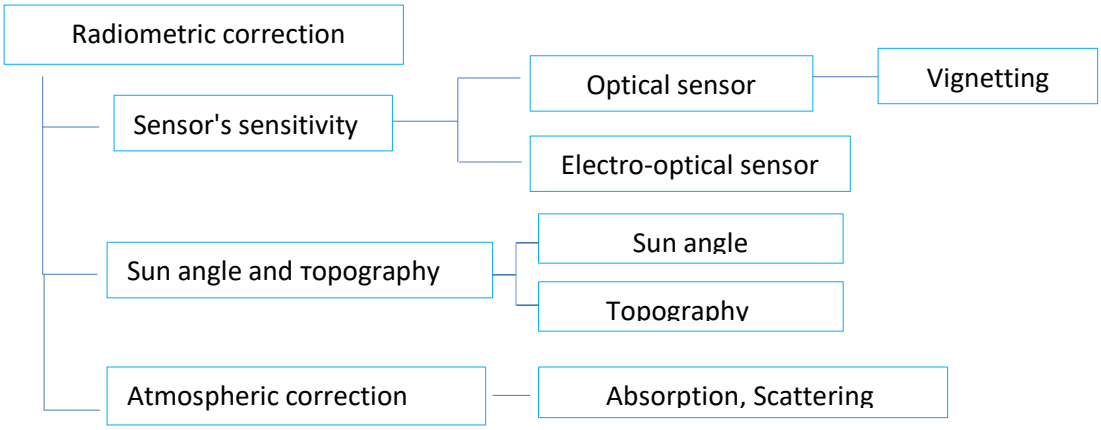
a. Sun spot: The solar radiation will be reflected diffusely onto the ground surface, which results in lighter areas in an image. It is called a sun spot. The sun spot together with vignetting effects can be corrected by estimating a shading curve which is determined by Fourier analysis to extract a low frequency component.

b.Shading: The shading effect due to topographic relief can be corrected using the angle between the solar radiation direction and the normal vector to the ground surface.

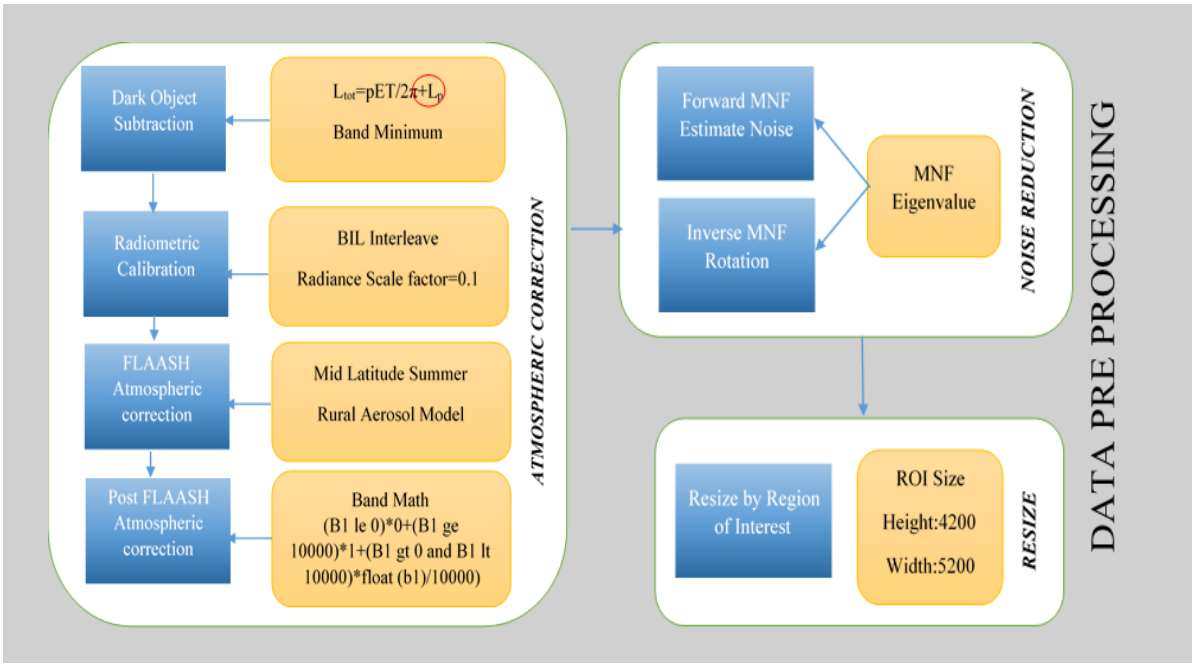
(3) Atmospheric correction

The solar radiation is absorbed or scattered by the atmosphere during transmission to the ground surface, while the reflected or emitted radiation from the target is also absorbed or scattered by the atmosphere before it reaches a sensor. The ground surface receives not only the direct solar radiation, but also sky light, or scattered radiation from the atmosphere. A sensor will receive not only the direct reflected or emitted radiation from a target, but also the scattered radiation from a target and the scattered radiation from the atmosphere, which is called a path radiance. Atmospheric correction is used to remove these effects.

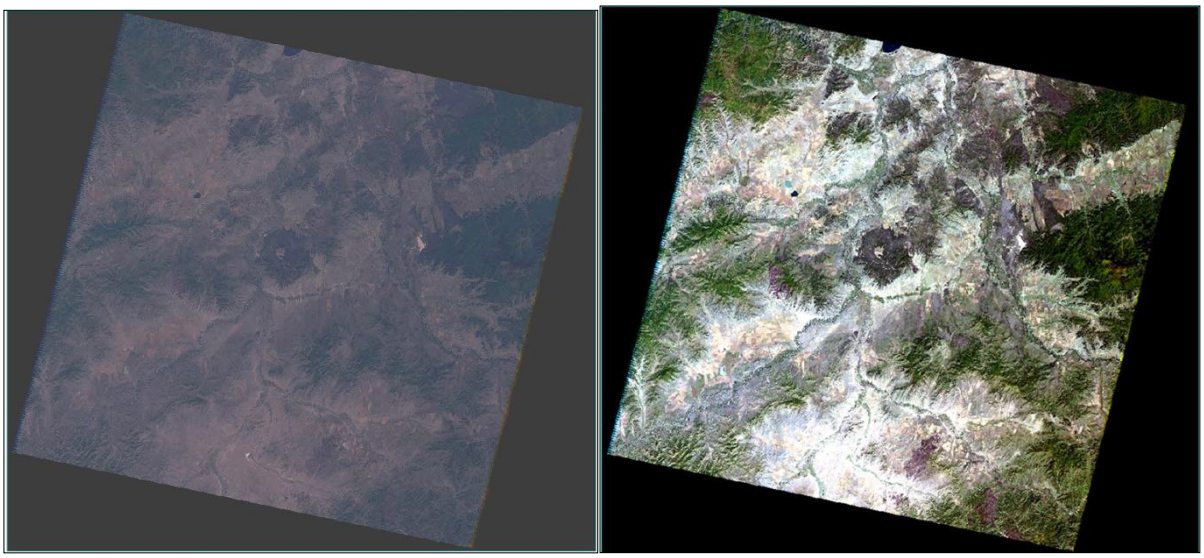
Schema 3. Radiometric correction types



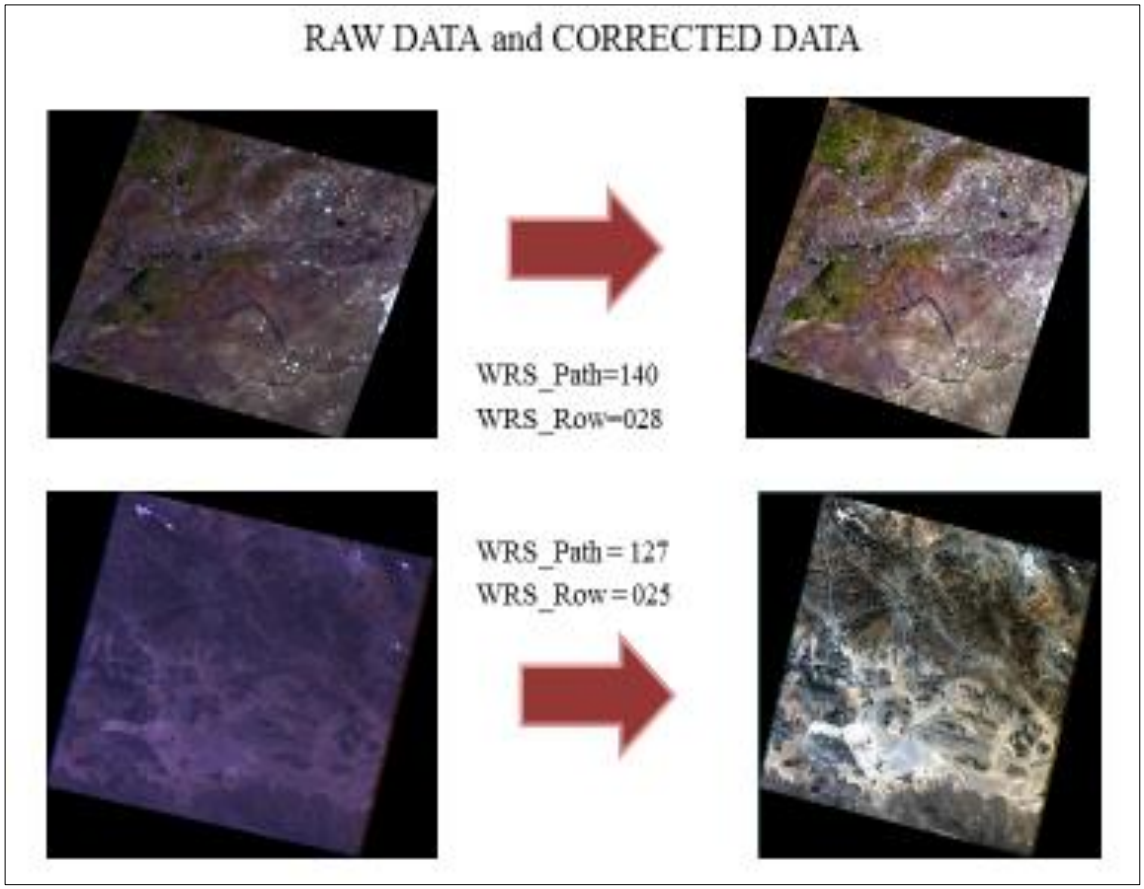
Schema 4. Correction process of Landsat data



Total 1800 Landsat data corrected by Schema 4 and those digital maps as shown below.



Picture 12. Comparison of raw data and corrected data of Landsat satellite data. Example-1



Picture 13. Comparison of raw data and corrected data of Landsat satellite data. Example-1

2.5. LEVEL 3 OF ACTIVITY
/FOREST COVER MAPPING – DIGITAL IMAGE PROCESSING/

Methodology refined by calssifying two pilot community area forest map to define a Mongolian forest cover area. Many land cover and forest cover products have been derived from remotely sensed imagery obtained by different satellite sensors, including the National Land Cover Dataset (NLCD) developed from Landsat Thematic Mapper (TM)/Enhanced Thematic Mapper Plus (ETM+) imagery and the Vegetation Continuous Fields (VCF) data from Moderate Resolution Imaging Spectroradiometer (MODIS) imagery. To extract forest cover from remotely sensed imagery, various methods have been proposed during the past decades.

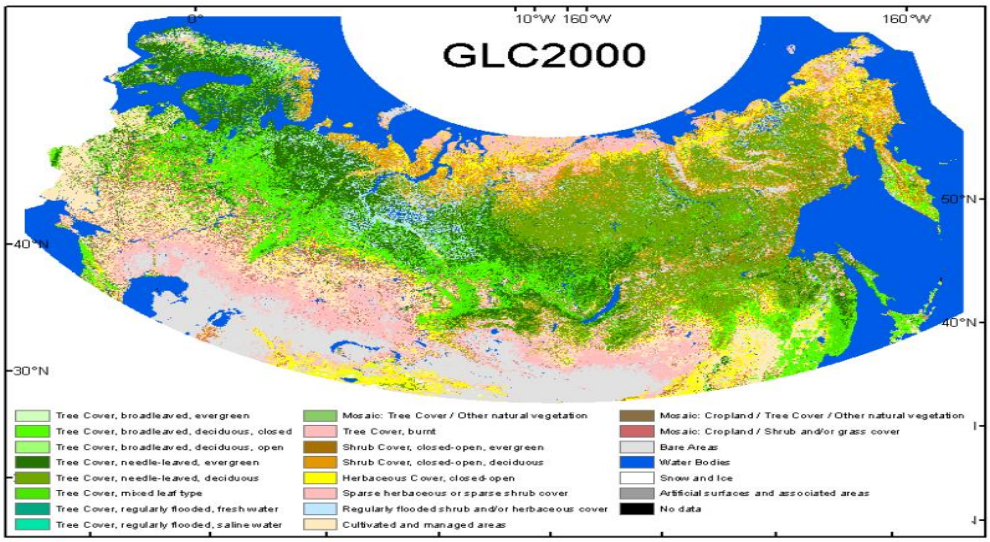
Some of these methods are based on supervised classification techniques to generate forest/non-forest classification maps, such as maximum likelihood [7], K-Nearest Neighbor [8], decision tree, logistic regression, support vector machine (SVM), and object-based classification.

We made supervised classification that is Maximum likelihood for chose a community area in Landsat satellite data from 2000 to 2015 and validate by field trip. Land cover type classification made by NELDA/Northern Eurasia Land cover Dynamics Analysis project/ approach [23]. The NELDA (Northern Eurasia Land Dynamics Analysis) project seeks to harness NASA remote sensing technology and local knowledge of land-cover conditions to validate and improve land cover and land-cover change products for Northern Eurasia.

Given the importance of Northern Eurasia for global ecosystem and climate processes, improved characterization of land cover and land-cover change in the region is a scientific priority. While multiple moderate and coarse-resolution land-cover products have been developed, their validation remains a challenge, particularly for boreal and temperate Northern Eurasia, where validation sites are sparse, several land-cover types are unique, and processes of ecosystem disturbance and land-cover change are widespread, including fire, timber harvest, insect outbreaks, agricultural conversion and abandonment, melting permafrost, and forest regrowth.

The region can be subdivided into three ecological zones: southern taiga, mixed forest and forest-steppe. The Volga River serves as the natural western border of physiographic and natural conditions. The northern part (Kirovskaya oblast) belongs to the taiga zone. Along the Volga River the central lowland extends as a wide band with a great number of lakes, marshes and rivers. The high right bank elevates above the valley of the Volga River in the form of a steep ledge with deep ravines and gullies. The forest cover ranges between 16% in the SE to 57

% in the NW and the dominant species include pine (Pinus sylvestris L.), birch (Betula pendula Roth. and Betula pubescens Ehrh.), spruce (Picea abies Karst. and Picea obovata Ledeb.), and aspen (Populus tremula L.). Forests of low (left) bank of the Volga river are dominated by pine on sandy soils and mixed stands of birch, lime (Tilia spp), and aspen on more productive soils. Forests on the high (right) bank are dominated by broad-leaved hardwoods including oak (Quercus robur), lime, maple (Acer platanoides), elm (Ulmus spp.), and ash (Fraxinus excelsior). The second most important type of landcover are cereal crops; there are also pastures in the flood plain; peatlands dispersed all over the region; ravines; young forest plantations. (Annex 3).

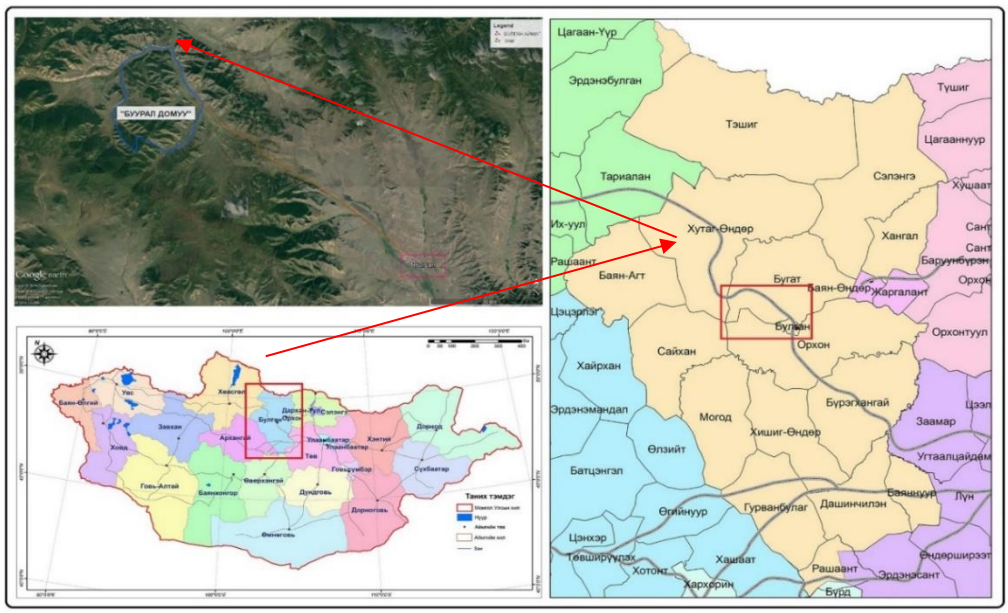


Picture 14. NELDA project land cover classification

We only use tree-dominated classification of this project and that defined forest has tree height is more than 3 meters and canopy cover is greater than 15%. Firstly, we checked up all those land cover classifications on two pilot community area's forest cover. Dominant land cover type of those two community areas are forested area and shrubs and grassland. In addition, it includes a stream of river and road.

2.5.1. Location of “Buuraldomuu” community

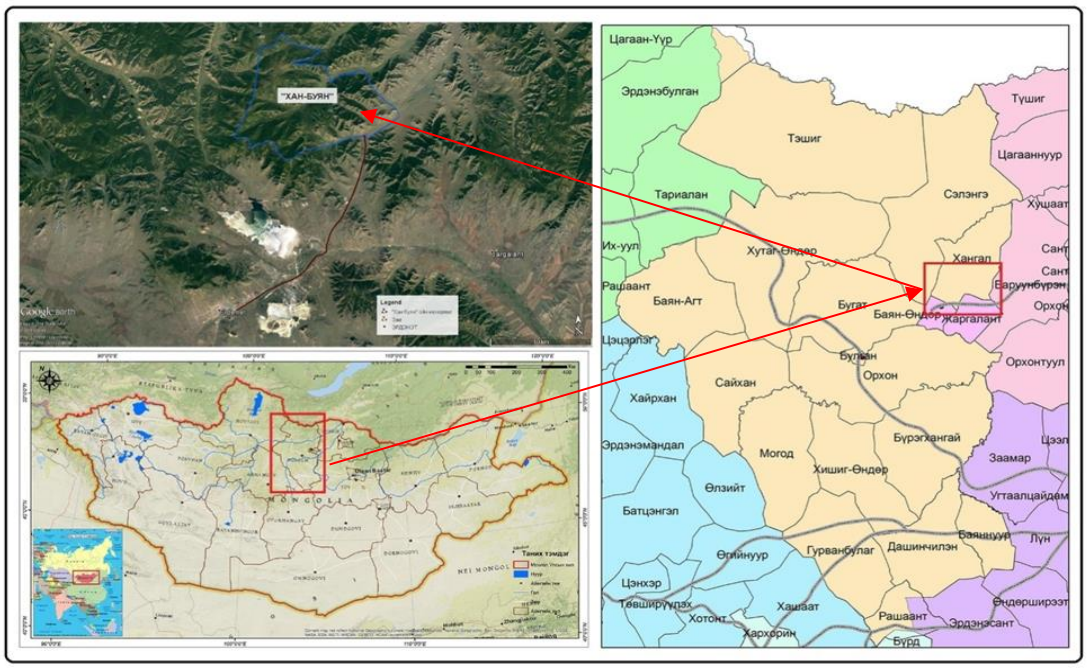
“Buuraldomuu” community locates as coordinate with 103˚14‘15“, 48˚57‘1.5”, 25 km from Bulgan center to the west.



Picture 15. “Buuraldomuu” forest community location

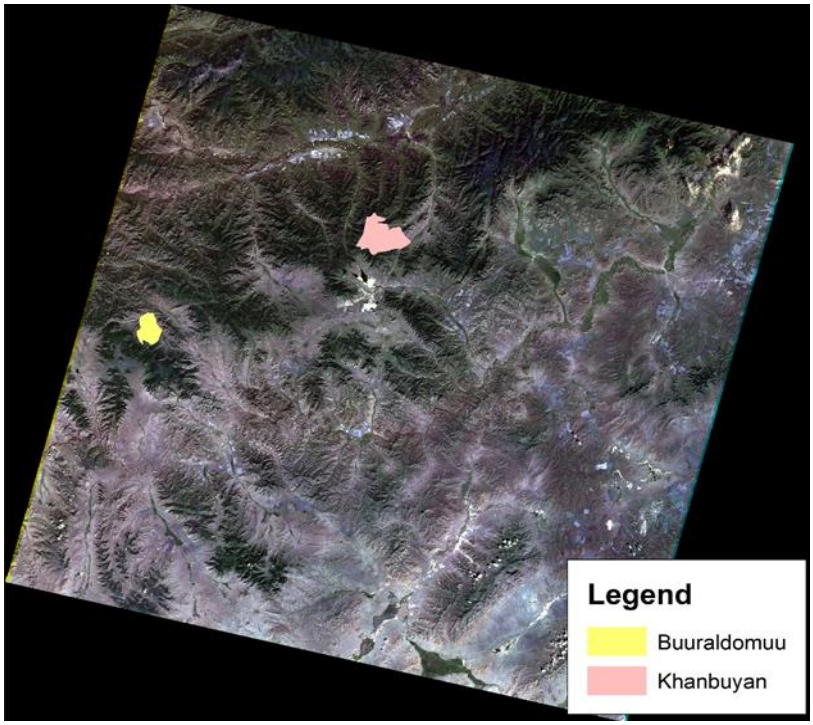
2.5.2. Location of “Khanbuyan” community

Khanbuyan community locates 1st bag of Khangal soum of Bulgan aimag as coordinate with 104˚10’48.4”, 49˚12’54.5”, 26km from Erdenet city of Orkhon aimag.



Picture 16. “Khanbuyan”forest community location

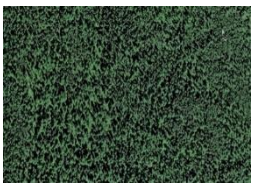
Two communities locate on scene that has path-133 and row-26 of Landsat satellite data.



Picture 17. Location of two communities on Landsat data.

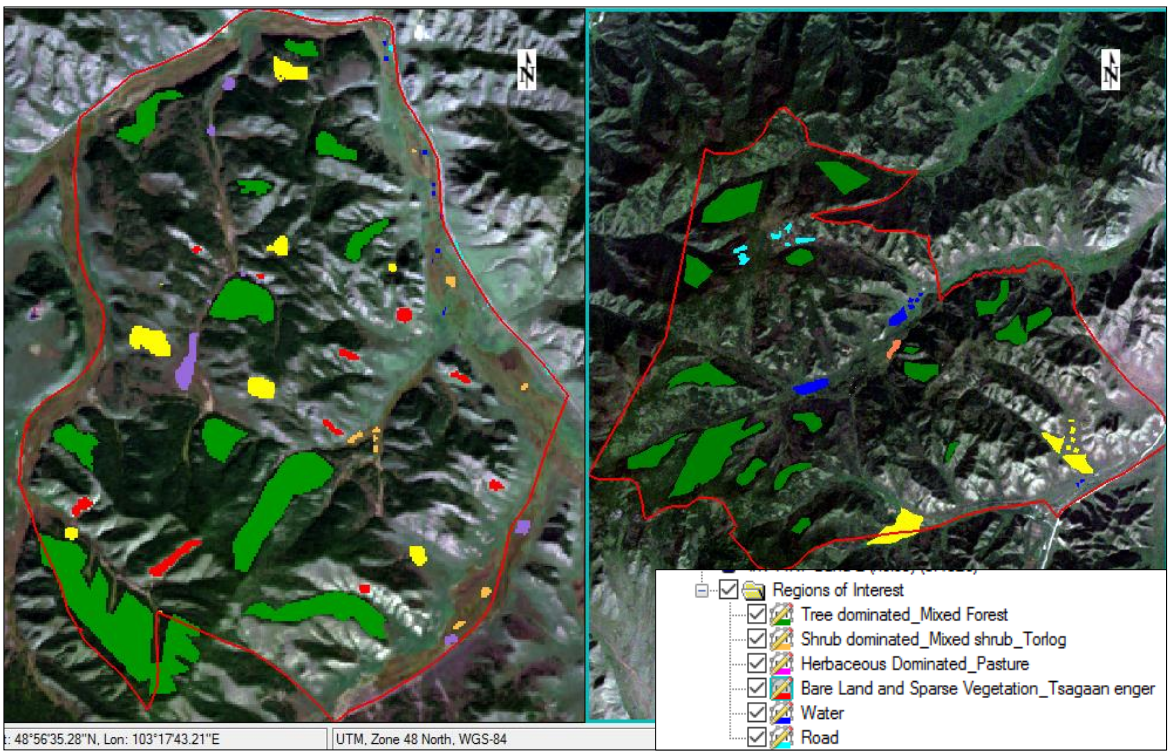
We picked up following 6-land cover type.

Table 6. Basic land cover type of community

Class_ID	Description	Examples	
		Photo	Satellite
1	Major types of land cover		
2	Tree Dominated Mixed Forest		
3	Shrub Dominated Mixed Shrub		
4	Herbaceuos Dominated_Pasture		
5			
6	Bare Land and Sparse Vegetation		
7	Water and Road		

2.5.3. Supervised classification method

The supervised classification is the essential tool used for extracting quantitative information from remotely sensed image data. Using this method, the analyst has available sufficient known pixels to generate representative parameters for each class of interest. This step is called training. Once trained, the classifier is then used to attach labels to all the image pixels according to the trained parameters. The advantage of this classification is it can choose every sub-class as ROI (Region of Interest) to classify the same class by calculating the average of those area points by statistic. How to choose ROI and which algorithm of classification will use is depends on location and environment and ecological condition. We have chosen ROI on Landsat satellite data of those two community areas as shown following map.



Picture 18. Picked ROIs for land cover classification of two forest communities.

Supervised classification has algorithm such as maximum likelihood, minimum distance and prallelpiped. In this study, we used maximum likelihood algorithm.

2.5.4. Maximum likelihood

Maximum Likelihood (ML) is a supervised classification method derived from the Bayes theorem, which states that the a posteriori distribution P(i|ω), i.e., the probability that a pixel with feature vector ω belongs to class i, is given by[10]:

$$P(ci|x) = P(x|Ci) * P(Ci) / P(x) \qquad (2.1)$$

Here:

$P(Ci\|x)$	-	Testing most probability
$P(x\|Ci)$	-	Conditional probability
$P(Ci)$	-	Prior probability, the probability that i is observed
$P(x)$	-	Probability of pixel for any class
Ci	-	That class
x	-	Pixel

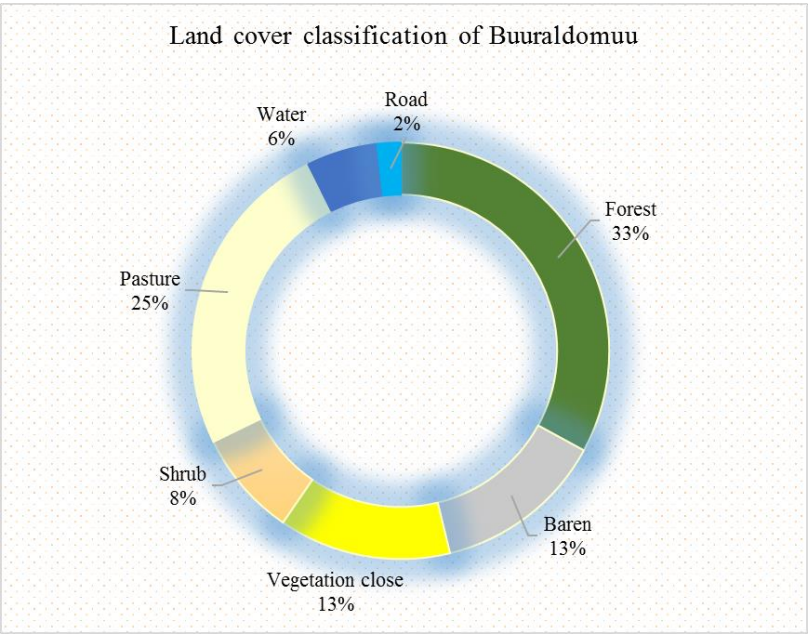
$$g_i(x) = Ln\{P(x|Ci)\} + Ln\{P(Ci)\} \qquad (2.2)$$

Each pixel (2.2) is assigned to the class with the highest likelihood or labelled $g_i(x)$ as unclassified if the probability values are all below a threshold set by the user.

This method is better than other methodology because of measure shape, size and navigation not only location.

We classified two-community area as land cover by maximum likelihood classification.

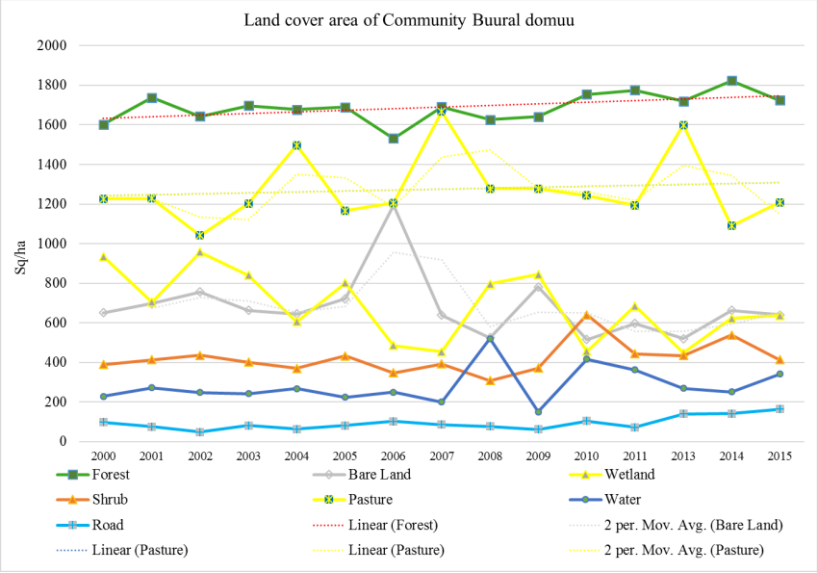
Buuraldomuu community area classified by maximum likelihood classification as 33% forest, 25% pasture, 13% bareland and 12% meadow.

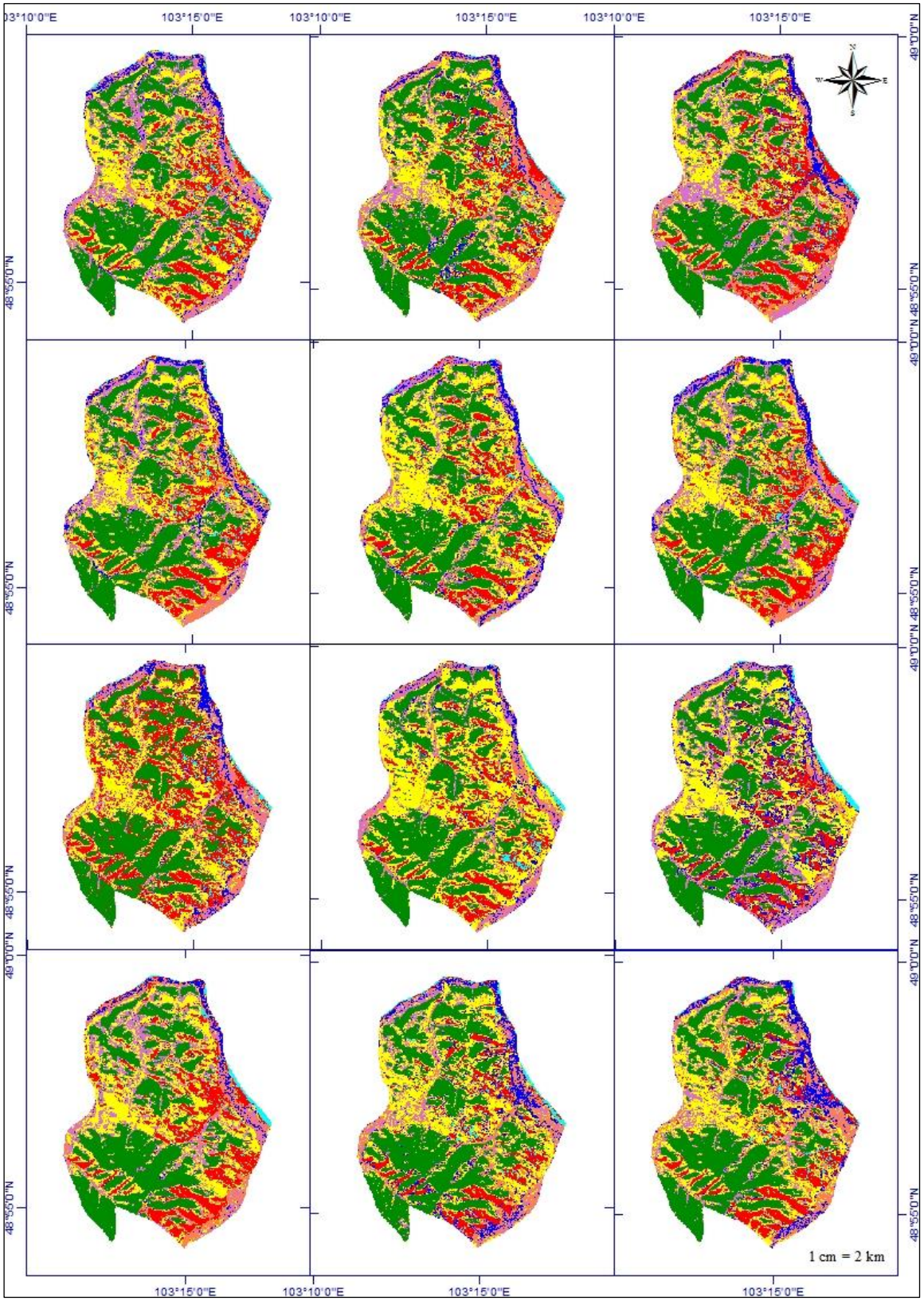


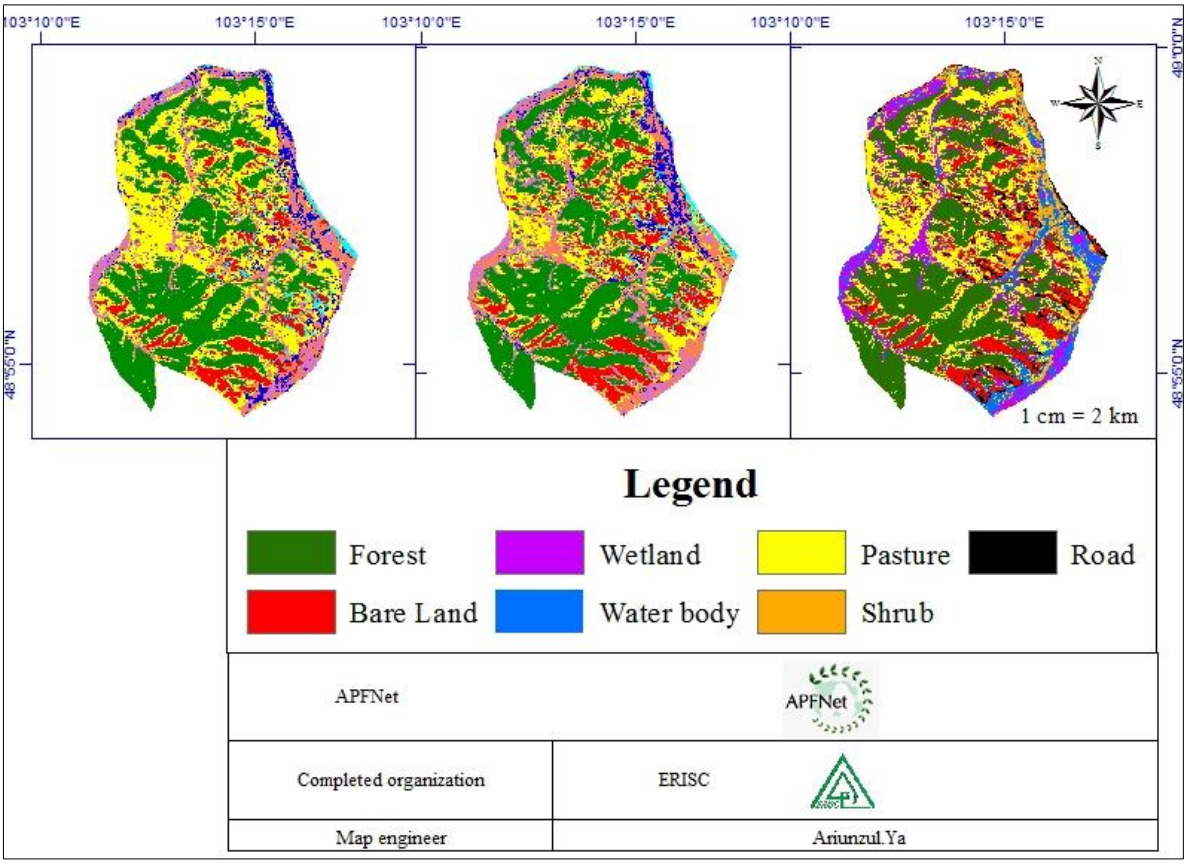
Picture 19. "Buuraldomuu" forest community area land cover classification

Forest area has not changed during 2000 to 2015. Forest area defined by forest taxation in 2015 and forest area measured by maximum likelihood classification is lower by 480 hectares than forest taxation data.

Graphic 1. Land cover classification area of the Buuraldomuu forest community.

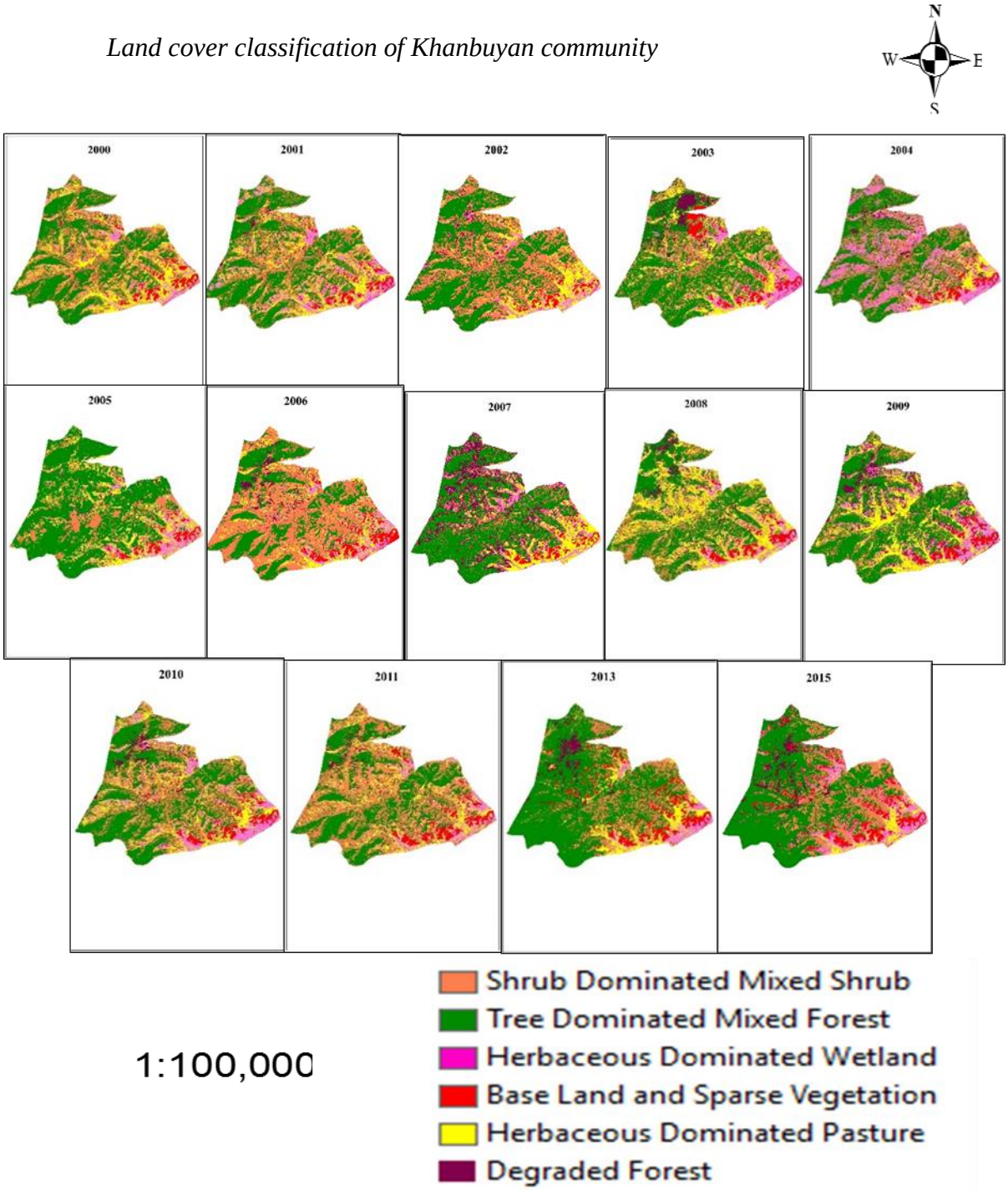



103°10'0"E
103°15'0"E
48°55'0"N
49°0'0"N
1 cm = 2 km



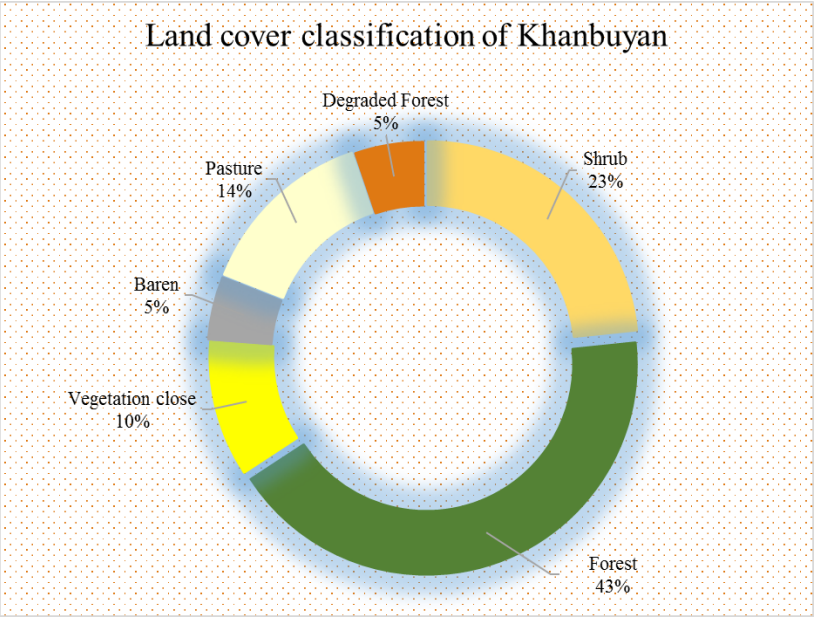
Picture 20. Land cover area that classified by maximum likelihood classification of Buuraldomuu community

Land cover classification of Khanbuyan community



Picture 21. Land cover classification by maximum likelihood classification of Khanbuyan community

Khanbuyan community area classified by maximum likelihood classification as 42% forest, 23% shrub, 13% pasture, 4% bareland and 10% meadow. The forest forest cover area degraded by 5%.



Picture 22. Land cover classification of Khanbuyan community

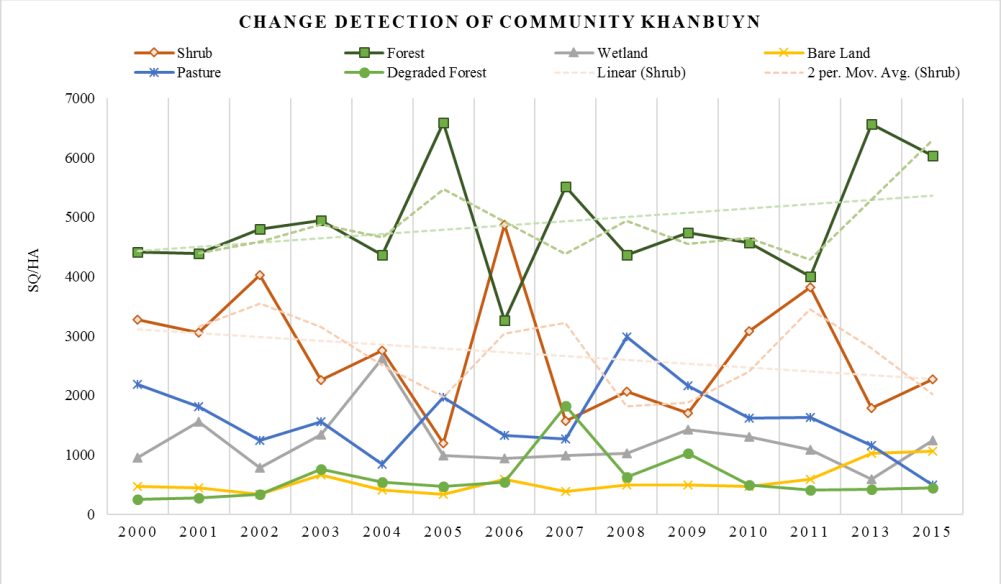
Forest area has increased during 2000 to 2015. As land cover classification in the Buuraldomuu forest community area, greatest area is with the forest and next pasture area and in the Khanbuyan forest community area, greatest area is with the forest and next shrub area by supervised classification.

As a field trip, it verified in two community areas.

Table 7. Land cover area of two community areas

№	Land cover name	Buuraldomuu %	Khanbuyan %
1.	Forest	33	43
2.	Degraded Forest	0	5
3.	Shrub	8	23
4.	Pasture	25	14
5.	Meadow	13	10
6.	Bareland	13	5
7.	Water	6	0
8.	Road	2	0
9.	Total	100	100

Graphic 2. Land cover classification area by maximum likelihood classification of Khanbuyan forest community



The maximum likelihood classification has less probability with vast area and map quality directly depends with training samples and classifying employers. The next methodology is classifying forest/nonforest by Forest Index /FI/. The project purpose was defining Mongolian forest cover area. In the community area, most suitable methodology was supervised classification method. However, it was only suitable with the small area. We studied other remote sensing indexes because spectral index is easy to use. Normalized difference vegetation index (NDVI), normalized difference water index (NDWI) has purpose with define different land cover type. For the vegetation many indexes produced in remote sensing such as NDVI, simple ratio vegetation index (SR), soil adjusted vegetation index (SAVI), enhanced vegetation index (EVI).

A healthy green leaf intercepts incident radiant flux directly from the sun or from diffuse skylight scattered onto the leaf. This incident electromagnetic energy interacts with the pigments, water, and intercellular air spaces within the plant leaf.

Cohen (1991) suggests that the first true vegetation index was the Simple Ratio (SR), which is the ratio of red reflected radiant flux (ρ_{red}) to near infrared radiant flux (ρ_{nir}) as described in Birth and McVey (1968) as:

$$RVI = \frac{RED}{NIR} \qquad (2.3)$$

Rouse et al. (1974) developed the generic Normalized difference vegetation index (NDVI):

$$NDVI = \frac{NIR - RED}{NIR + RED} \tag{2.4}$$

Ricardson and Wiegand (1977) used the perprendicular distance to the "soil line" as an indicator of plant development, which Perprendicular Vegetation Index (PVI) is based on MSS band for data was [18]:

$$PVI = \alpha NIR + \beta RED \tag{2.5}$$

Here: PVI- Perpindicular Vegetation index

α - coefficient of soil line

β - value of soil intersection

Huete (1988) developed soil adjusted vegetation index (SAVI) expressed as [13]:

$$SAVI = \frac{NIR - RED}{NIR + RED + L}(1 + L) \tag{2.6}$$

Here: SAVI – Soil Adjusted Vegetation index

L-coefficient (0.5)

$$ARVI = \frac{NIR - RB}{NIR + RB} \tag{2.7}$$

Here: ARVI – Atmospheric Resistance Vegetation Index

B- Blue of visible light

$$GEMI = \eta(1 - 0.25\eta) - \frac{RED - 0.125}{1 - RED} \tag{2.8}$$

Here: GEMI – Global Environmental Monitoring Index

$$\eta = \frac{2(NIR^2 - RED^2) + 1.5NIR - 0.5RED}{NIR + RED + 0.5} \tag{2.9}$$

The forest sector uses satellite data from 1990, and started to produce forest cover map using remote sensing data [19]. Nowadays, many researches for forest cover mapping, forest type, forest degradation, fire of the forest, insected area uses active and passive remote sensing.

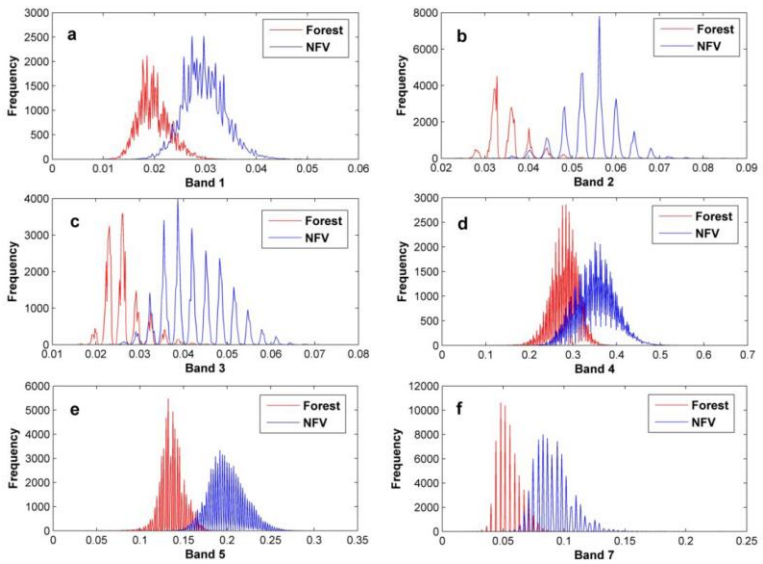
Vegetation indexes created for defining vegetation and the non-vegetation area not for forest and non-forested area. That is why it is difficult to differentiate the similar area between forest and non-forest vegetation area. The reason of that we picked up Forest Index for our research.

2.5.5. Forest Index /FI/

The scientists Wentao Yea, Xi Li, Xiaoling Chena, Guo Zhanga of the State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing of Wuhan University, China. To make the process of forest cover mapping simple and rapid, a simple spectral index called forest index (FI) was proposed to highlight the forest land cover by a threshold in Landsat scenes. FI uses three band of Landsat such as green, red and near infrared. Accuracy assessment validated by 97.8% and 96.2 in two scenes respectively. FI gives a positive value on forested area and vice versa negative value on the non-forested area.

The design of the FI based on the observation of forest spectral features, which agrees with the historical observations that forest is a kind of dark vegetated surfaces and is usually darker than other vegetation.

Graphic 3. Histograms (a-f for bands 1-5 and 7) of forest and non-forest vegetation created using the six spectral bands of the sub-image shown in Figure 1(a).



Graphic-3 indicates that the visible and SWIR bands (i.e. 1-5 and 7) show good performance in distinguishing forest from non-forest vegetation. Also shows that the NIR band

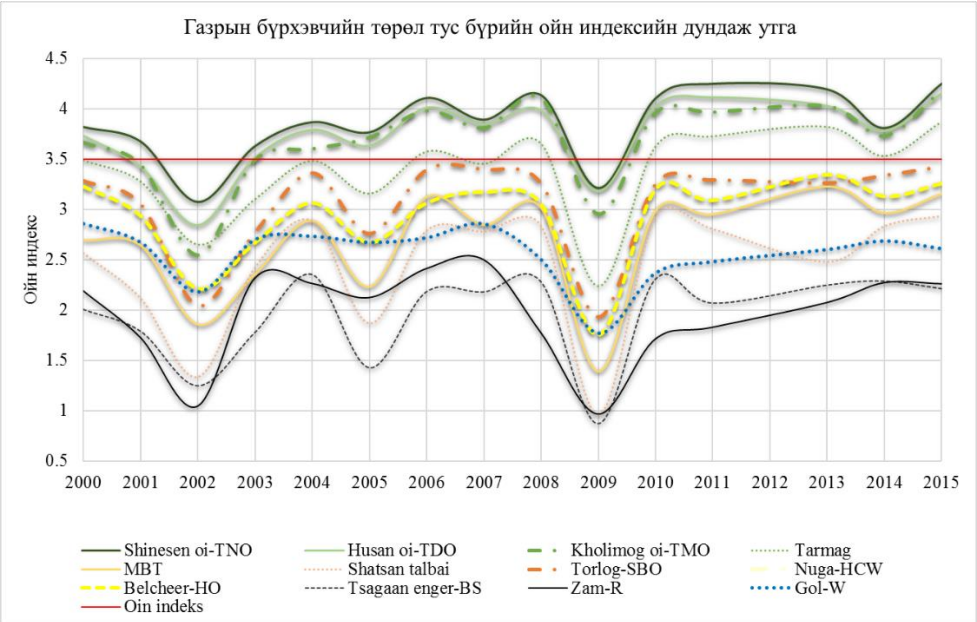
has potential to distinguish forest from non-forest vegetation as well. Because of the high correlation between each two bands in vegetated surfaces, all over 0.8, it is unnecessary to use two or more these bands in the FI. Only one of these five bands is required and the green band was used in this study. FI equation:

$$FI = \left(\frac{\rho_{NIR}-\rho_{red}-L}{\rho_{NIR}+\rho_{red}}\right)\left(\frac{c_1-\rho_{NIR}}{c_2+\rho_{green}}\right) \qquad (2.10)$$

where L, C1 and C2 are empirically set to 0.01, 1 and 0.1 in this study, respectively. Thus, the range of the FI is from minus infinity to 10. In this study FI threshold has been use as 3.5, 3.5-10 as forest less than 3.5 as non-forest. Accuracy assessment validated by 96.2% and cappa coefficient was 0.911%.

We used FI calculated in the radiometrically and atmospherically corrected Landsat scenes. We had to check threshold of the FI in Mongolian condition. Because the study was validated in China and Canada forest [12].

Graphic 4. FI value of each landcover type in Buuraldomuu community

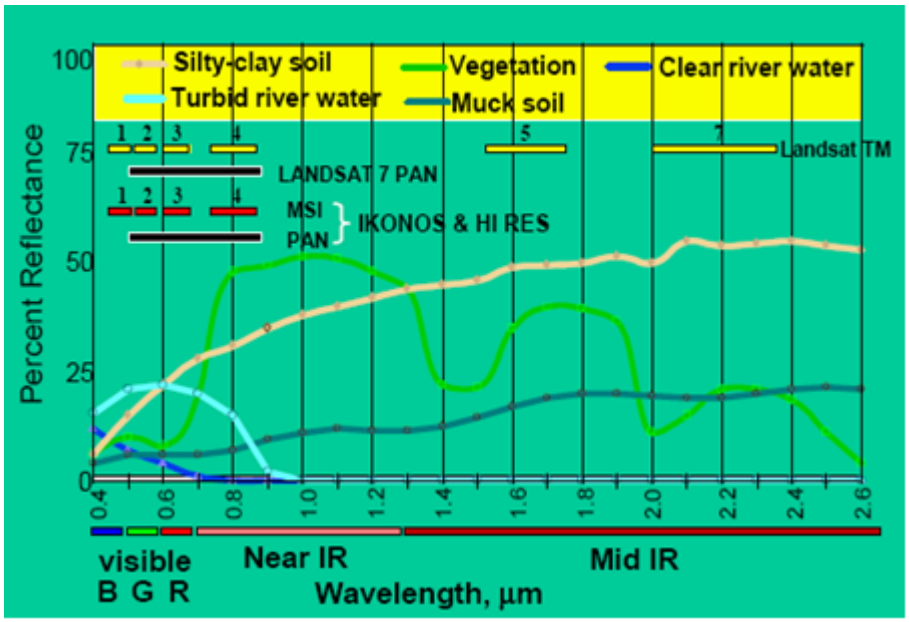


The graph shows the FI index value and shrubs, pasture, meadow, grassland, bare land, logging area, fired area, river and roads all gives lower value than 3.5. Although, scattered forest sometimes gives FI value lower than 3.5. The most of the Larex forest, birch forest and mixed forest gives a value higher than 3.5 that can classify into the forest. In this graph in 2009, there was only 31st May Landsat-5 data available and that is why all value has peak.

Generally, the basic idea to study green vegetation from the remote sensing is visible electromagnetic wave red, blue and near infrared. Which means, it is better to study green vegetation in the season of the growth. Before our study, Mongolian scientist has perceptions

about fall and winter season is most suitable for forest study. But in our research growth season of the forest is more suitable for passive remote sensing in Landsat satellite data. In other words, green plants give the minimum value in spectral value of red, and the maximum value in the near infrared spectral region. The values of this characteristic do classes on satellite data to improve green vegetation index calculated by a mathematical formula using. Many vegetation indexes that used this characteristic. Historical researches of remote sensing studied natural object spectral reflectance value.

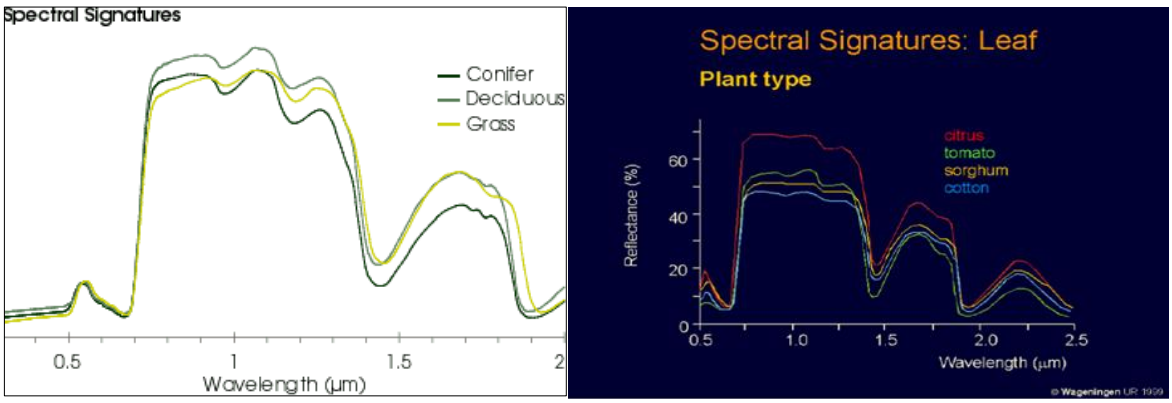
Graphic 5. General graph of natural object spectral value.



Source from: http://wwwitc.nl/~bakker

For example, following graph shows electromagnetic wave spectral graph of deciduous and conifer trees. Those two graph has similar but not exactly same means it can be classifying.

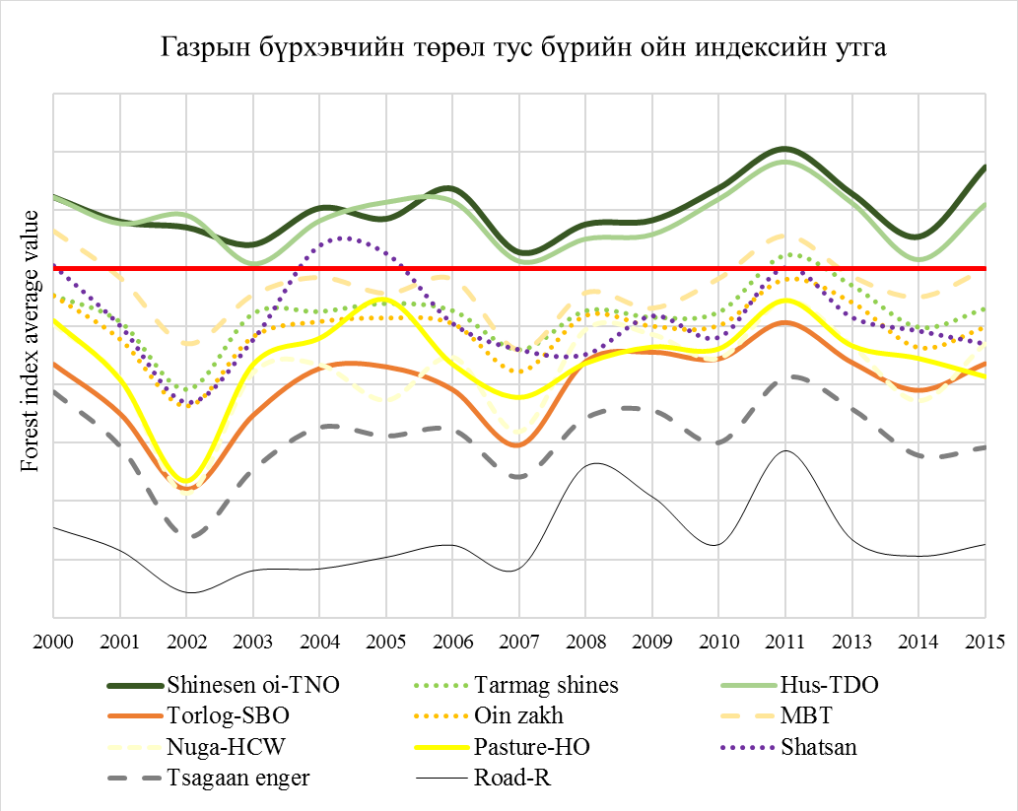
Graphic 6. Difference spectral graph between vegetation types



Source from: http://wwwitc.nl/~bakker

As we see from the graph 2002 year gives low value because of smoke that day Bugat soum of Bulgan province has fire.

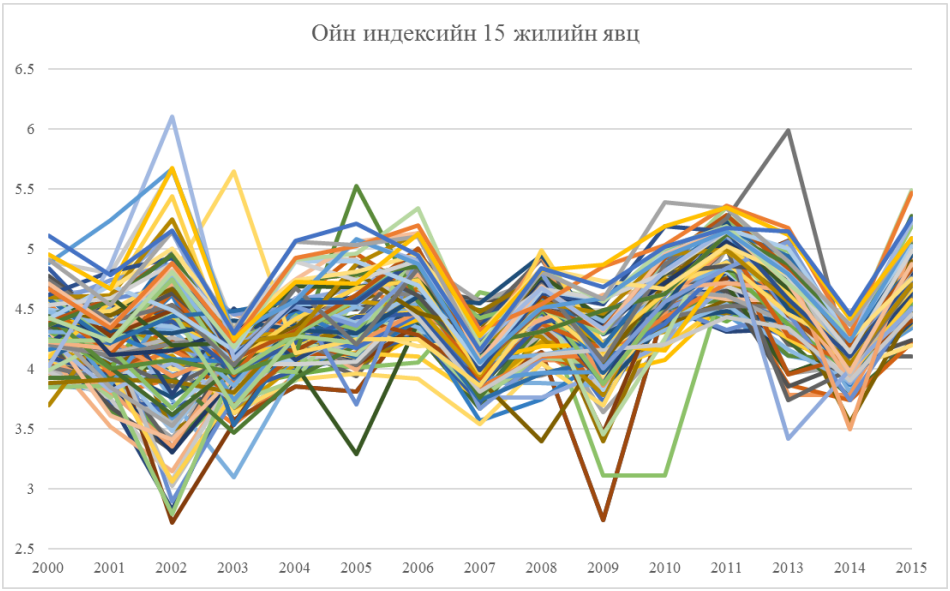
Graphic 7. Forest Index value of land cover type of Khanbuyan community.

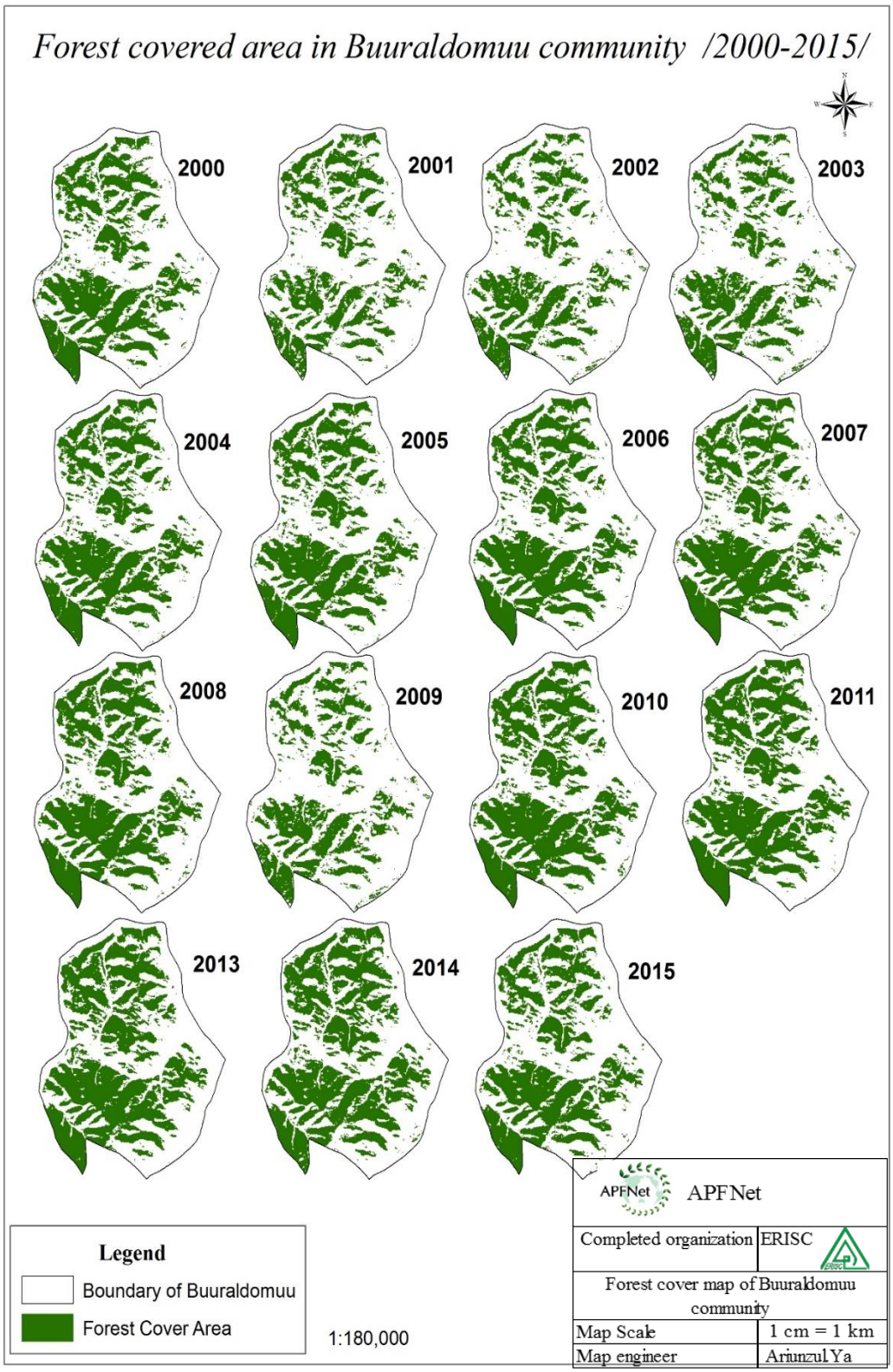


From the Khanbuyan forest community land cover classification larex and birch of FI value is greater than 3.5. Also road, grassland, bareland, pasture, meadow scattered forest gave lower value than 3.5.

Forest index threshold chosen as 3.5 and produced a land cover map of forest community area from 2000 to 2015 from the Landsat data.

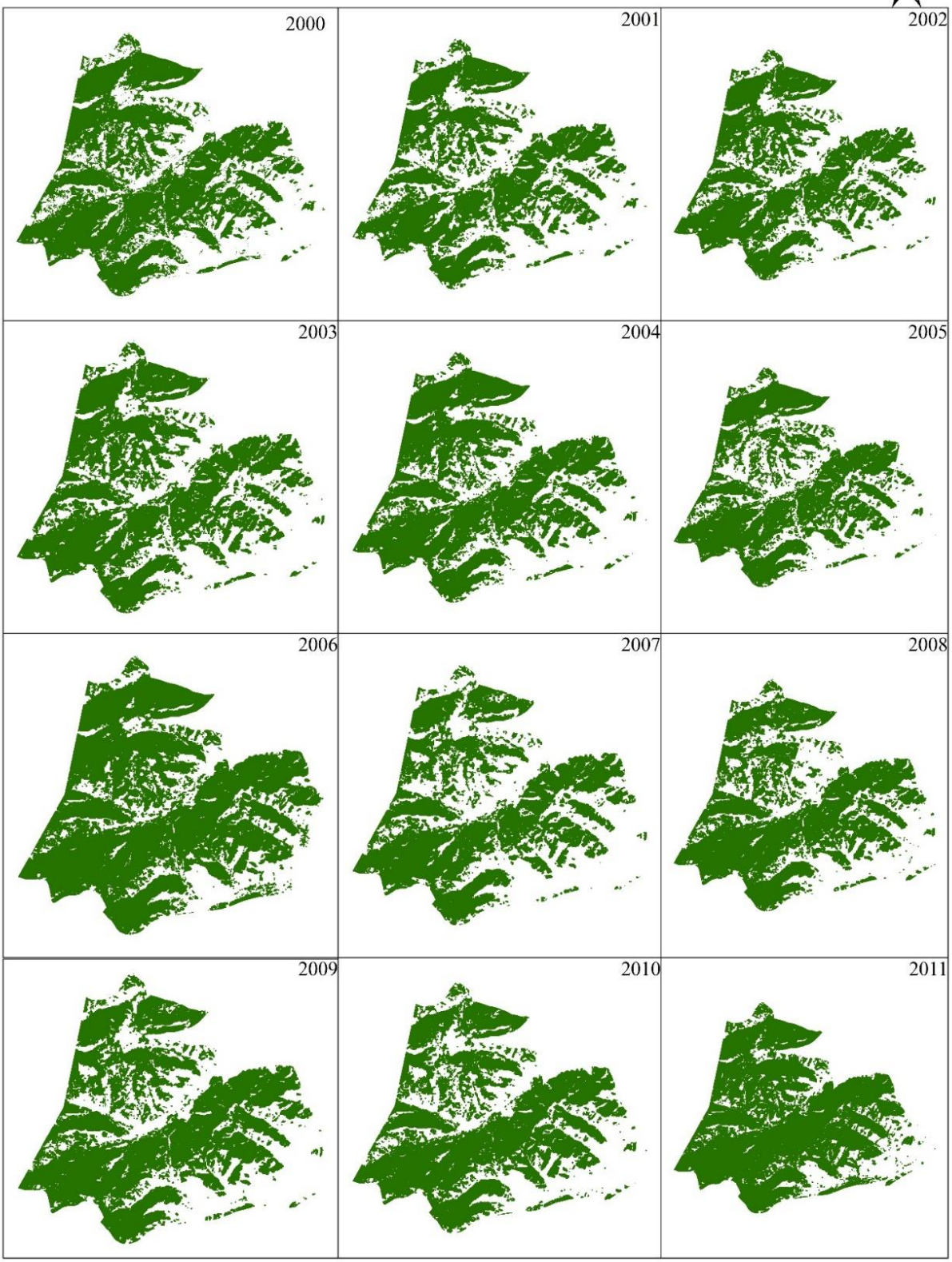
Graphic 8. 15 years process of FI

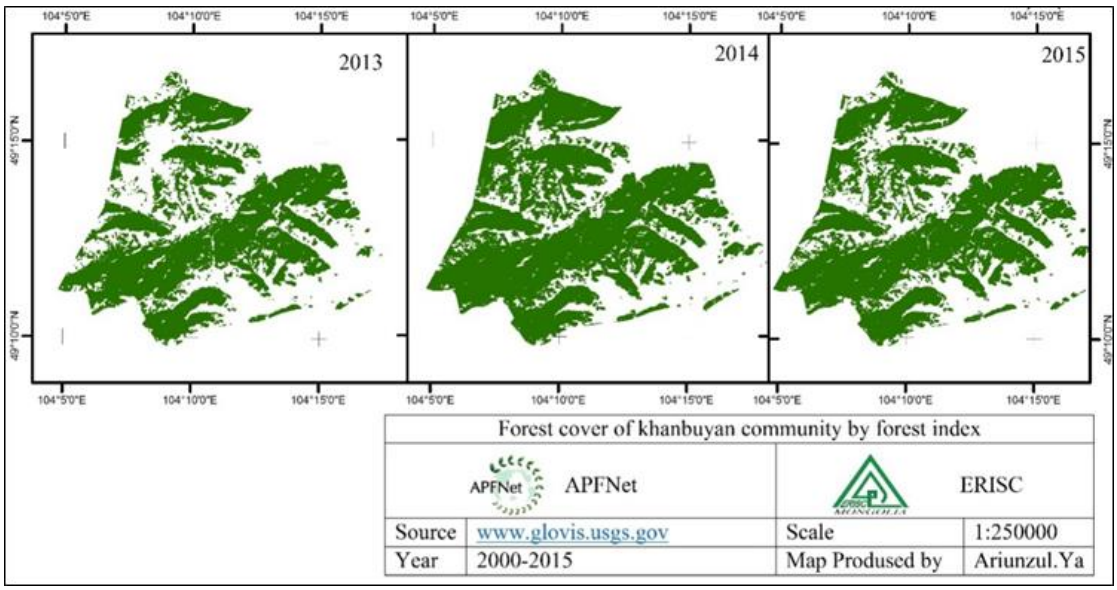




Picture 23. Forest cover map of Buuraldomuu by 15 year

Forest cover map "Khanbuyan" by Forest Index

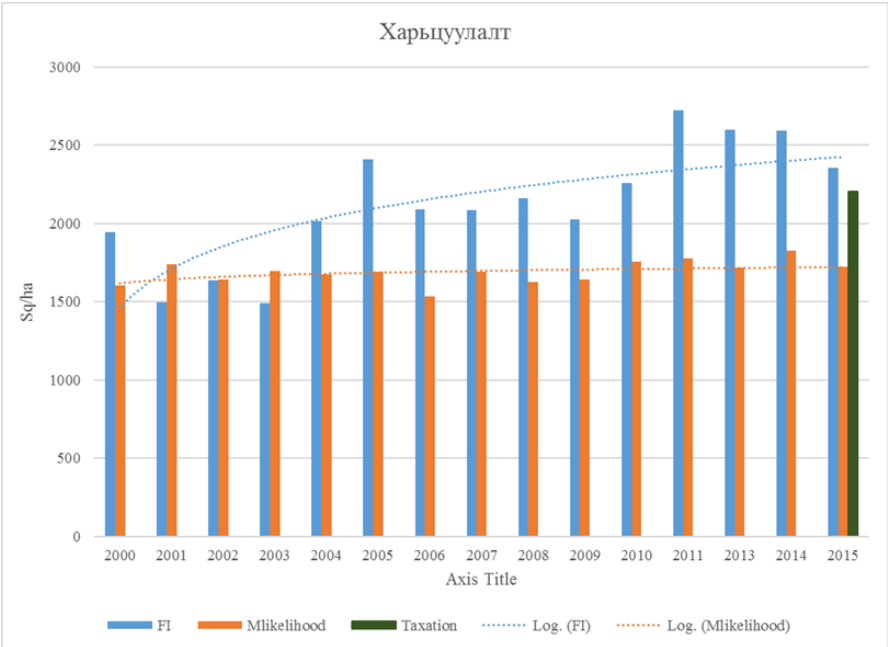




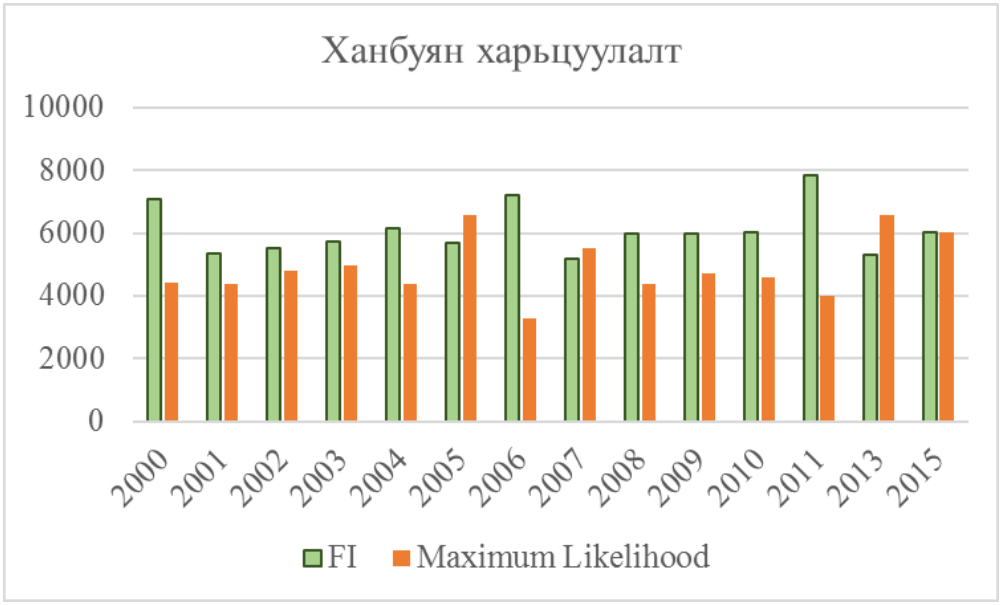
Picture 24. Forest cover map of Khanbuyan by 15 year

We compared of two-community area classifications FI forest between with land cover type of maximum likelihood method. Unfortunately, Khanbuyan community has not forest management plan then they do not know their forest taxation. Buuraldomuu community has 2015 forest taxation, so we compared 2015 FI classification and maximum likelihood classification with taxation data.

Graphic 9. Comparison between FI and maximum likelihood classification and forest taxation data of 2015



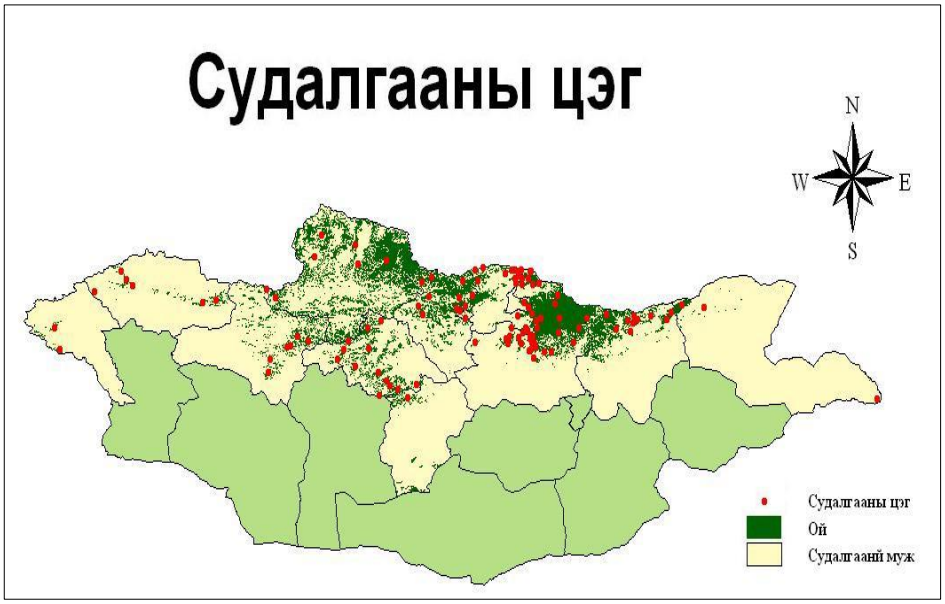
Graphic 10. Comparison between FI and maximum likelihood classification



The Forest index gives more probability results from those comparisons. FI is not fixed and the advantage of the FI is its threshold can be change because of the season and data quality. From all those studies, we have chosen FI as define forest cover of Mongolia from the Landsat satellite data by 15 years.

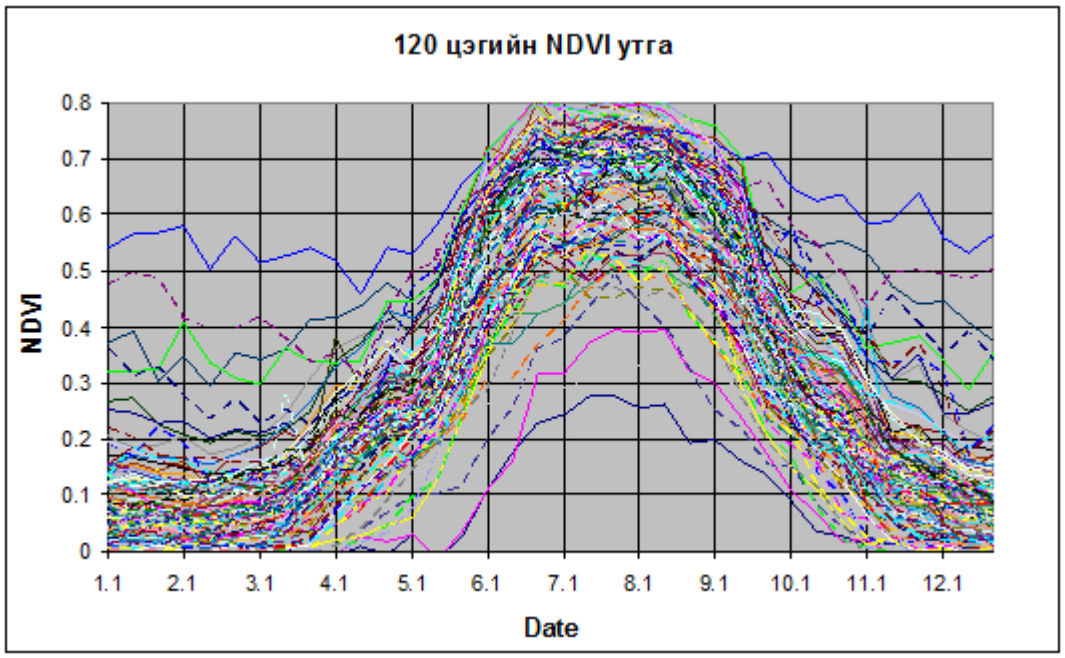
2.5.6. Data period

Forest cover mapping from Landsat data period has chosen from 15th June to 15th September. As a doctorate thesis of Ariunzul.Ya defined forest cover area monthly by NDVI index and it shows May to October can identify forest and vegetation by the index. Mongolian forest includes deciduous and coniferous forest and mostly forest trees left leaves in winter. The reason of that winter NDVI gives low value in Mongolian forest. The following picture shows the yearly process of NDVI average value for 120 points of the Mongolian forested area.



Picture 25. NDVI yearly sample points

Graphic 11. NDVI yearly progress of Mongolian forest steppe



The graph shows the maximum NDVI value for 1st of June to 1st of September. The average calculation of NDVI in Mongolian forested zone is in summer 0.5 and spring 0.117691 and autumn 0.124465. Because of lack of data, it can be more probability from 15th May to 15th September. Firstly, we used July and August data in project first term, and second term we downloaded June and September Landsat data. However, when we use data of before 15th of June and after the 15th of September data sometimes we dropdown threshold of FI.

Mongolian forest cover calculation depends on each province because Mongolia has vast landscape and different climate zones. Forest Index is flexible and it can be differentiating and more accurate for each province each soum. There was difference between July forest data and September forest data. We solved that problem with changed the threshold. The final result has to be more accurate. Project team tried to use data without any differenced scenes. Landsat scenes has usually overlapped with each other, that gives us opportunity to replace cloudy area with another scene same area. The data has chronological, then we have opportunity to take valid data of the forest. Because if there was any year with some mistake will checked by next year's valid data.

2.6. FOREST DISTRIBUTION MAP

Mongolian forest cover map produced from the Landsat and MODIS satellite data. We faced problem with produce full Mongolian forest cover map because of huge data, then we decided to produce forest cover map by province. Landsat satellite data taken from 1st of June to 15th of September, but from 1st June to 15th June and from 5th September to 15th September FO threshold dropdown. Total 120 scenes of one year, 1800 scenes of 15 year processed and produced forest distribution map.

Table 8. Landsat satellite data forest digital database

№	Province	Data	Data type
1.	Arkhangai	135 data of 9 scenes	
2.	Bayan-Ulgii	120 data of 8 scenes	
3.	Bayankhongor	120 data of 8 scenes	
4.	Bulgan	135 data of 9 scenes	
5.	Darkhan-Uul	15 data of 1 scenes	
6.	Dornod	75 data of 5 scenes	
7.	Orkhon	15 data of 1 scenes	
8.	Uvurkhangai	105 data of 7 scenes	
9.	Selenge	105 data of 7 scenes	
10.	Tuv	135 data of 9 scenes	
11.	Uvs	120 data of 8 scenes	
12.	Khentii	180 data of 12 scenes	
13.	Khovd	150 data of 10 scenes	
14.	Khuvsgul	225 data of 15 scenes	
15.	Zavkhan	150 data of 10 scenes	
16.	Ulaanbaatar	15 data of 1 scenes	
17.	Total	1800 data of 120 scenes	

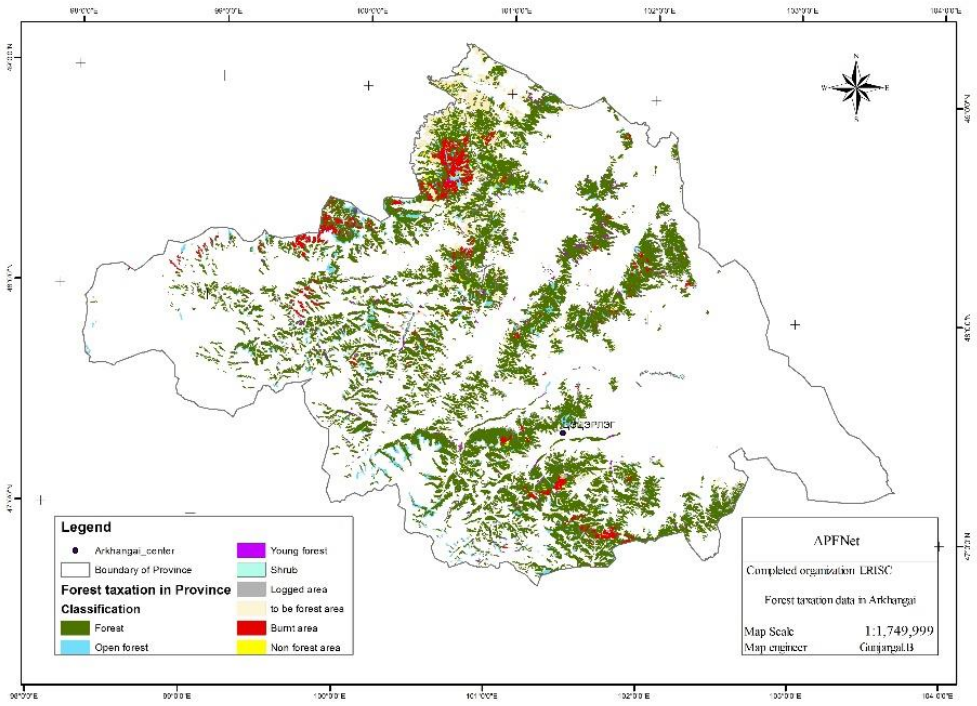
2.6.1. Forest definition

Mongolian forest definition has different ways from plenty of sources. Mongolia uses forest definition described on forest law. Our project used NELDA land cover classification.

№	Source	Forest definition
1.	Mongolian "Forest law" 3.1.1	Forest is ecological and geographic specific condition, which includes co-components with trees, shrubs, bushes, vegetation, lichen, animals and microorganisms.
2.	Guideline of Mongolian forest taxation workspace	Forest covered area includes forest, saxual forest, natural seabucks, shrubs with 0.3 density. Scattered forest means less than 0.3 density forest originate from strong wind, snow, insect, fire.
3.	FAO definition of UN	Forest has a certain life cycle and with at least 2 meter height and greater than 10 percent canopy cover tree covered area.
4.	UNREDD+	Forest has at least 5-meter height and greater than 10 percent canopy cover with atleast one-hectare area.
5.	Multipurpose Forest Inventory methodology	Forest has a certain life cycle and with at least 2-meter height and it covers atleast 1.35-hectare area. The definition based on FAO definition of UN.
6.	NELDA	Forest has at least 3 to 5-meter height and greater than 15 percent canopy cover with atleast one-hectare area.

2.6.2. Forest dispersion map of Arkhangai province

Forest fund of Arkhangai aimag made a Forest taxation in 1995-1996. The forest fund performance developed from next forest taxation in 2008. Total forest fund area of the Arkhangai province is 1008.6 thousand hectare and from that forest covered area is 808.2 thousand hectare as 80.2%. 799.4 thousand hectare as 98.9% of forest-covered area is natural forest and left 8.8 thousand hectare as 1.1 percentage is shrub. Total reserve of forest fund is 104.1 million m3. The dominant tree species are larch 768, 2 million.ha, cedar 14, 8 million.ha, and betula 2,9 million.ha, Shrub 8,7 thousand.ha, Poplar 4.1 million.ha.

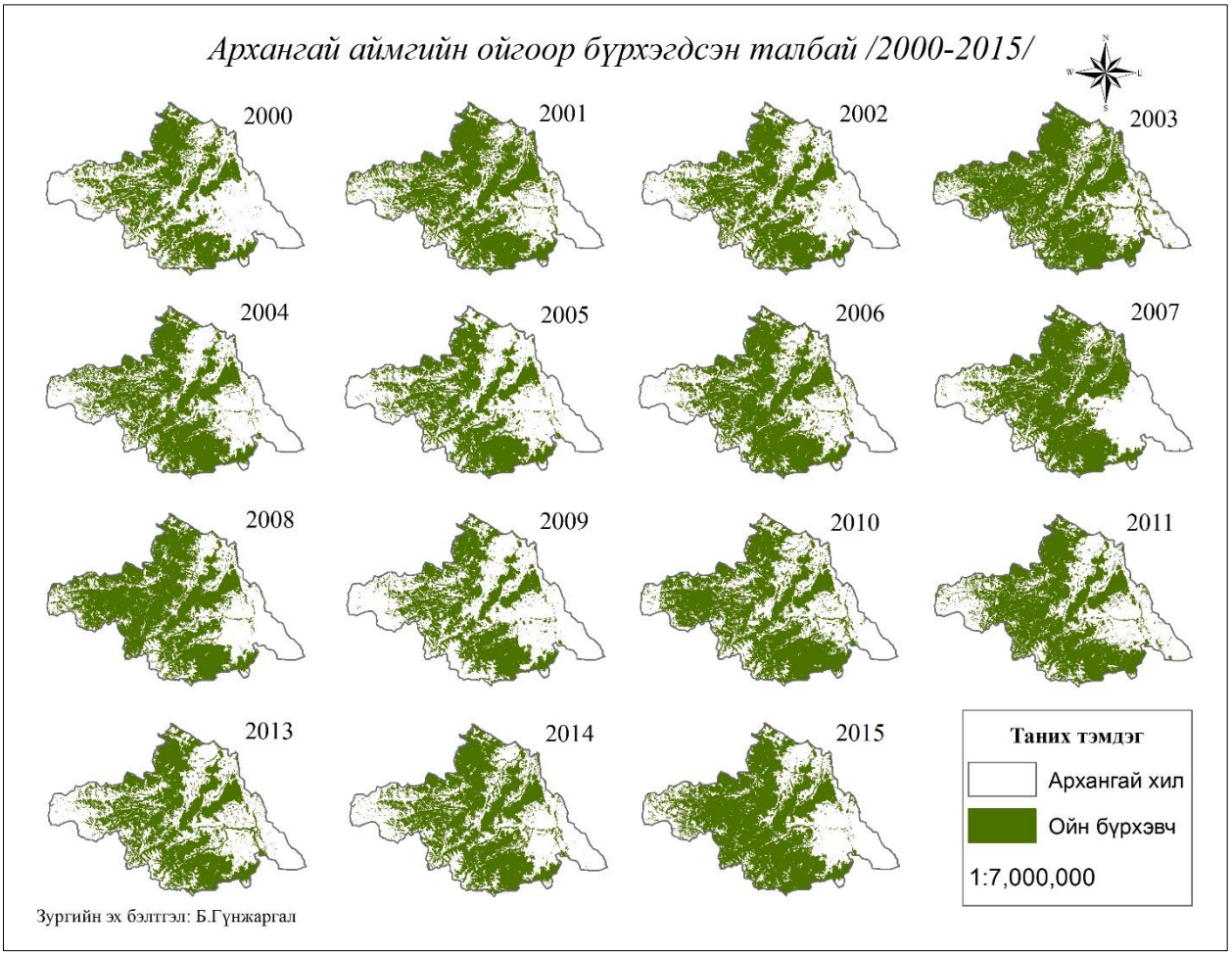


Picture 26. Forest taxation map of Arkhangai province

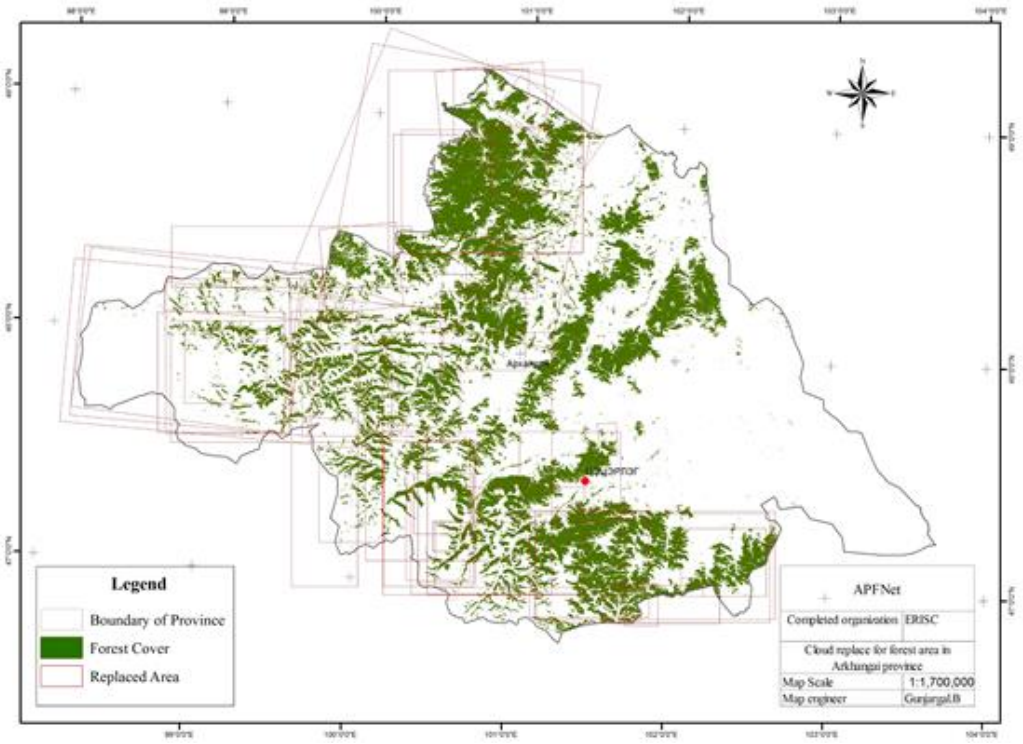
Arkhangai forest covered area is 821.3 thousand hectares and it has trend to increase.

Following distrebution map shows forest cover from the Forest index of Landsat data by 15 years in Arkhangai province.

It shows replacement and repairment of the cloudy data adjacent scene. Cloudy data has probably calculate as forest area then we replaced by nearby scenes on that cloudy area. Where the replacement located area shown in replacement map.



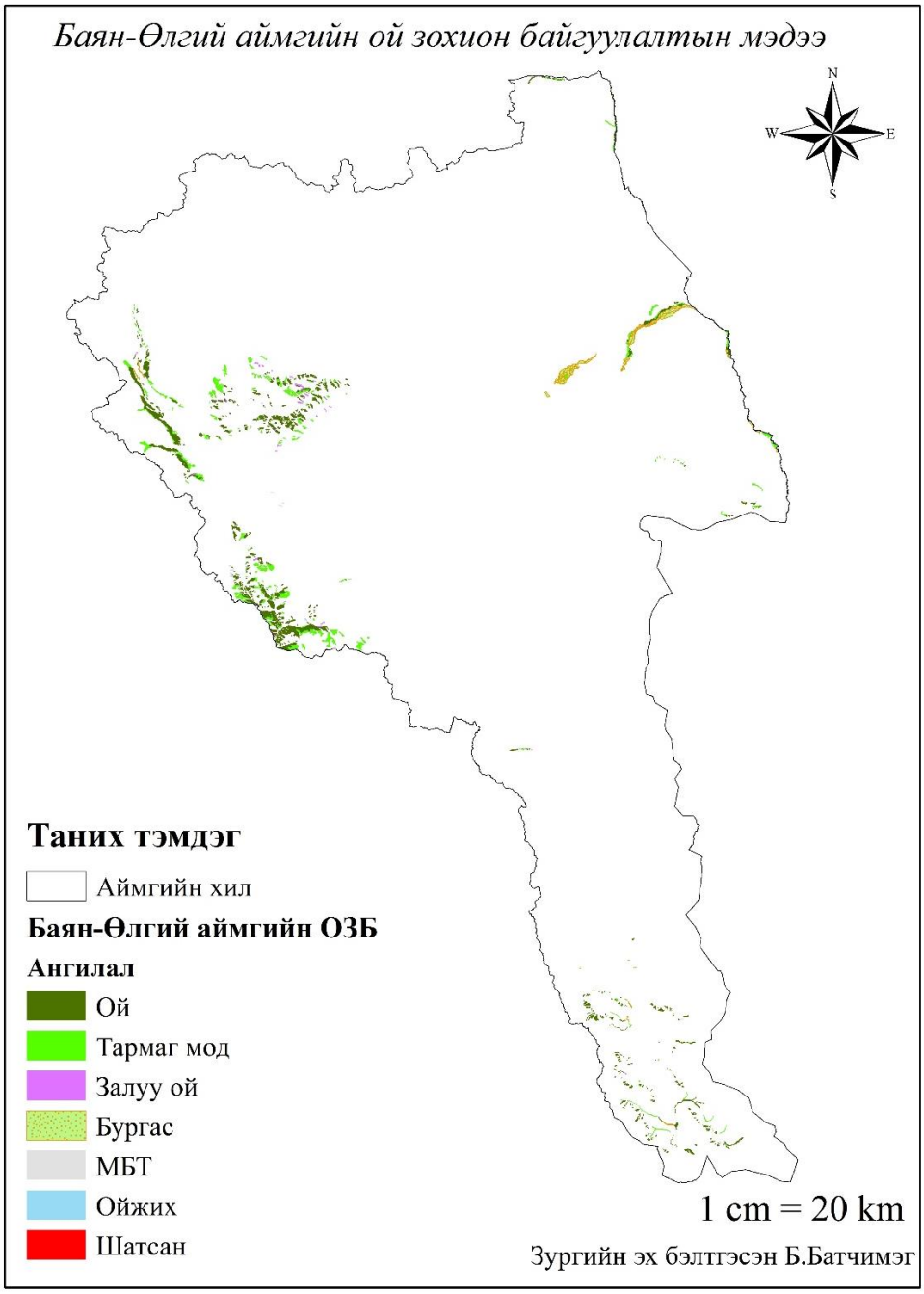
Picture 27. Forest dispersion map by 15 years in Arkhangai province.



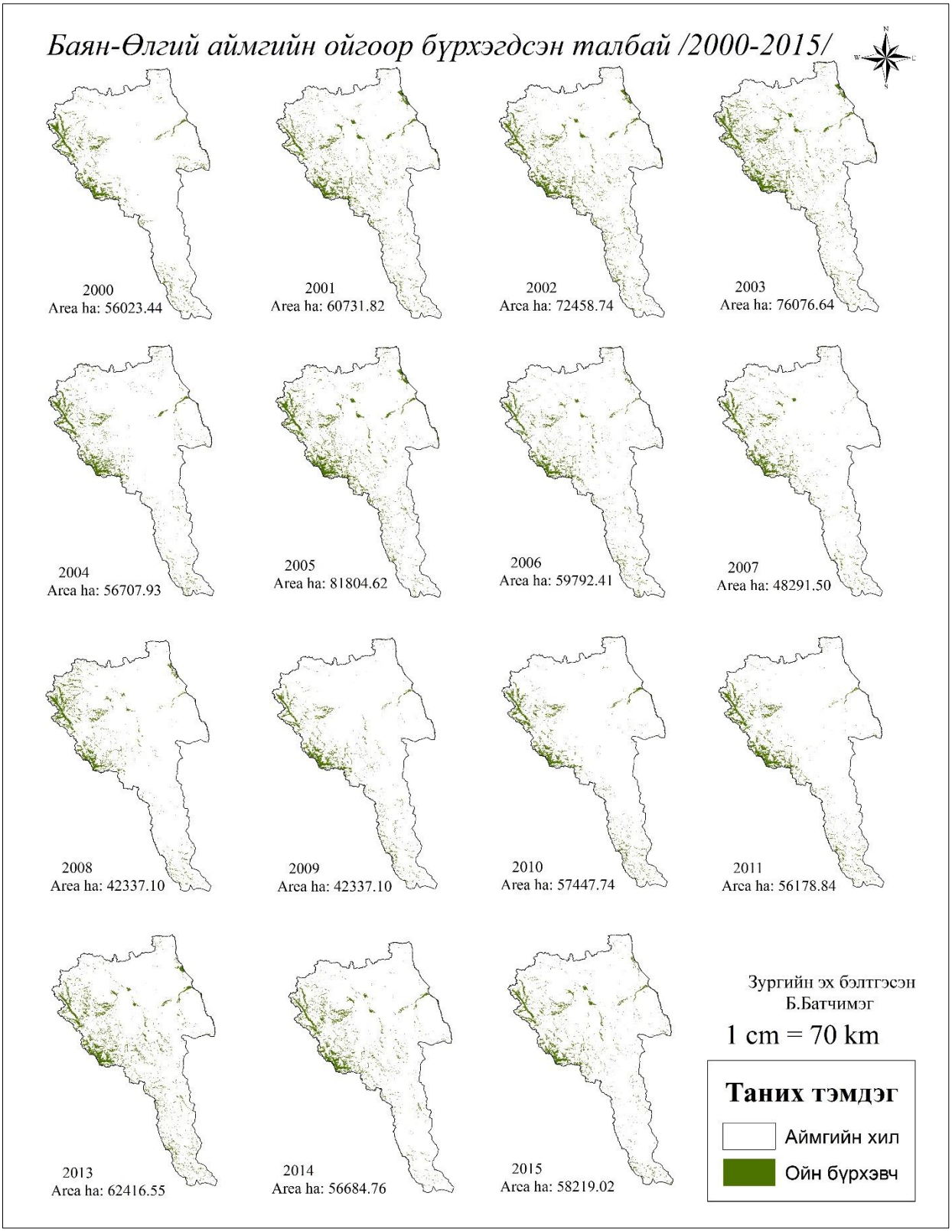
Picture 28. forest dispersion map which shows cloud replacement

2.6.3. Forest dispersion map of Bayanolgii province

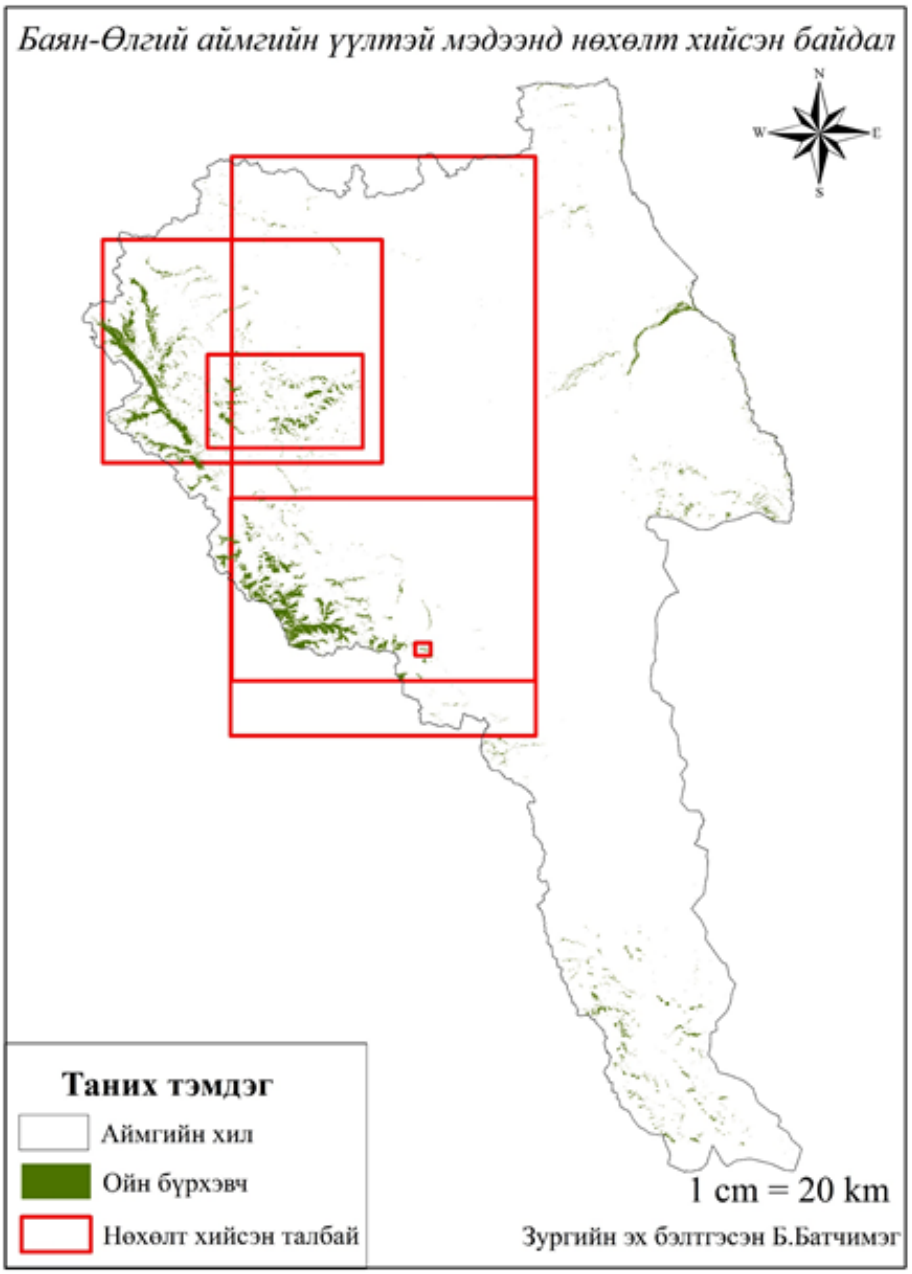
Forest fund of Bayanolgii aimag made a Forest taxation in 1995. The forest fund performance developed from next forest taxation in 2008. Total forest fund area of the Bayanolgii province is 68.1 thousand hectares and from that forest, covered area is 52.1 thousand hectares as 76.5%. 42.3 thousand hectares as 81.2% of forest-covered area is natural forest and left 9.8 thousand hectares as 1.2 percentage is shrub. Total reserve of forest fund is 4, 1 million m3. The dominant tree species are larch 35.6 thousand hectares, Poplar 2.7 thousand hectares, Shrub 3.5 thousand hectares.



Picture 29. Forest taxation map of Bayanolgii province



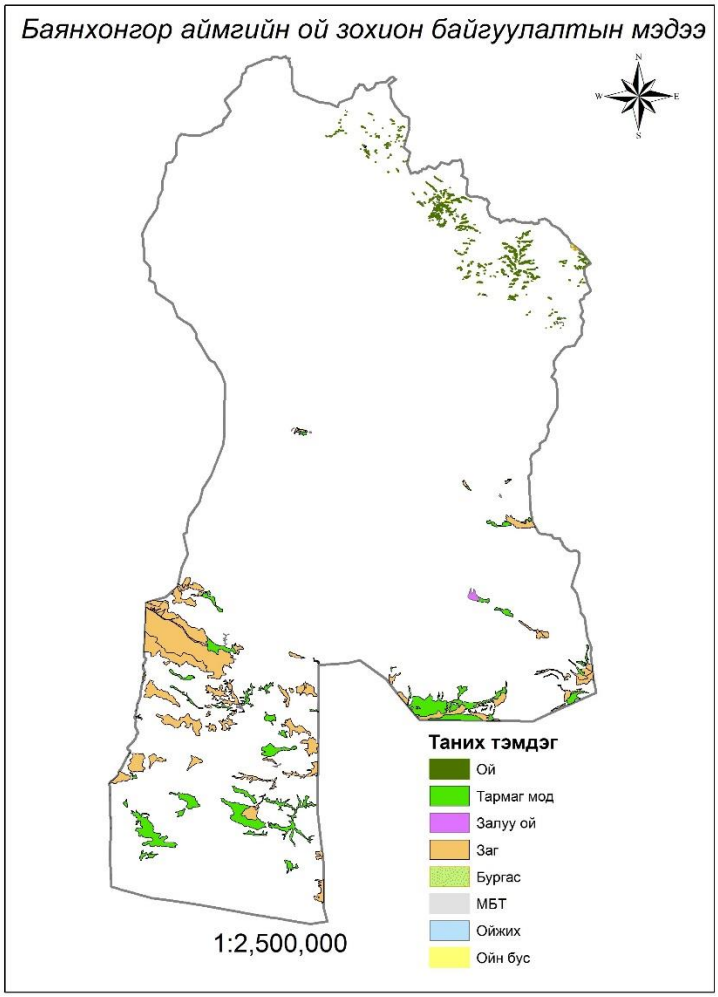
Picture 30. Forest dispersion map by 15 years in Bayanolgii province.



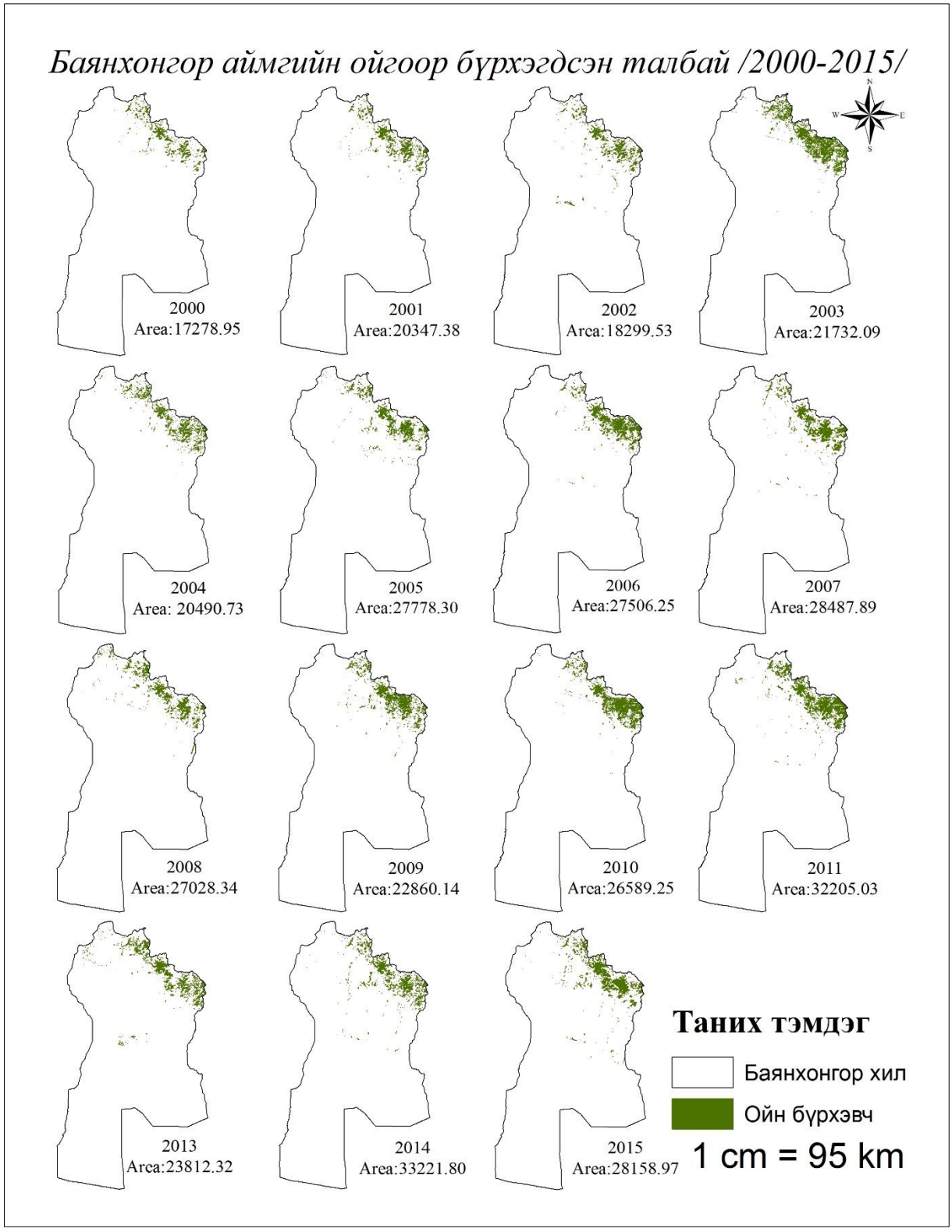
Picture 31. forest dispersion map which shows cloud replacement

2.6.4. Forest dispersion map of Bayankhongor province

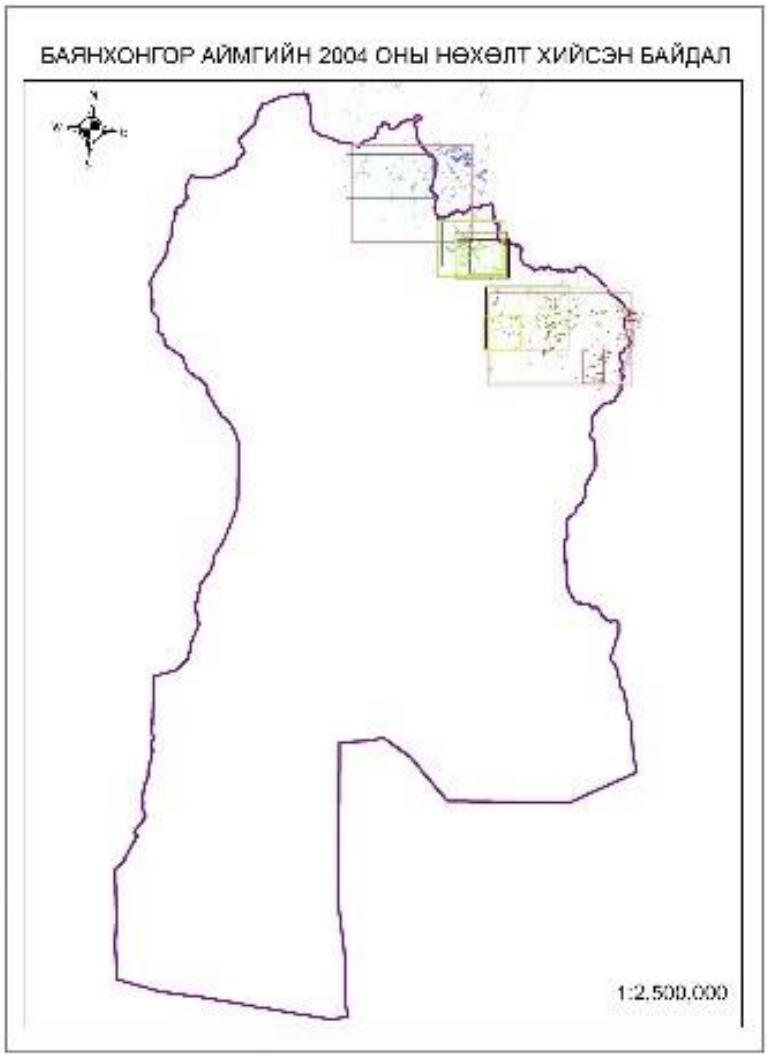
Forest fund of Bayankhongor aimag made a Forest taxation in 1991. The forest fund performance developed from next forest taxation in 2006, 2015. Total forest fund area of the Bayankhongor province is 33.5 thousand hectares and from that forest, covered area is 29.8 thousand hectares as 88.9%. 29.7 thousand hectare as 99.6% of forest-covered area is natural forest and left 0.1 thousand hectare is shrub. Total reserve of forest fund is 2.5 million cubic meter. The dominant tree species are larch 29.5 thousand hectares.



Picture 32. Forest taxation map of Bayankhongor province



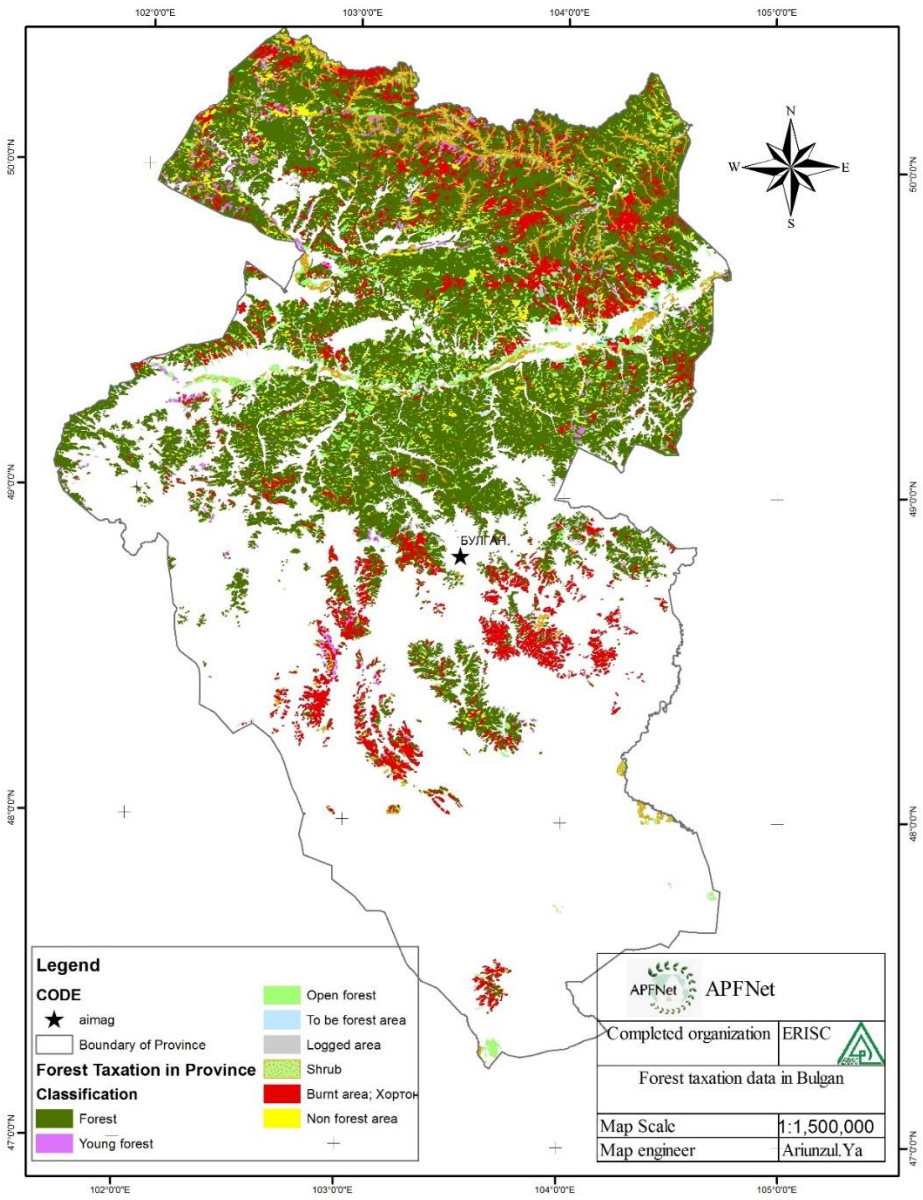
Picture 33. Forest dispersion map by 15 years in Bayankhongor province.



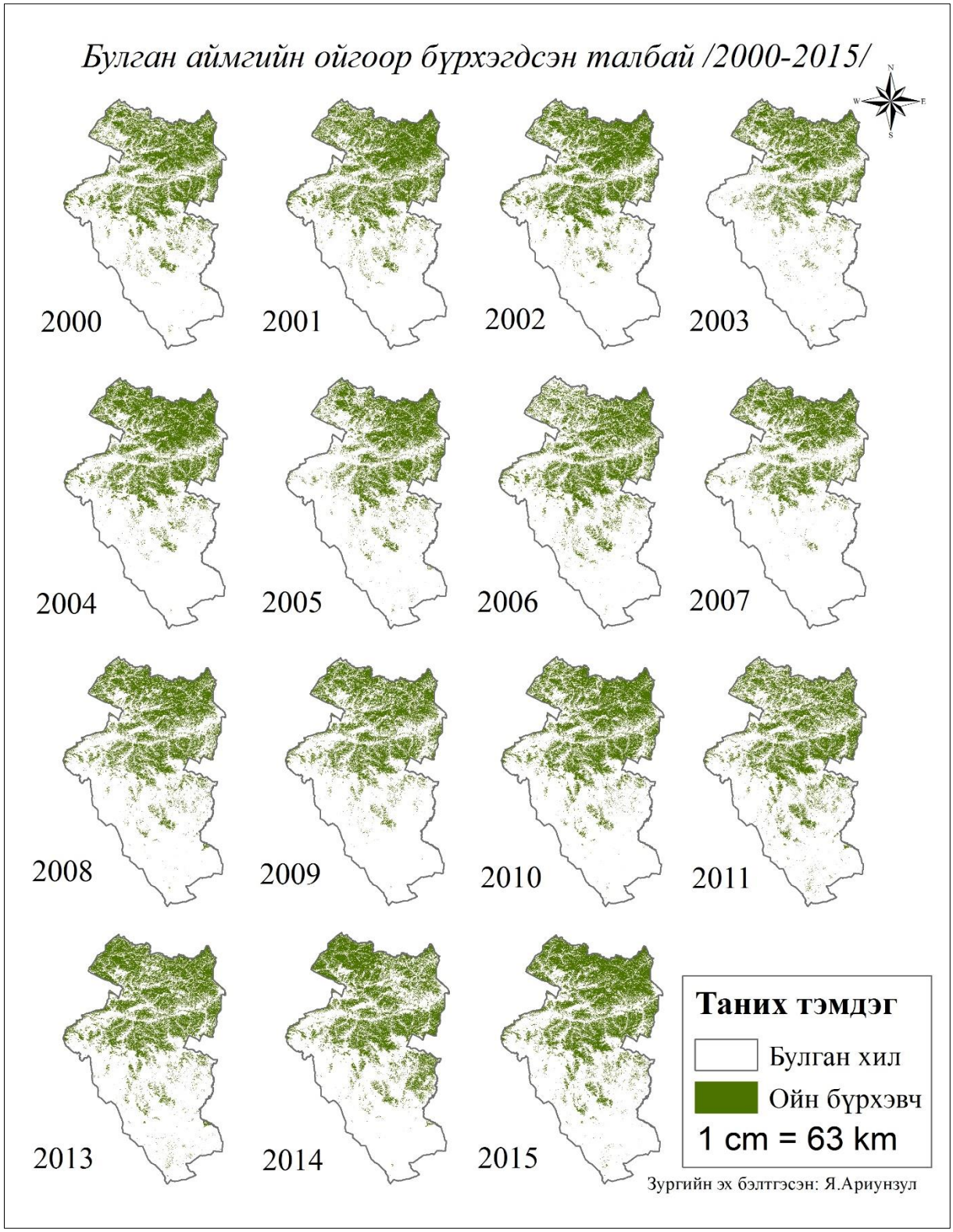
Picture 34. forest dispersion map which shows cloud replacement

2.6.5. Forest dispersion map of Bulgan province

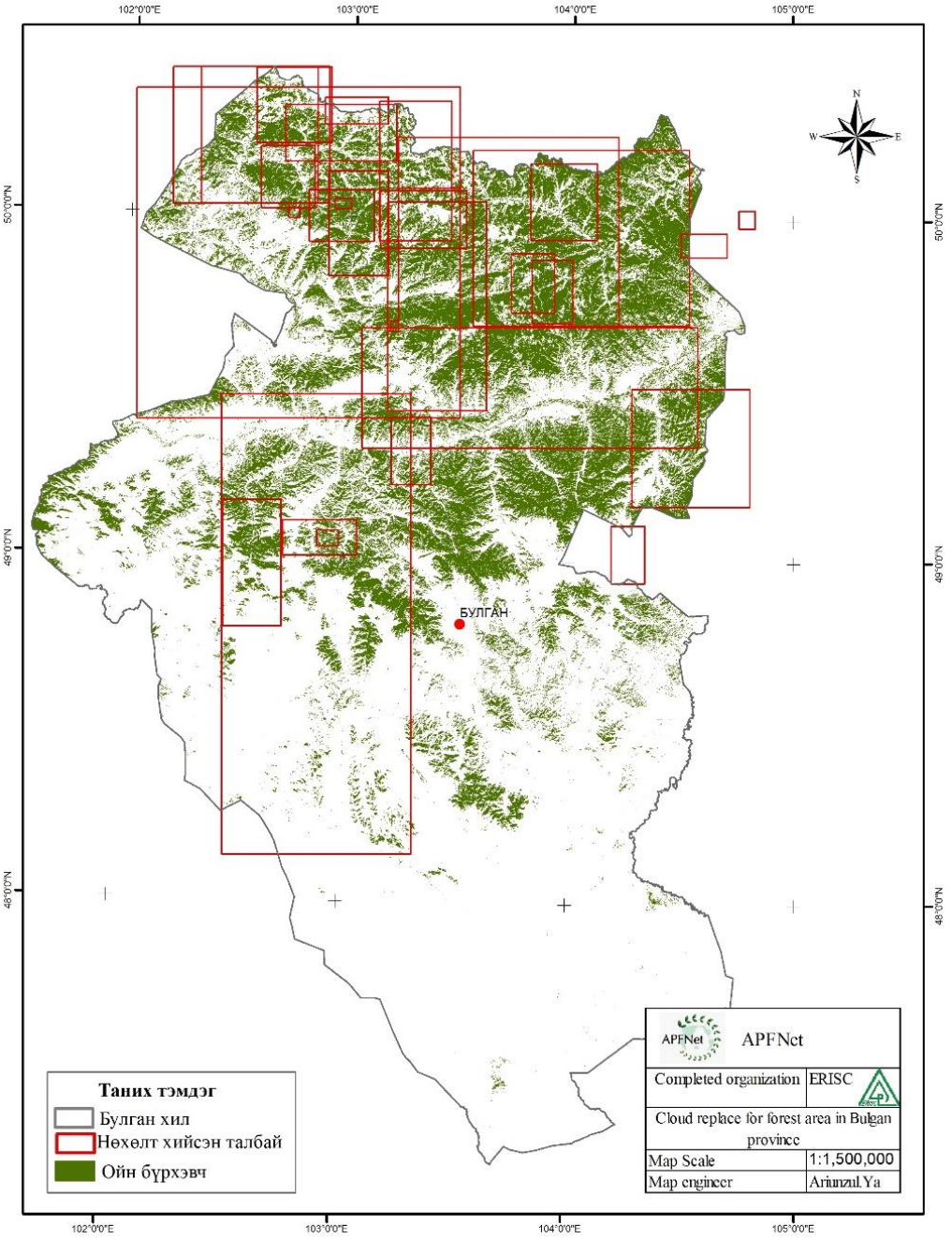
Forest fund of Bulgan aimag made a Forest taxation in 1997-1999. The forest fund performance developed from next forest taxation in 2010. Total forest fund area of the Bulgan province is 1917.7 thousand hectares and from that forest, covered area is 1382.1 thousand hectares as 72%. 1315thousand hectare as 95.1% of forest-covered area is natural forest and left 67.1 thousand hectare is shrub and 0,04 thousand hectares is Nurse forest. Total reserve of forest fund is 152.9 million m3. The dominant tree species are larch 29.5 thousand hectares.



Picture 35. Forest taxation map of Bulgan province



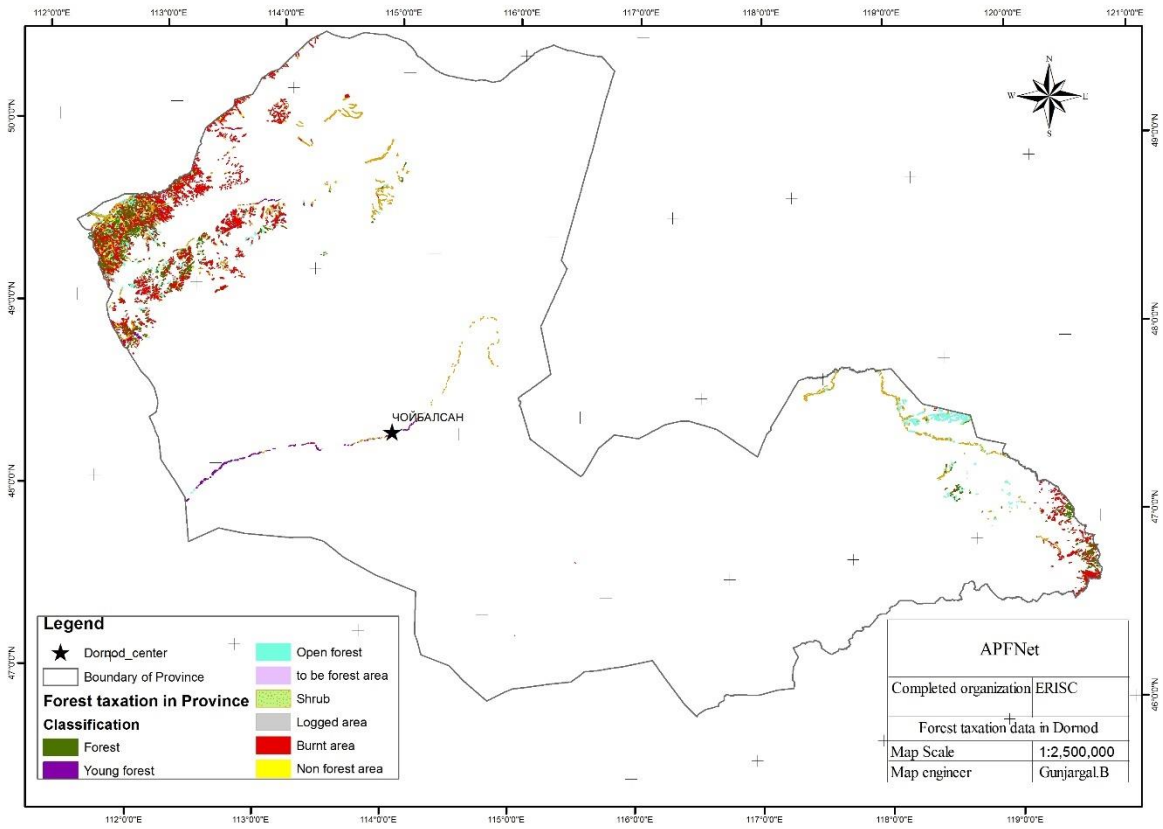
Picture 36. Forest dispersion map by 15 years in Bulgan province.



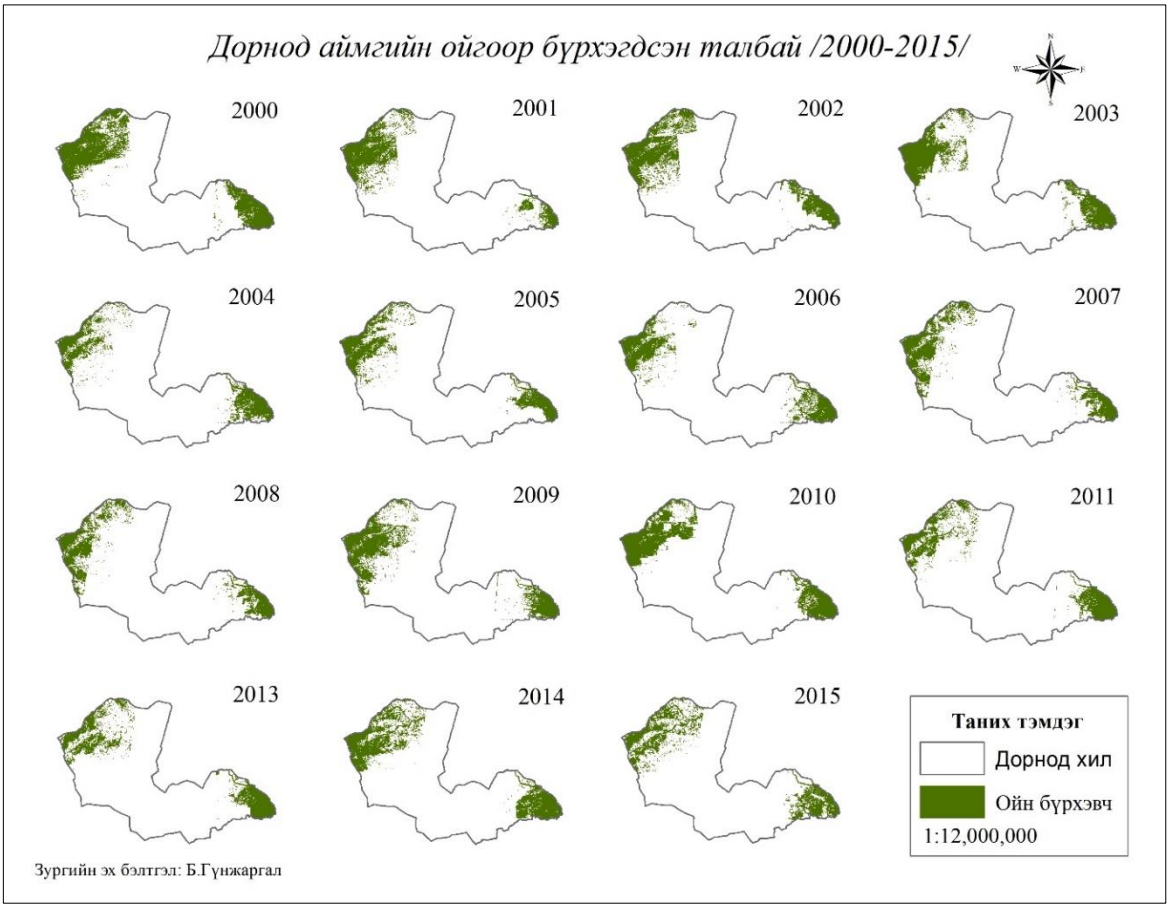
Picture 37. forest dispersion map which shows cloud replacement

2.6.6. Forest dispersion map of Dornod province

Forest fund of Dornod aimag made a Forest taxation in 2003. The forest fund performance developed from next forest taxation in 2012. Total forest fund area of the Dornod province is 243.9 thousand hectares and from that forest, covered area is 91 thousand hectares as 37.3%. 1315thousand hectare as 82.8% of forest-covered area is natural forest and left 15,5 thousand hectare as 0,06 percentage is shrub. Total reserve of forest fund is 4.5 million cubic meter. The dominant tree species are Pinus 21.9 thousand hectares, and betula 25.8 thousand hectares, Shrub 20 thousand hectares.

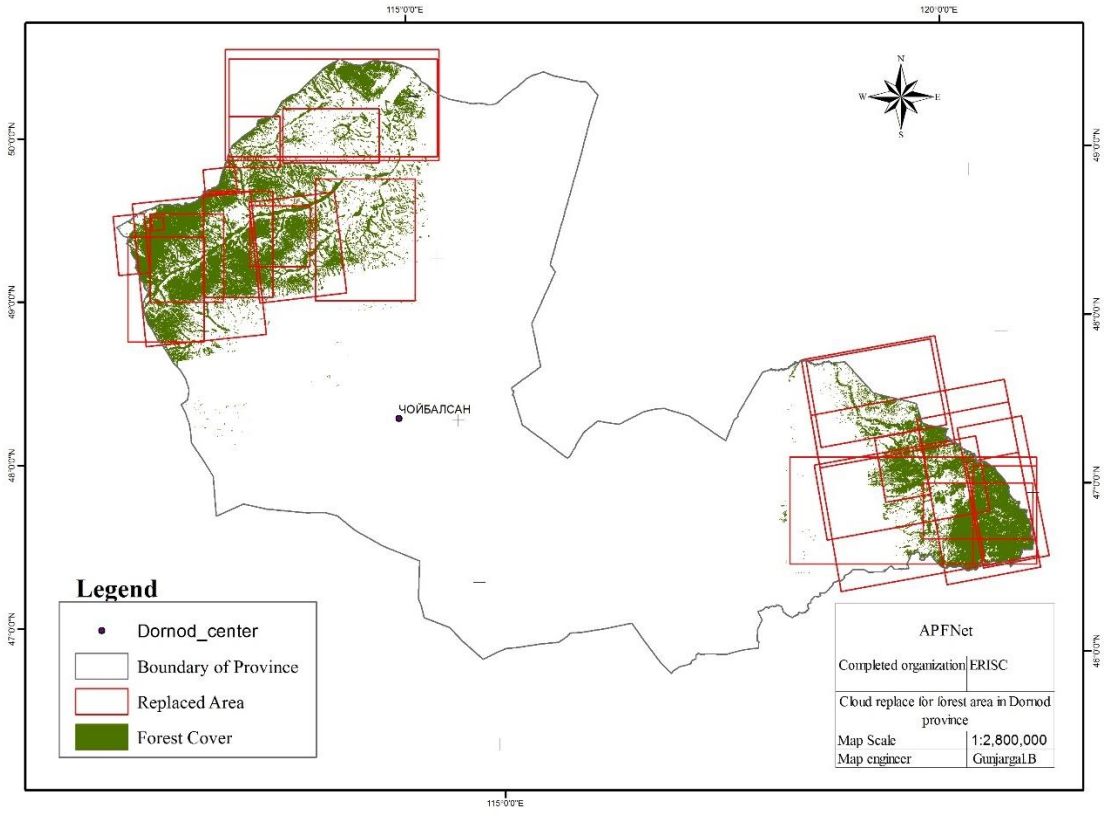


Picture 38. Forest taxation map of Dornod province



z

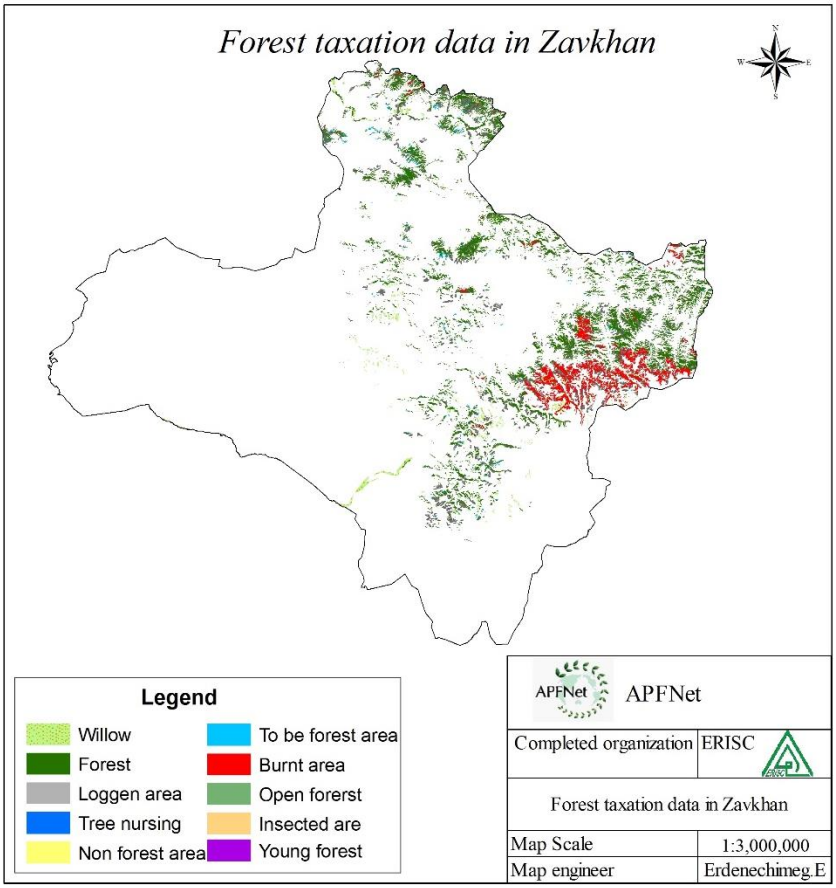
Picture 39. Forest dispersion map by 15 years in Dornod province.



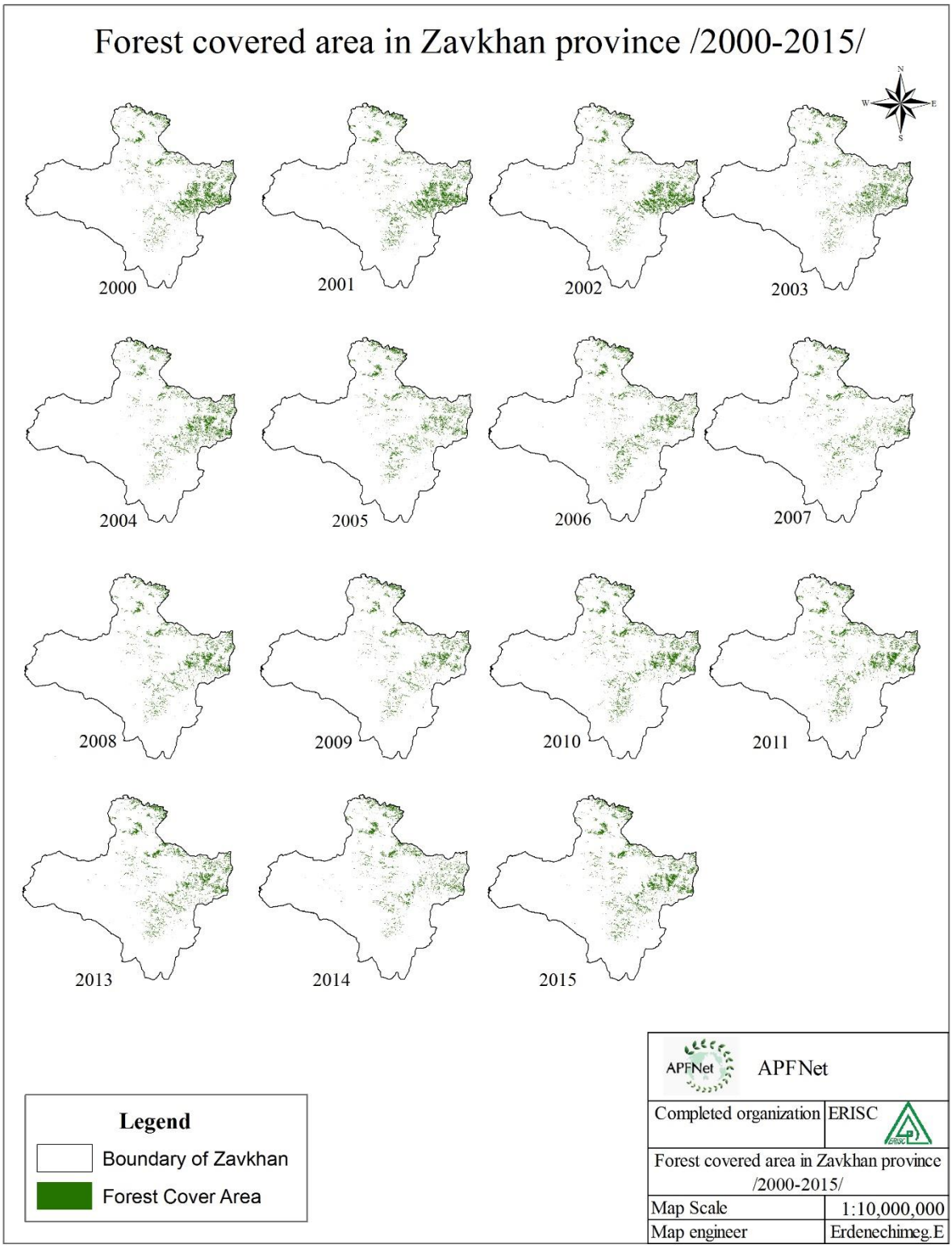
Picture 40. forest dispersion map which shows cloud replacement

2.6.7. Forest dispersion map of Zavkhan province

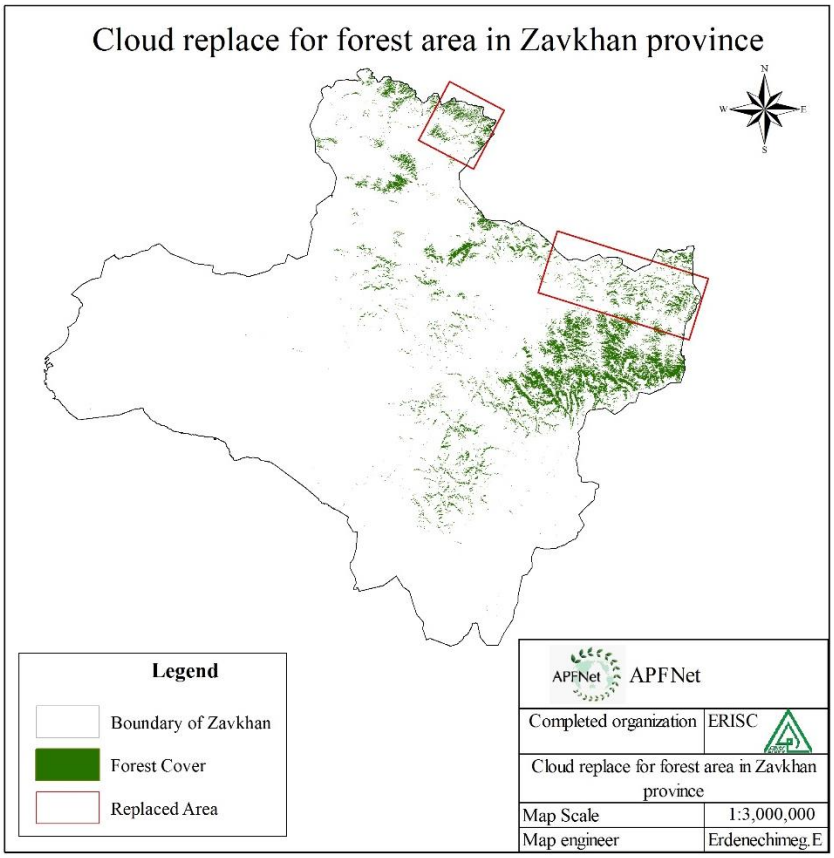
Forest fund of Zavkhan aimag made a Forest taxation in 2006. The forest fund performance developed from next forest taxation in 2013. Total forest fund area of the Zavkhan province is 732 thousand hectares and from that forest, covered area is 500.2 thousand hectares as 68.3%. 456.8 thousand hectare as 91.3% of forest-covered area is natural forest and left 43.5 thousand hectare as 0.06 percentage is shrub. Total reserve of forest fund is 4.5 million m3. The dominant tree species are larix 439.8 thousand hectares, Cedar 2 thousand hectares, spruce 4.8 thousand hectares and betula 9.6 thousand hectares, Shrub 96 thousand hectares.



Picture 41. Forest taxation map of Zavkhan province



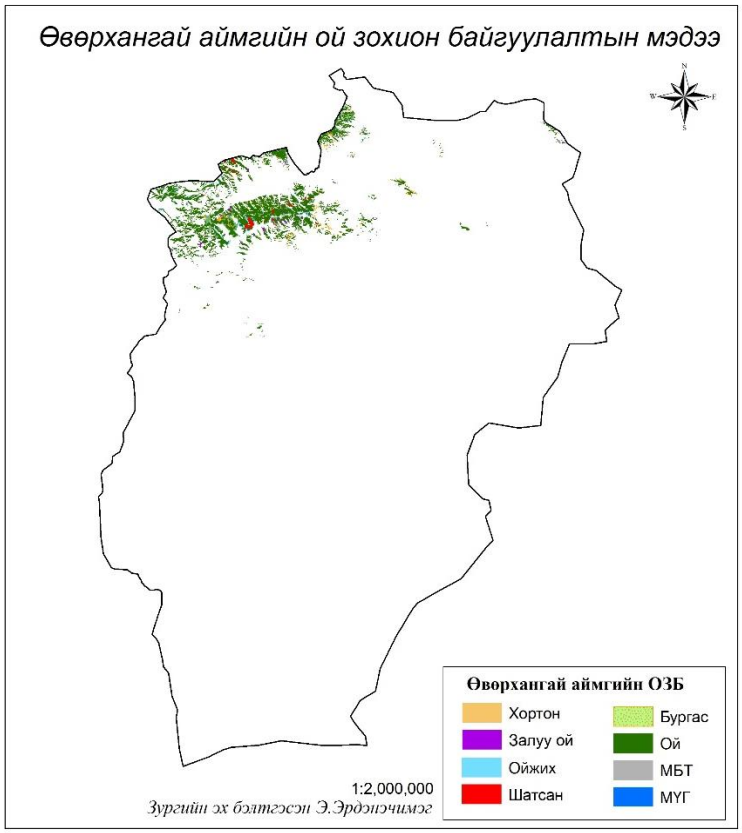
Picture 42. Forest dispersion map by 15 years in Zavkhan province.



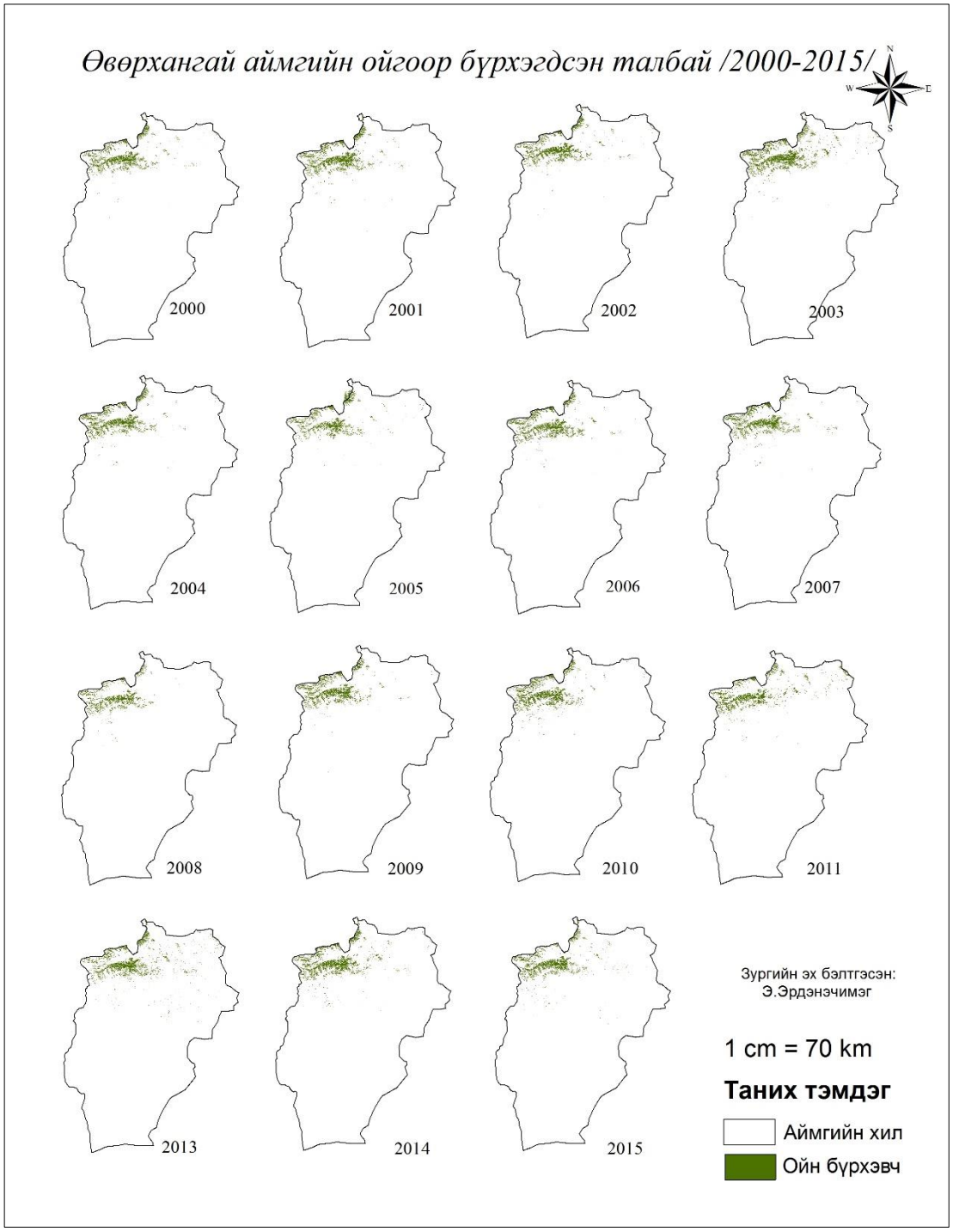
Picture 43. forest dispersion map which shows cloud replacement

2.6.8. Forest dispersion map of Ovorkhangai province

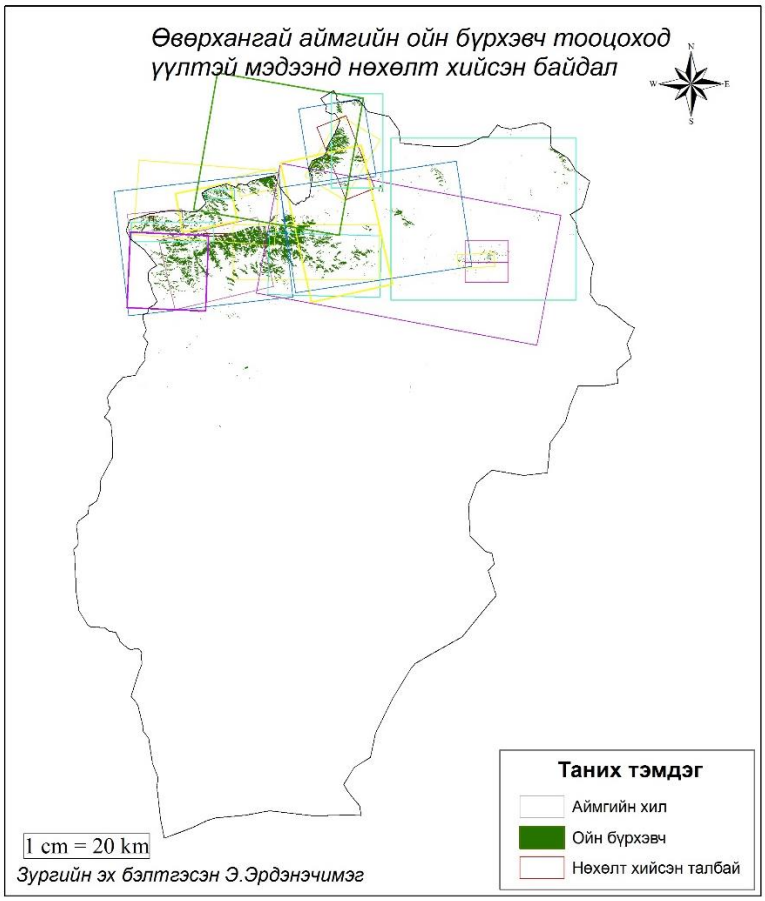
Forest fund of Ovorkhangai aimag made a Forest taxation in 1997. The forest fund performance developed from next forest taxation in 2008. Total forest fund area of the Ovorkhangai province is 171.7 thousand hectares and from that forest, covered area is 135 thousand hectares as 78.4%. 134.6 thousand hectare as 99.7% of forest-covered area is natural forest and left 0.4 thousand hectare is shrub. Total reserve of forest fund is 17.6 million m3. The dominant tree species are larix 114.4 thousand hectares, Cedar 17.9 thousand hectares, and betula 1.7 thousand hectares, Shrub 19.6 thousand hectares**.**



Picture 44. Forest taxation map of Ovorkhangai province



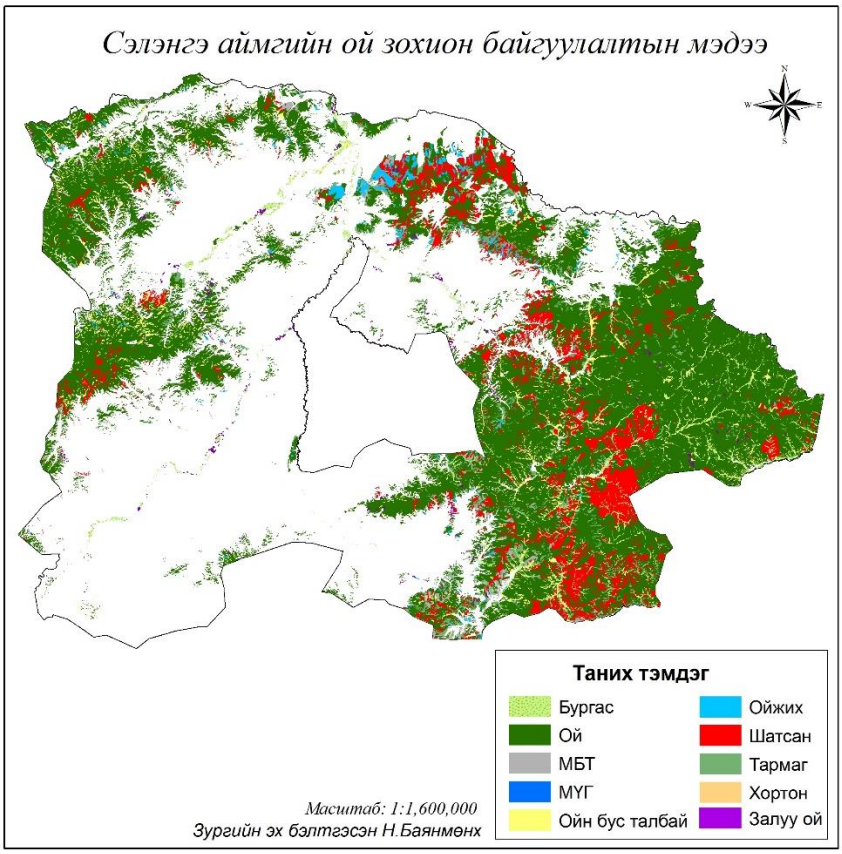
Picture 45. Forest dispersion map by 15 years in Ovorkhangai province.



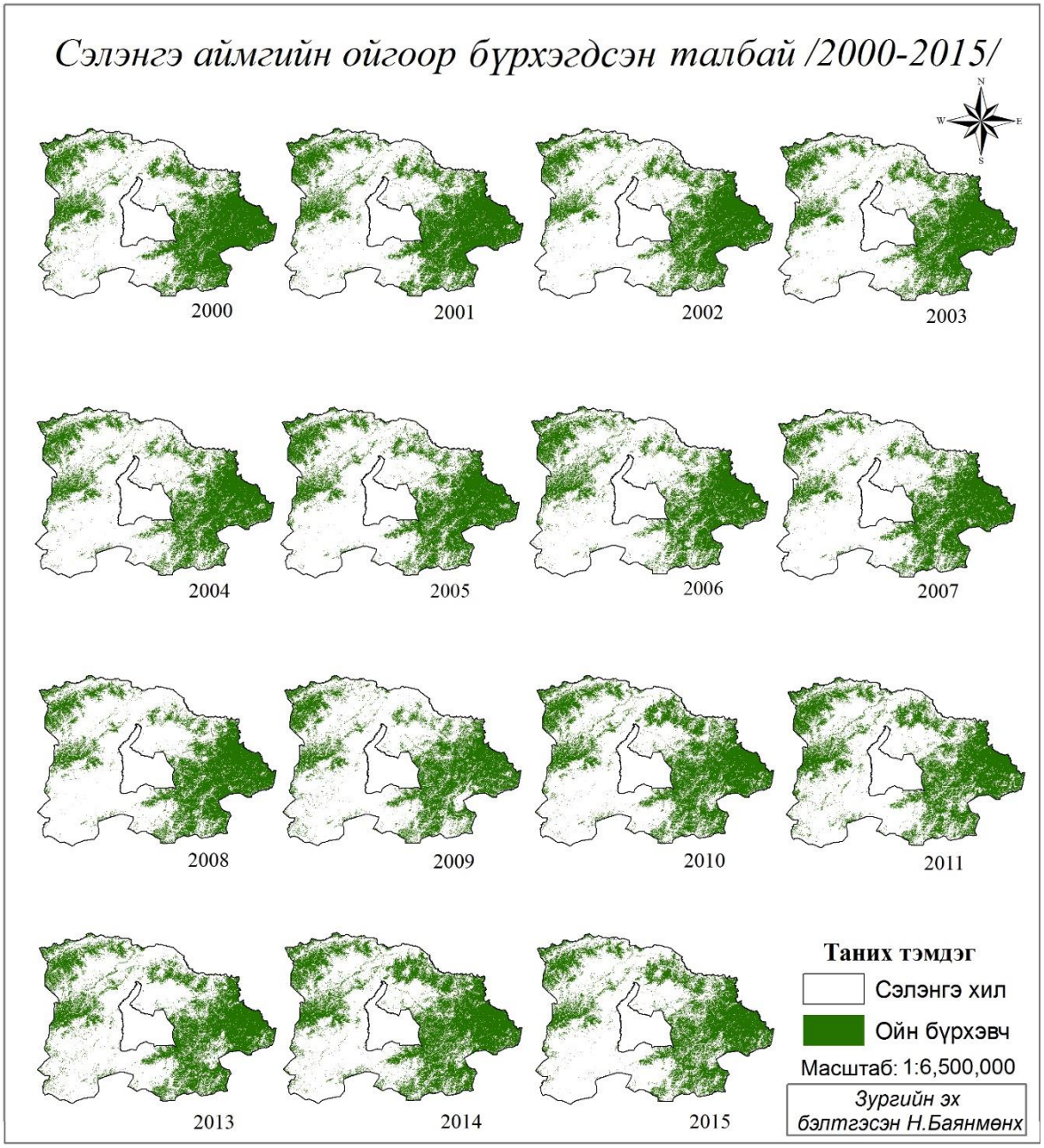
Picture 46. forest dispersion map which shows cloud replacement

2.6.9. Forest dispersion map of Selenge province

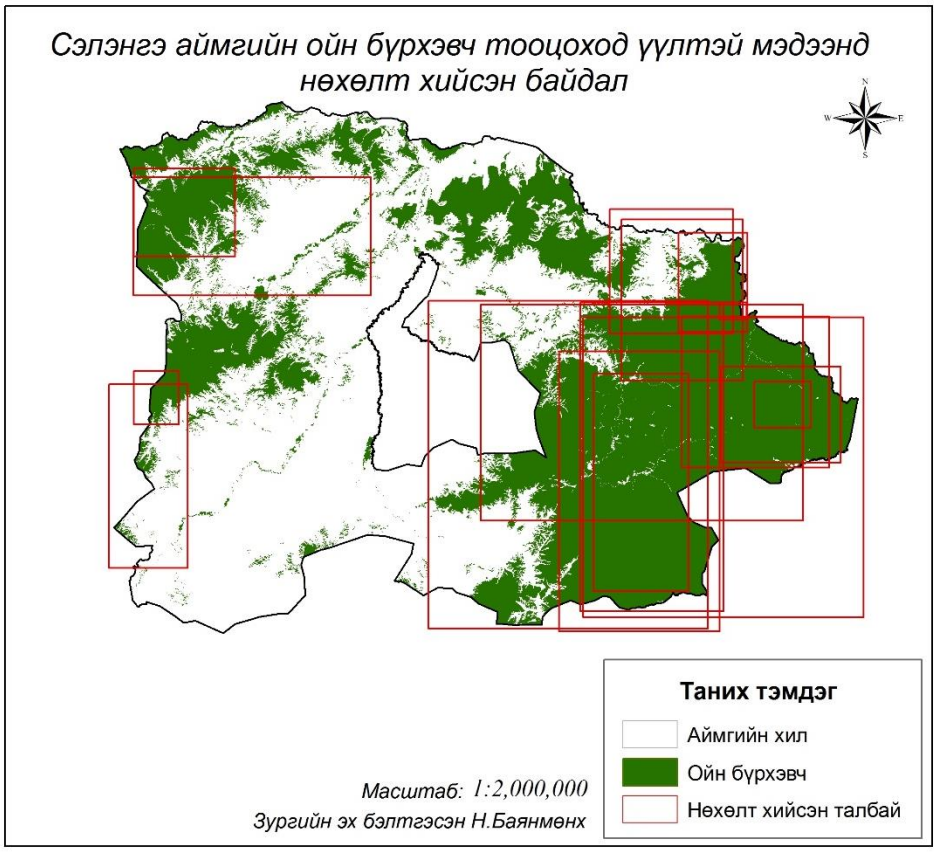
Forest fund of Selenge aimag made a Forest taxation in 1992-1994. The forest fund performance developed from next forest taxation in 2008-2009. Total forest fund area of the Selenge province is 1931.2 thousand hectares and from that forest, covered area is 1441 thousand hectares as 74.6%. 1397.4 thousand hectare as 96.9% of forest-covered area is natural forest and left 42.1 thousand hectare is shrub and 1.53 thousand hectare Nurse forest. Total reserve of forest fund is 168.3 million m3. The dominant tree species are larix 404,1 thousand hectares, *Pinus* 276.3 thousand hectares, Cedar 163 million.ha, spruce 6 thousand hectares, Abies sibirica 1.3 thousand hectares and *Betula platyphylla* 520 thousand hectares, *Poplar* 1.7 thousand hectares, *Tremula populus* 5 thousand hectares, *Shrub* 19.6 thousand hectares.



Picture 47. Forest taxation map of Selenge province



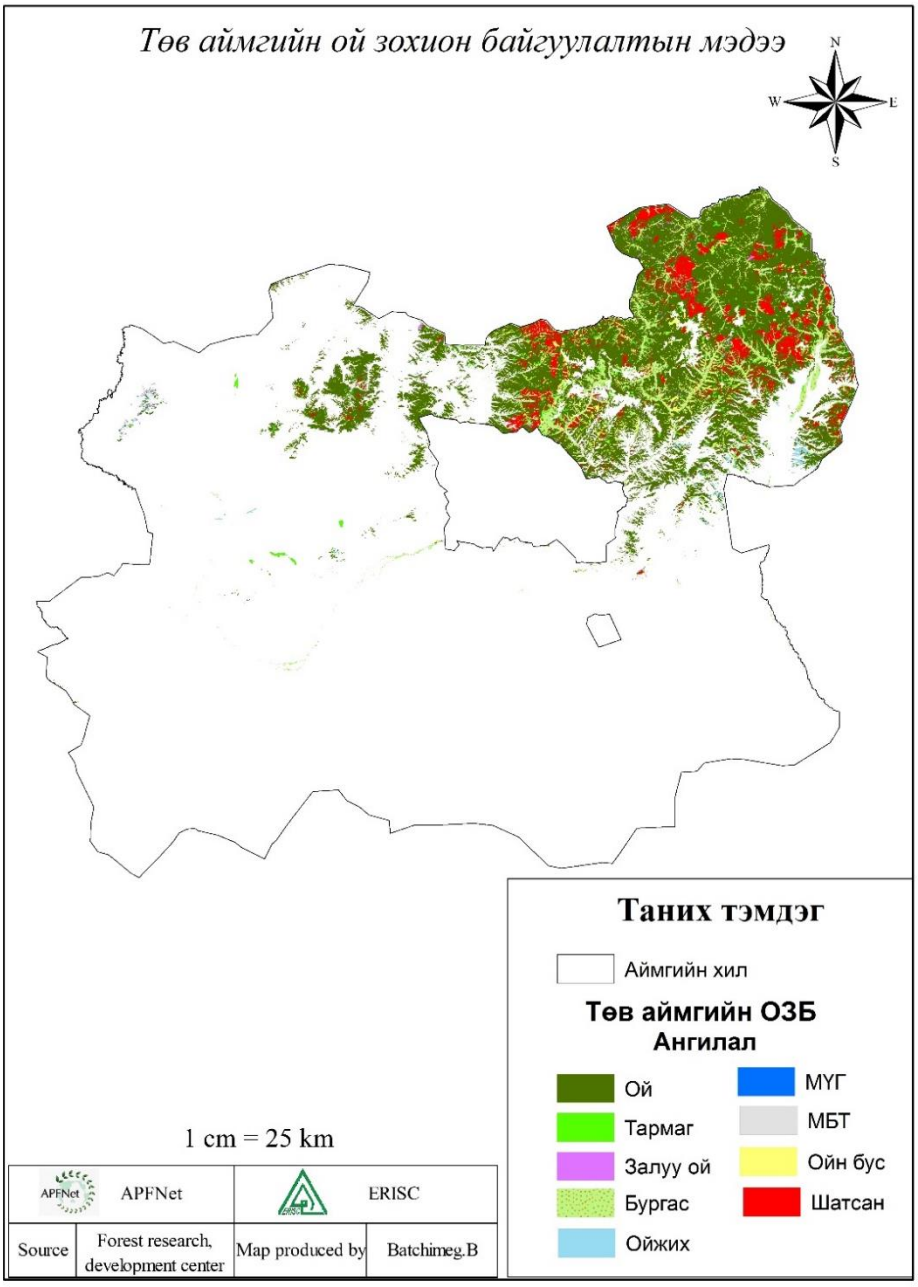
Picture 48. Forest dispersion map by 15 years in Selenge province.



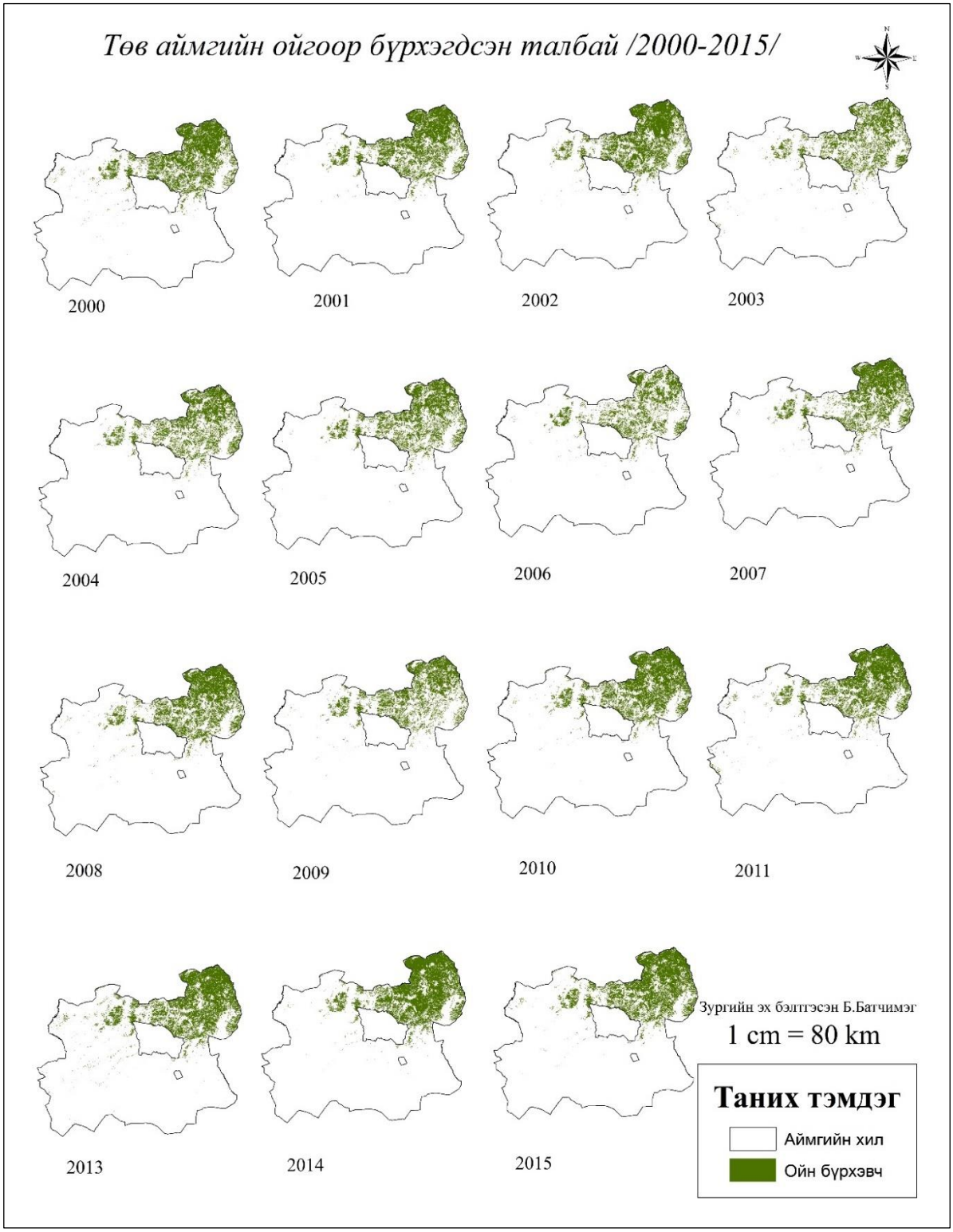
Picture 49. Forest dispersion map which shows cloud replacement

2.6.10. Forest dispersion map of Tuv province

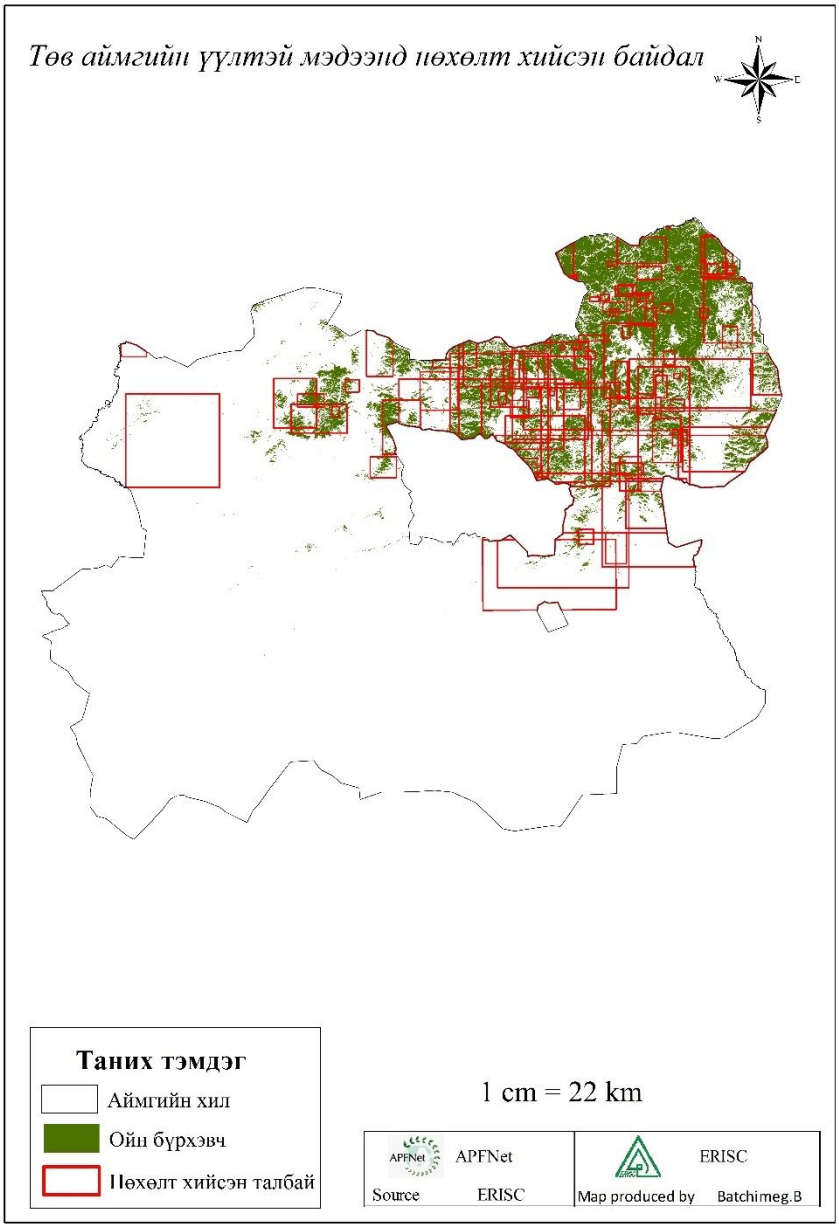
Forest fund of Tuv aimag made a Forest taxation in 2007. The forest fund performance developed from next forest taxation in 2013. Total forest fund area of the Tuv province is 1388,2 thousand hectares and from that forest, covered area is 1095.2 thousand hectares as 78.9%. 957.2 thousand hectares as 87.4% of forest-covered area is natural forest and left 137.9 thousand hectares is shrub and 0,14 thousand hectares is Nurse Forest. Total reserve of forest fund is 146.6 million m3. The dominant tree species are larix 519,9 thousand hectares, Pinus 88.5 thousand hectares, Cedar 242.2 million hectares, spruce 2.9 thousand hectares, *Betula platyphylla* 94.2 thousand hectares, *Poplar* 1,9 million hectares, *Tremula populus* 2 thousand hectares, *Shrub* 5.3 thousand hectares.



Picture 50. Forest taxation map of Tov province



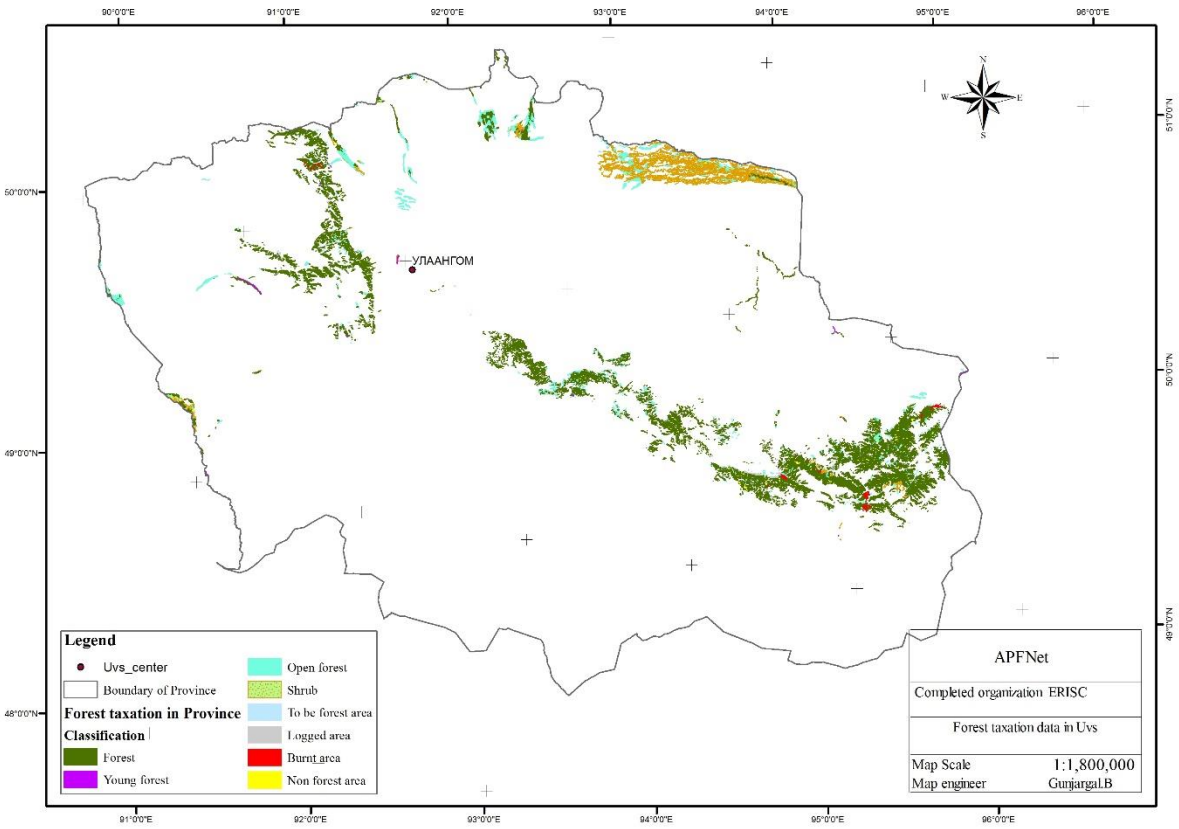
Picture 51. Forest dispersion map by 15 years in Tov province.



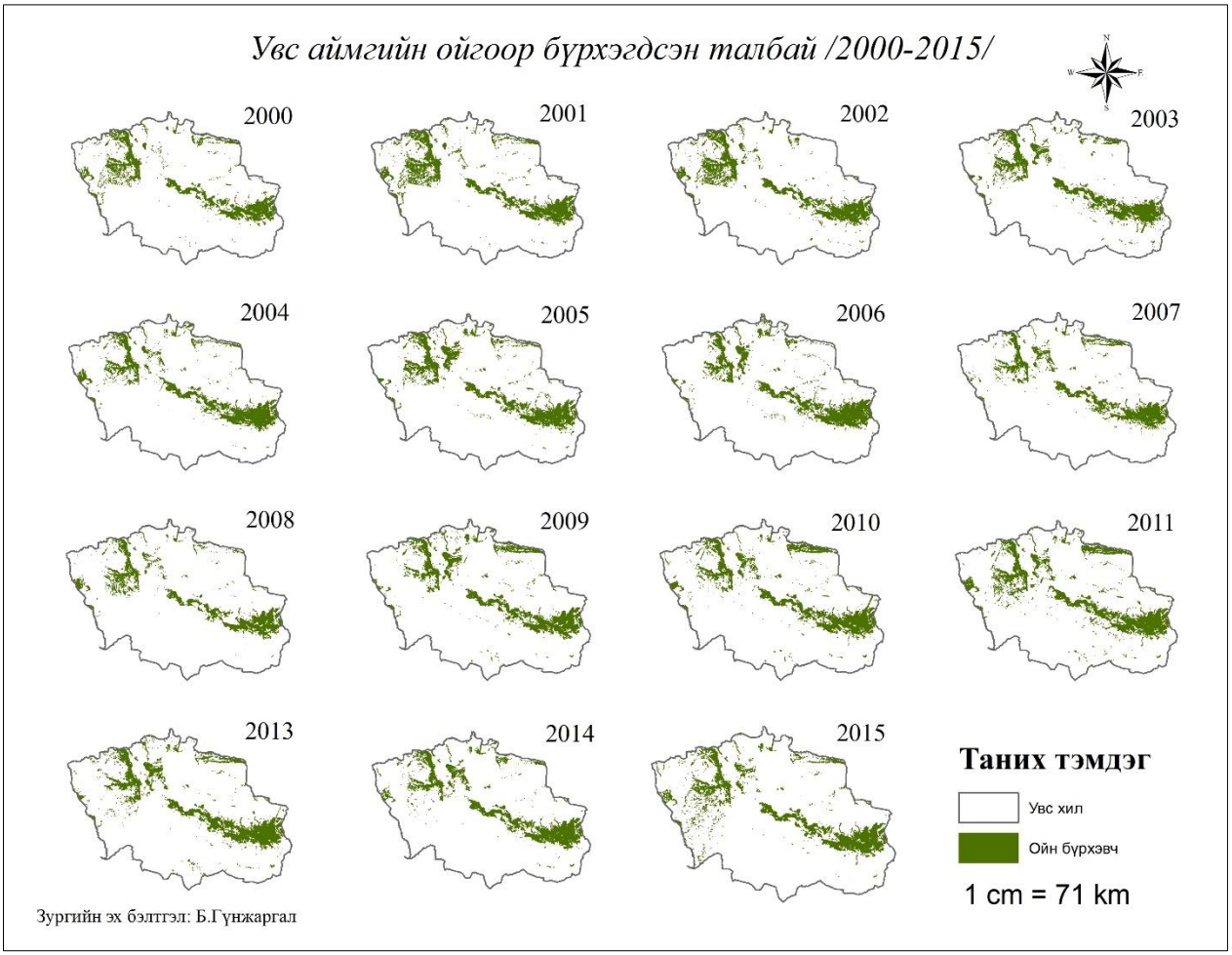
Picture 52. Forest dispersion map which shows cloud replacement

2.6.11. Forest dispersion map of Uvs province

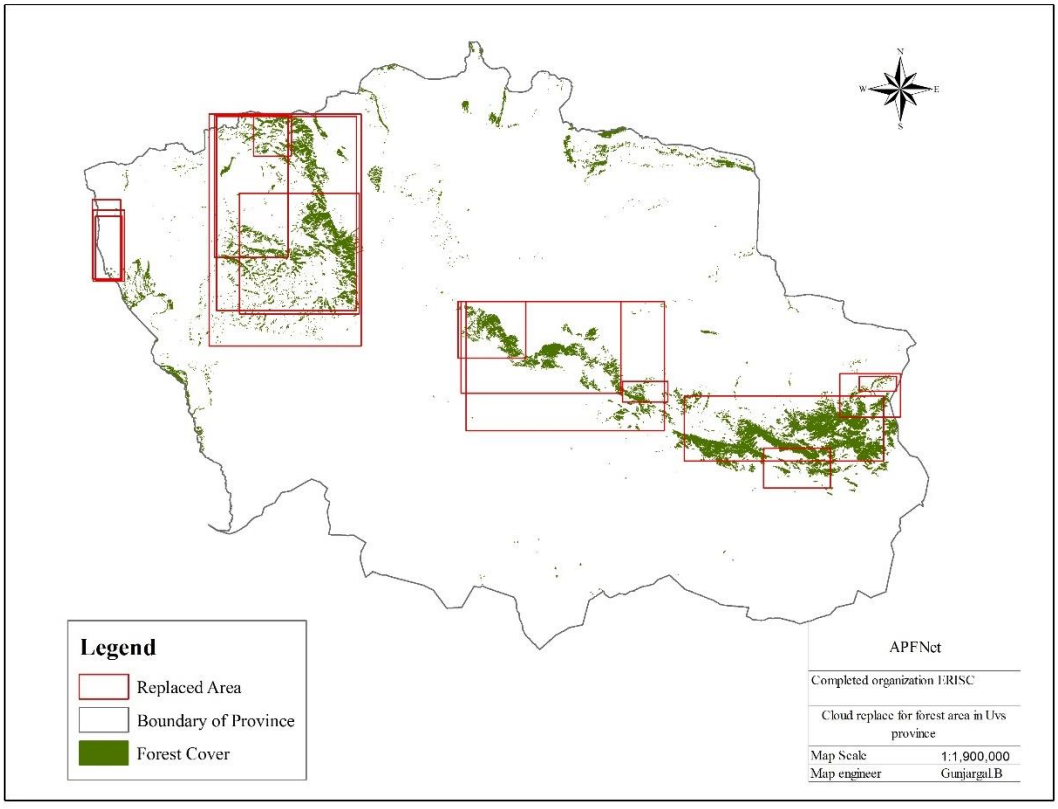
Forest fund of Uvs aimag made a Forest taxation in 1990. The forest fund performance developed from next forest taxation in 2011. Total forest fund area of the Uvs province is 236.6 thousand hectares and from that forest, covered area is 200.9 thousand hectares as 84.9%. 197.3 thousand hectare as 98.2% of forest-covered area is natural forest and left 3.6 thousand hectare is shrub and 0.03 thousand hectare Nurse forest. Total reserve of forest fund is 20.9 million cubic meter. The dominant tree species are larix 141.3 thousand hectares, Pinus 1.5 thousand hectares, Betula 1.3 thousand hectares, *Poplar* 11.1 thousand hectares, Shrub 41.7 thousand hectares.



Picture 53. Forest taxation map of Uvs province



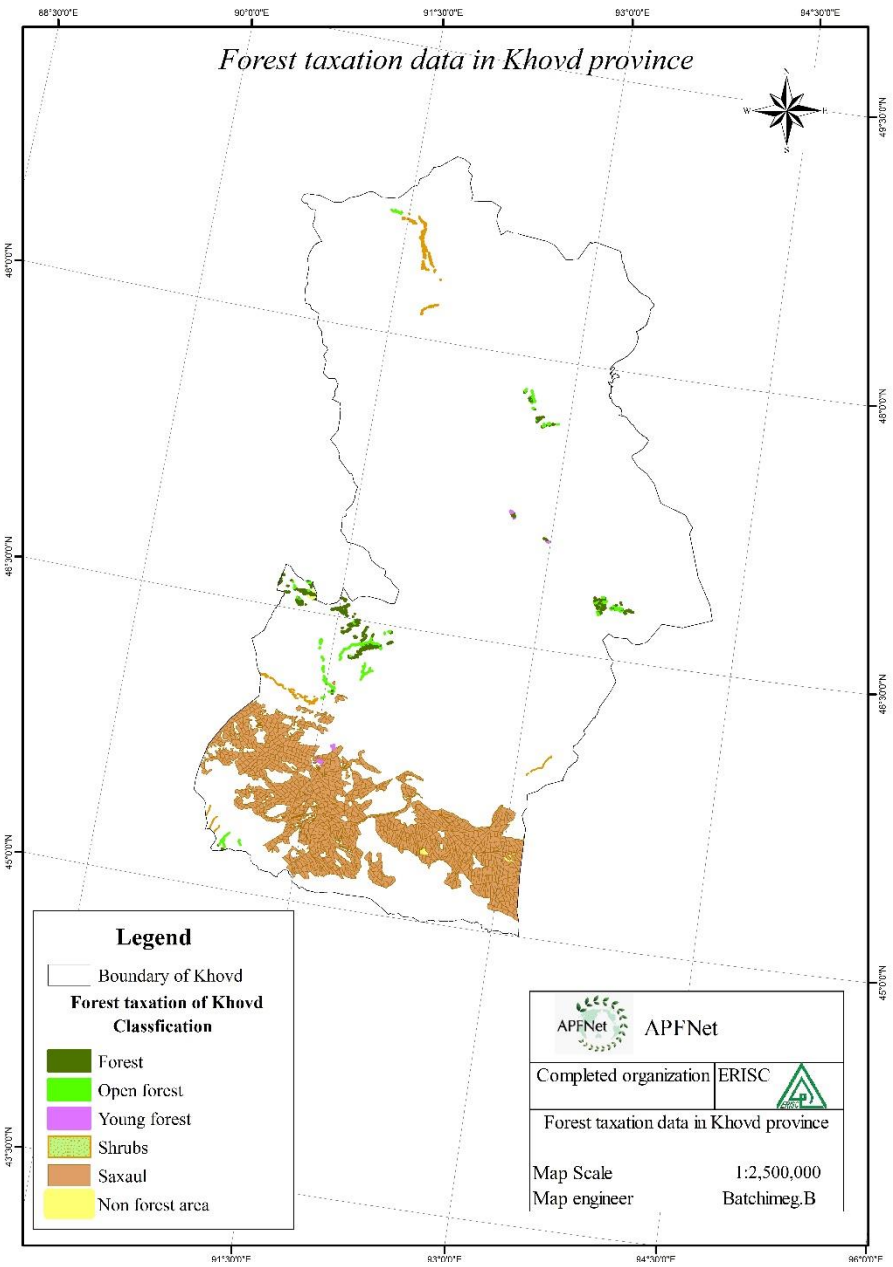
Picture 54. Forest dispersion map by 15 years in Uvs province.



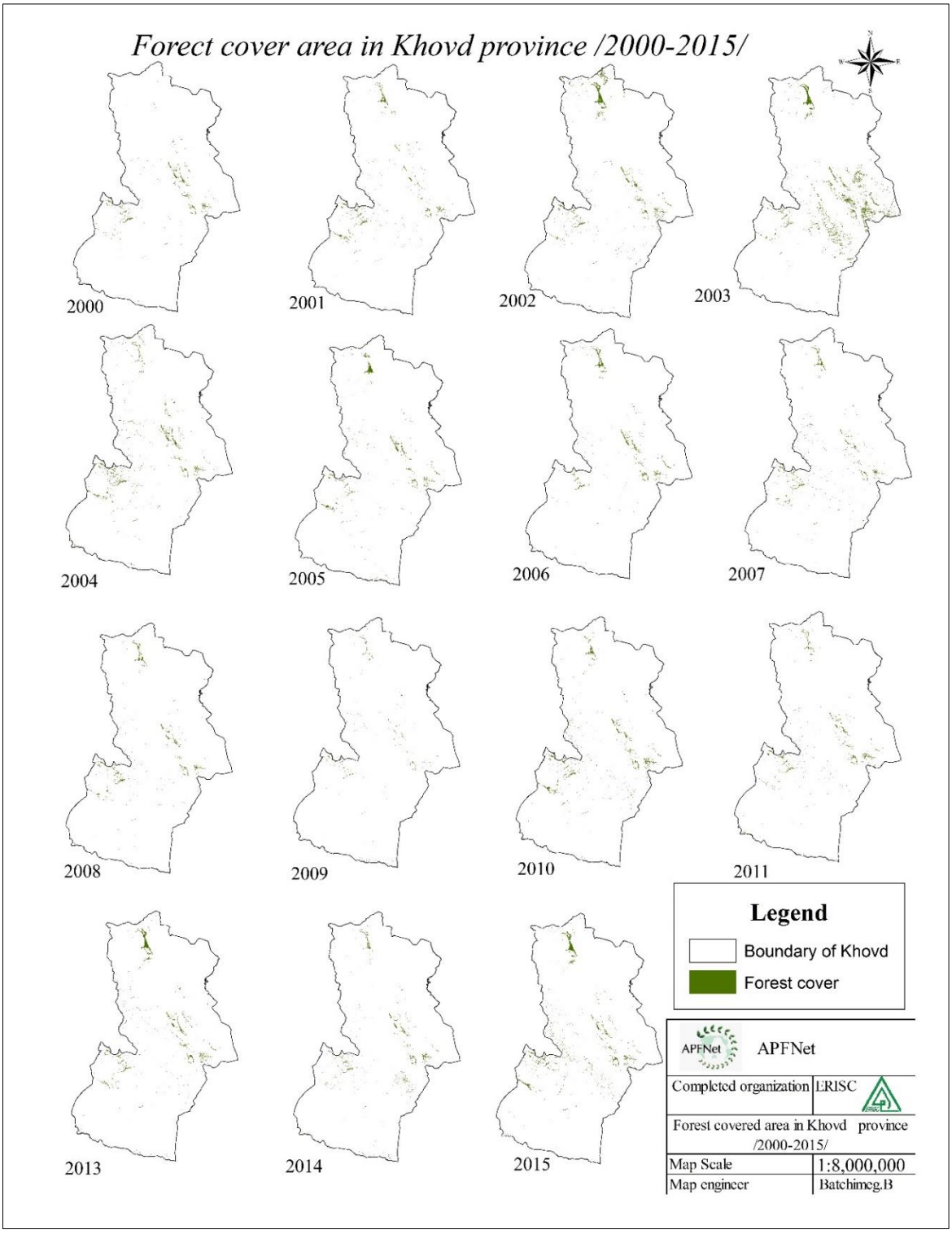
Picture 55. Forest dispersion map which shows cloud replacement

2.6.12. Forest dispersion map of Khovd province

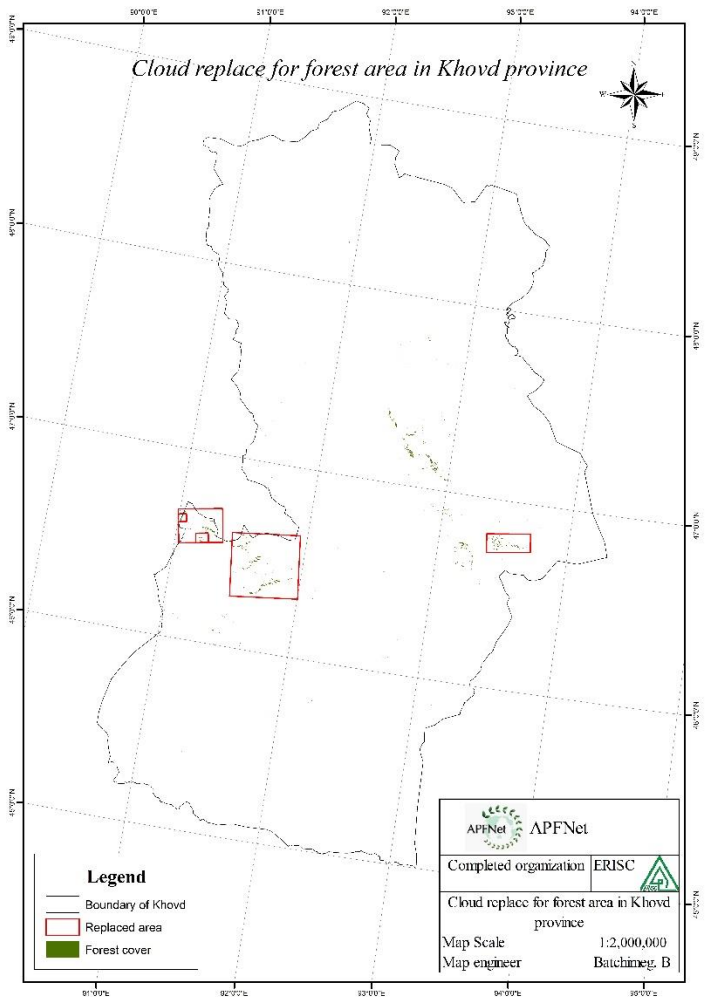
The forest fund of Khovd identified to performance developed from next forest taxation in 2011. Total forest fund area of the Khovd province is 16 thousand hectares and from that forest, covered area is 12.4 thousand hectares as 77.5%. 197.3 thousand hectare as 100% of forest-covered area is natural forest and non shrub and nurse forest. Total reserve of forest fund is 0.9 million cubic meter. The dominant tree species are larix 5 thousand hectares, Betula *platyphylla* 1.3 thousand hectares, *Salix pentandra* 5.9 thousand hectares.



Picture 56. Forest taxation map of Khovd province



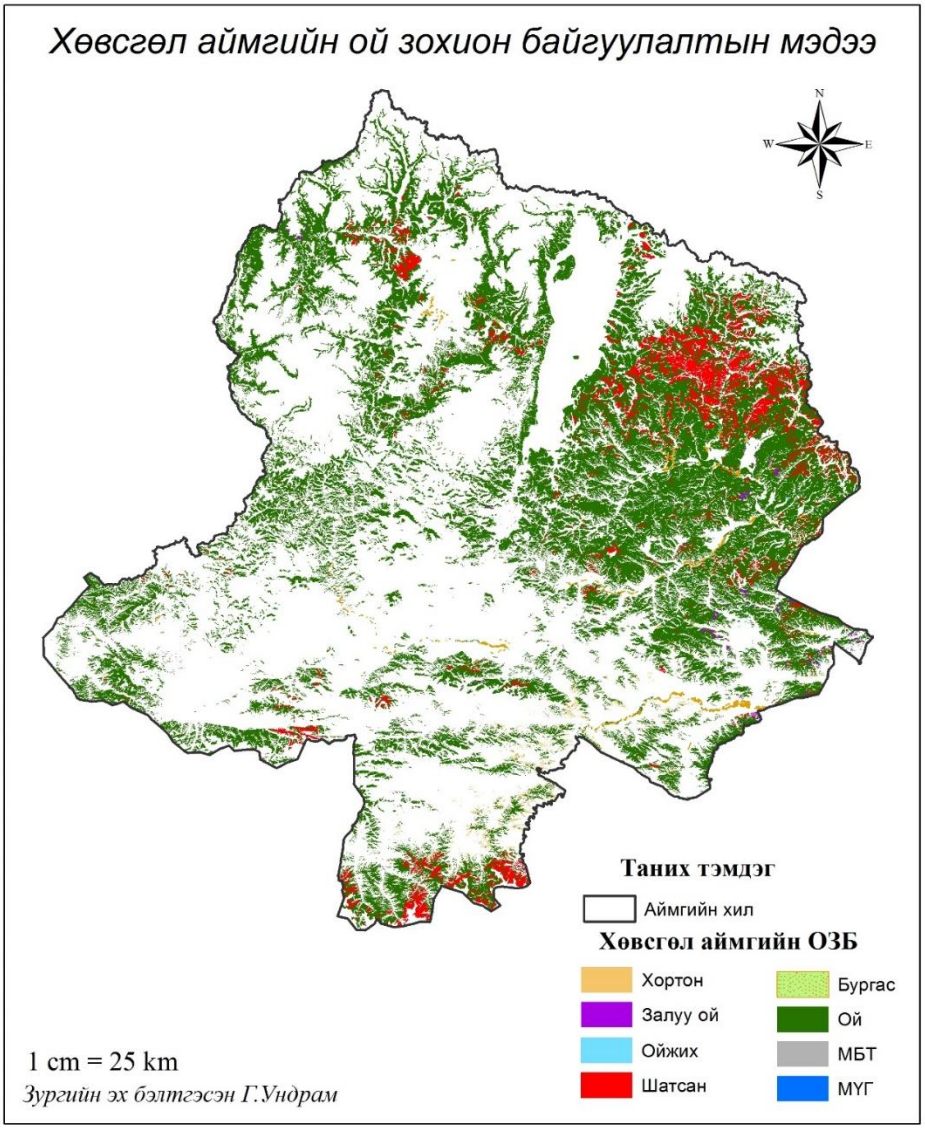
Picture 57. Forest dispersion map by 15 years in Khovd province.



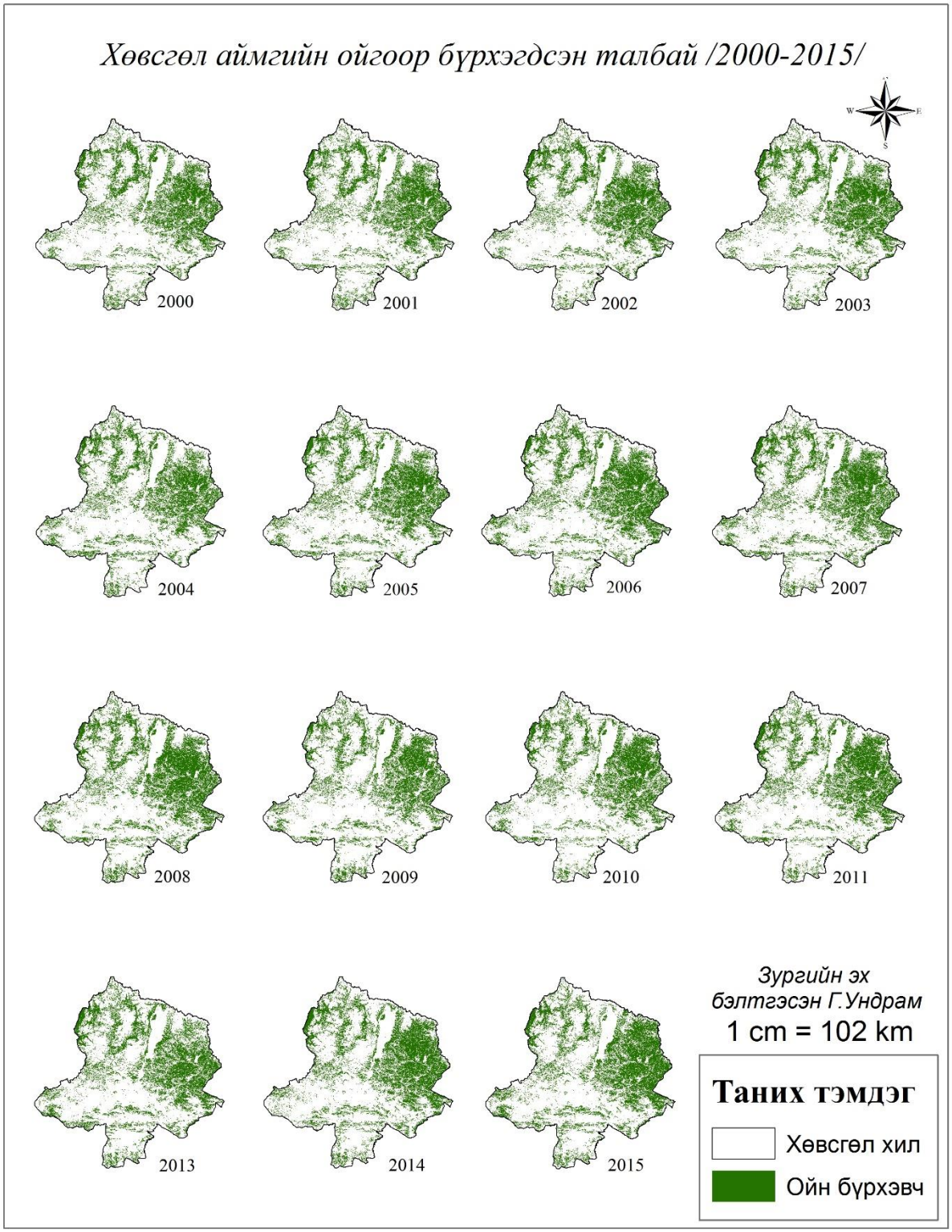
Picture 58. Forest dispersion map which shows cloud replacement

2.6.13. Forest dispersion map of Khuvsgul province

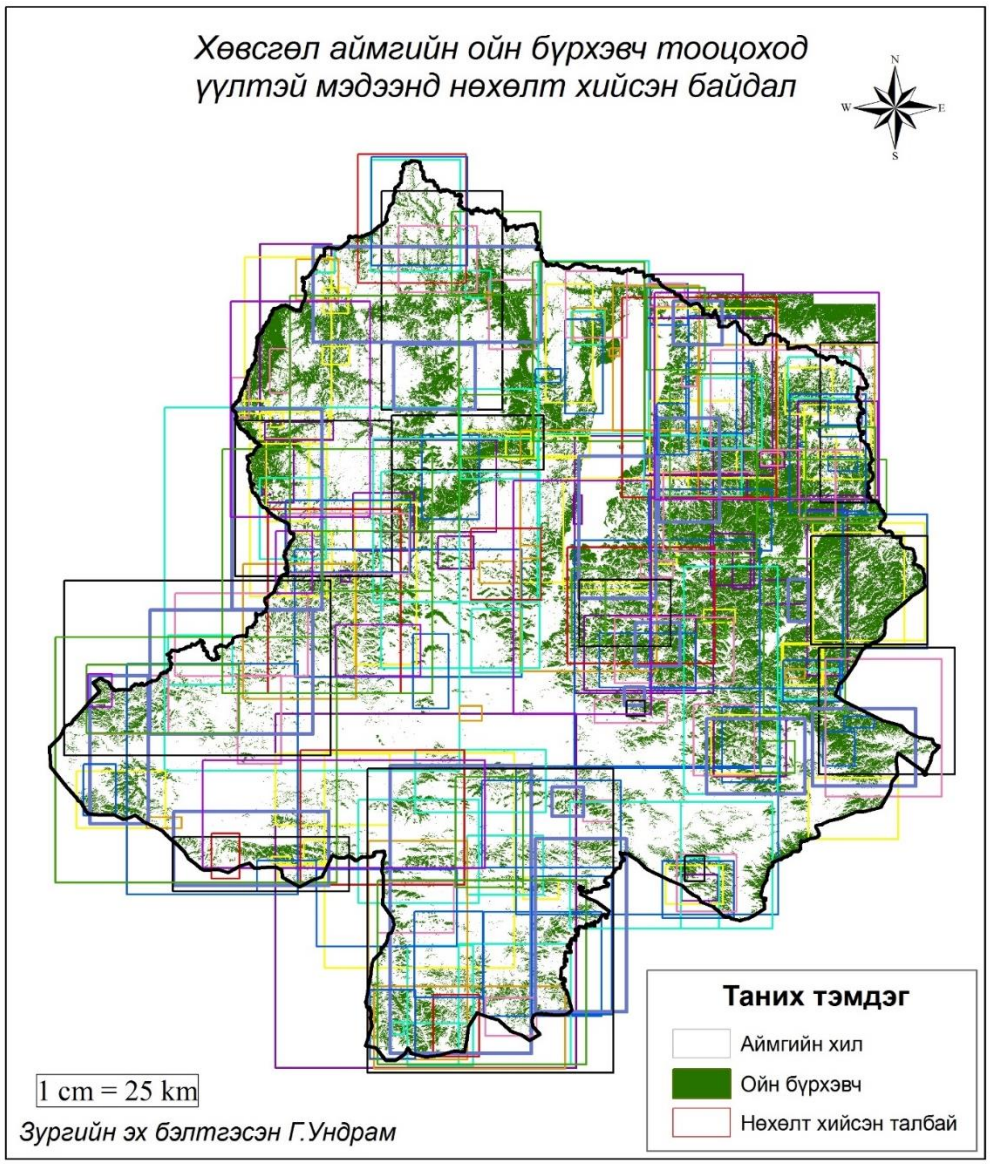
Forest fund of Khuvsgul aimag made a Forest taxation in 2000-2003. The forest fund performance developed from next forest taxation in 2012. Total forest fund area of the Khuvsgul province is 4011.8 thousand hectares and from that forest covered area is 3275.9 thousand hectares as 81.6%. 3152.5 thousand hectare as 96.2% of forest-covered area is natural forest and left 123.4 thousand hectare is shrub and 0.02 thousand hectare Nurse forest. Total reserve of forest fund is 433.9 million cubic meter. The dominant tree species are larix 2974.8 thousand hectares, *Pinus* 2.2 thousand hectares, Cedar 86.1 thousand hectares, spruce 4.7 thousand hectares, *Betula platyphylla* 71.2 million hectares, *Poplar* 2.5 million hectares, *Shrub* 10.6 thousand hectares.



Picture 59. Forest taxation map of Khuvsgul province



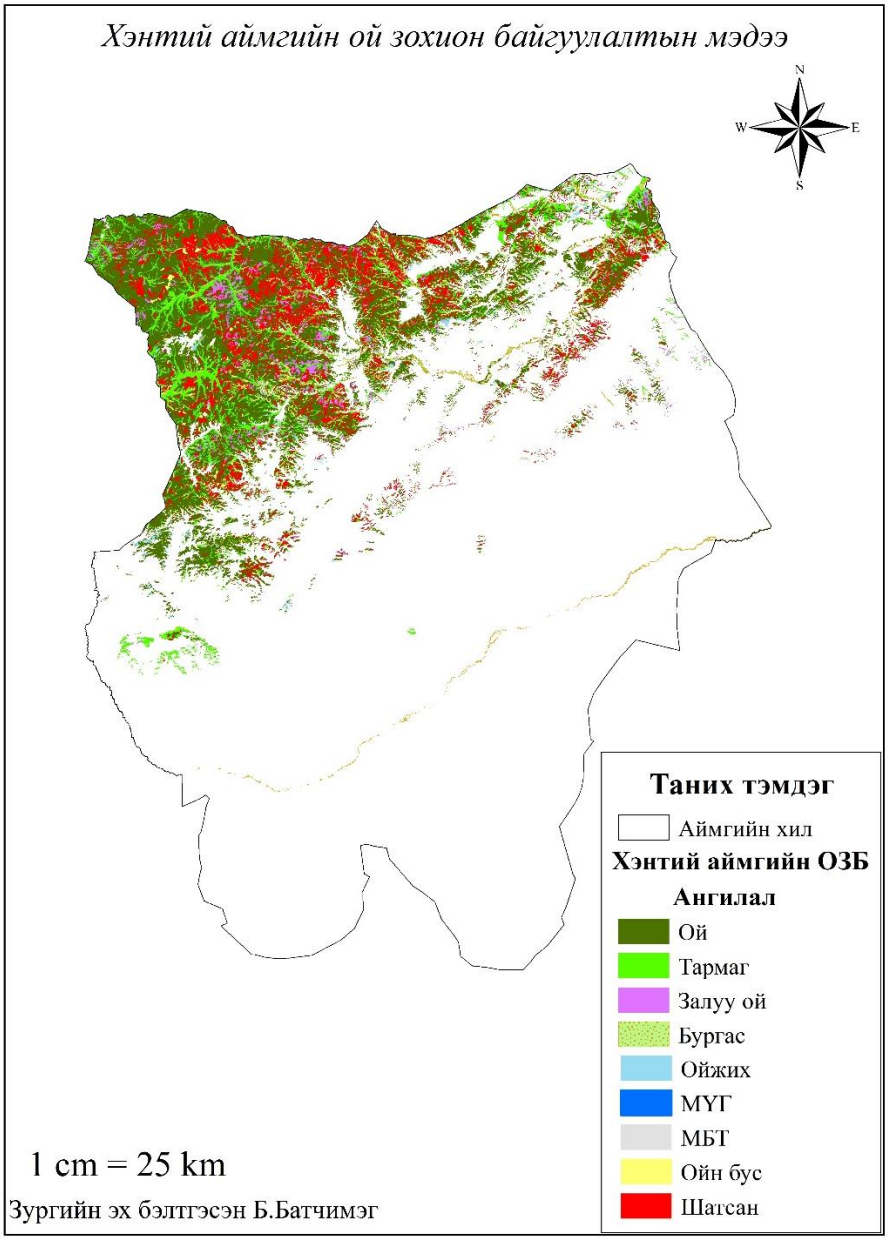
Picture 60. Forest dispersion map by 15 years in Khuvsgul province.



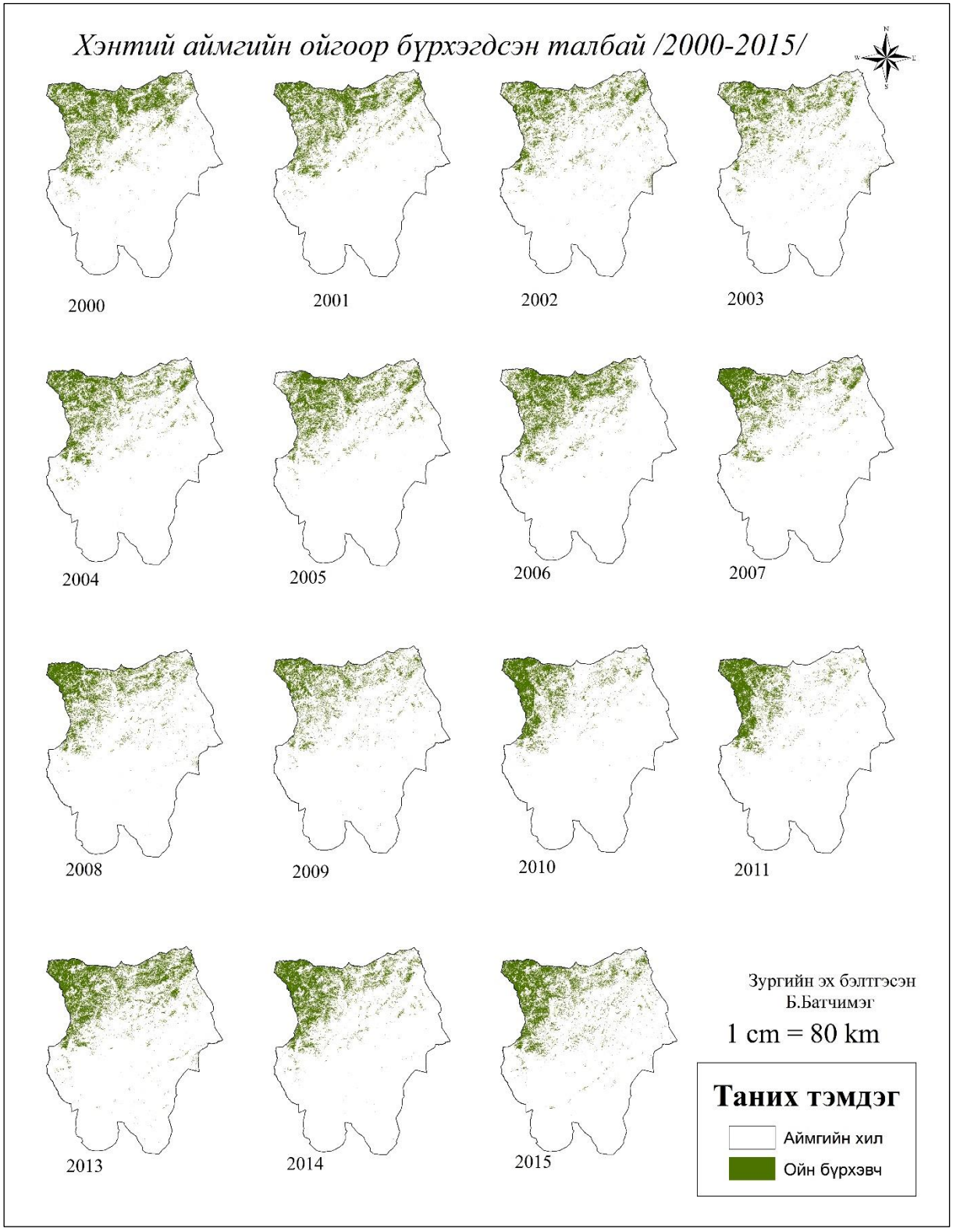
Picture 61. Forest dispersion map which shows cloud replacement

2.6.14. Forest dispersion map of Khentii province

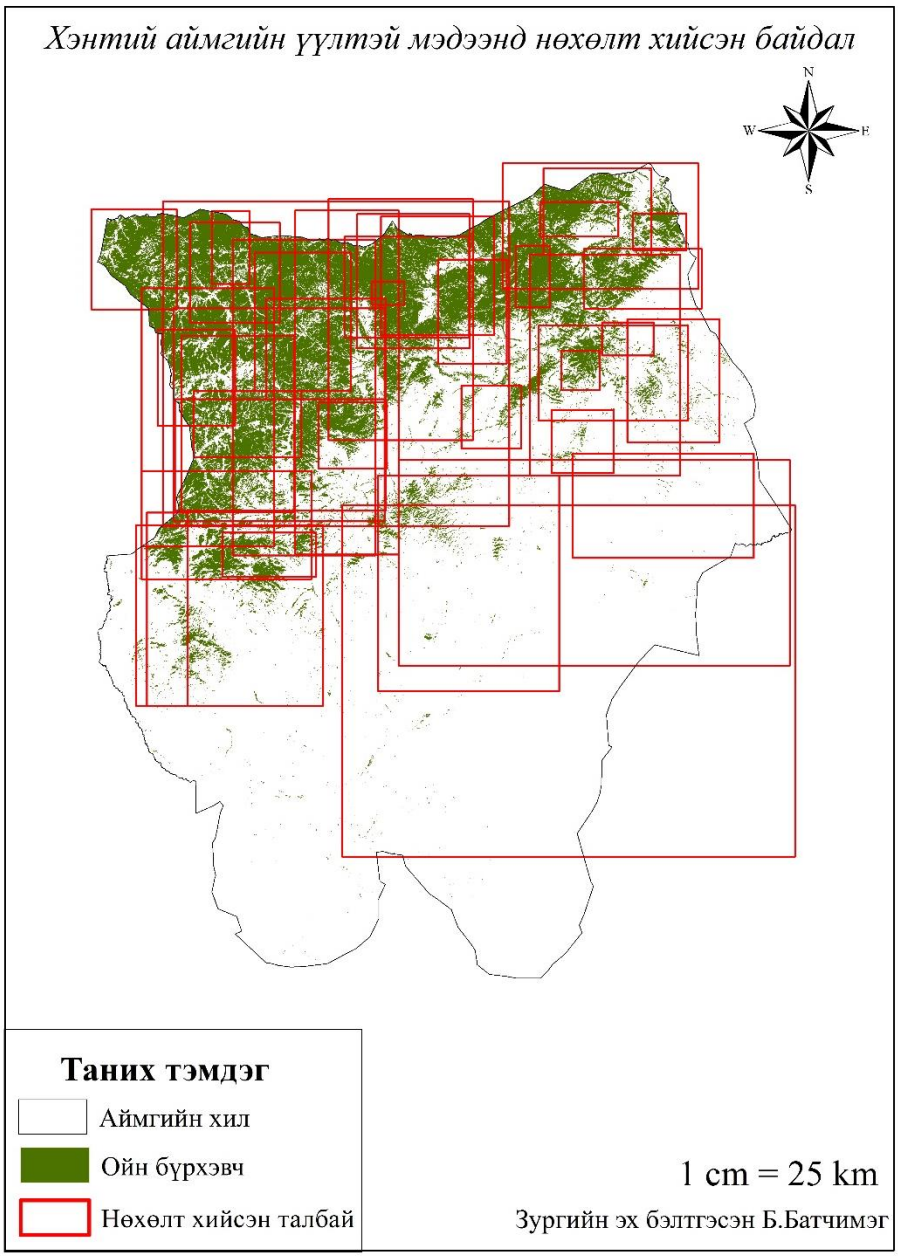
Forest fund of Khentii aimag made a Forest taxation in 2004-2005. The forest fund performance developed from next forest taxation in 2013. Total forest fund area of the Khentii province is 1754. 7 thousand hectare and from that forest, covered area is 1176. 1 thousand hectare as 67%. 989.7 thousand hectares as 84.2% of forest-covered area is natural forest and left 186.2 thousand hectares is shrub and 0.16 thousand hectares Nurse forest. Total reserve of forest fund is 109. 7 million cubic meter. The dominant tree species are larix 696.2 thousand hectares, *Pinus* 45.1 thousand hectares, Cedar 66.7 thousand hectares, *Betula platyphylla* 154.8 thousand hectares, *Polar* 8.8 thousand hectares, *Tremula populus Ldb* 1.4 thousand hectares, *Shrub* 16.6 thousand hectares.



Picture 62. Forest taxation map of Khentii province



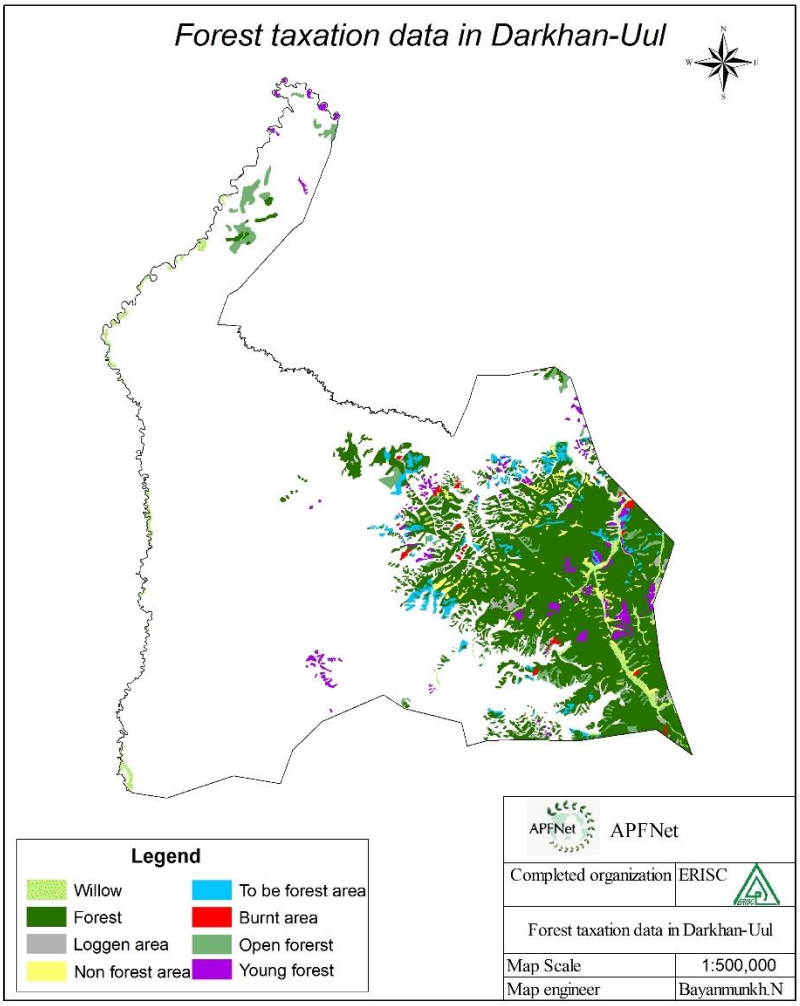
Picture 63. Forest dispersion map by 15 years in Khentii province.



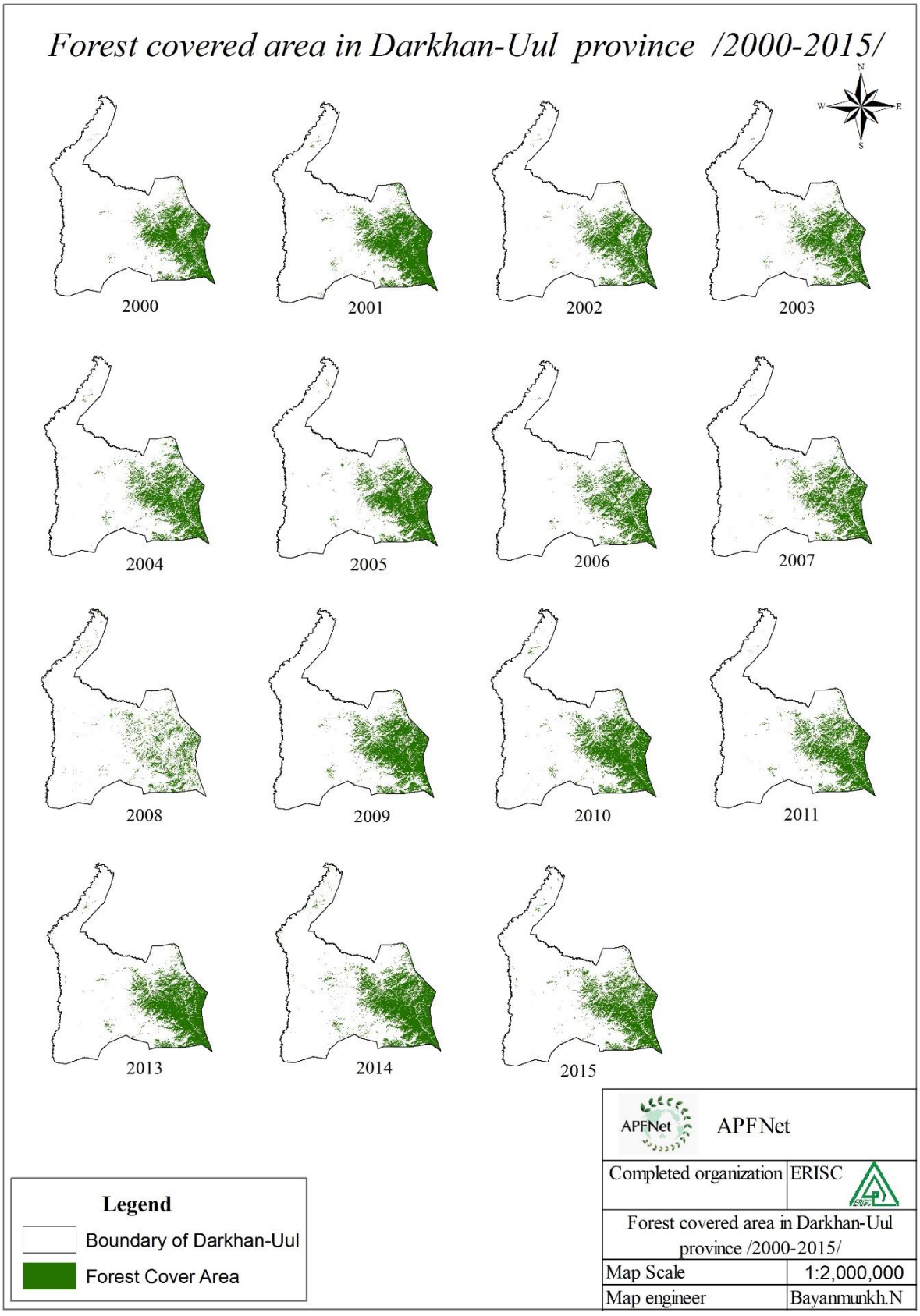
Picture 64. Forest dispersion map which shows cloud replacement

2.6.15. Forest dispersion map of Darhan-uul province

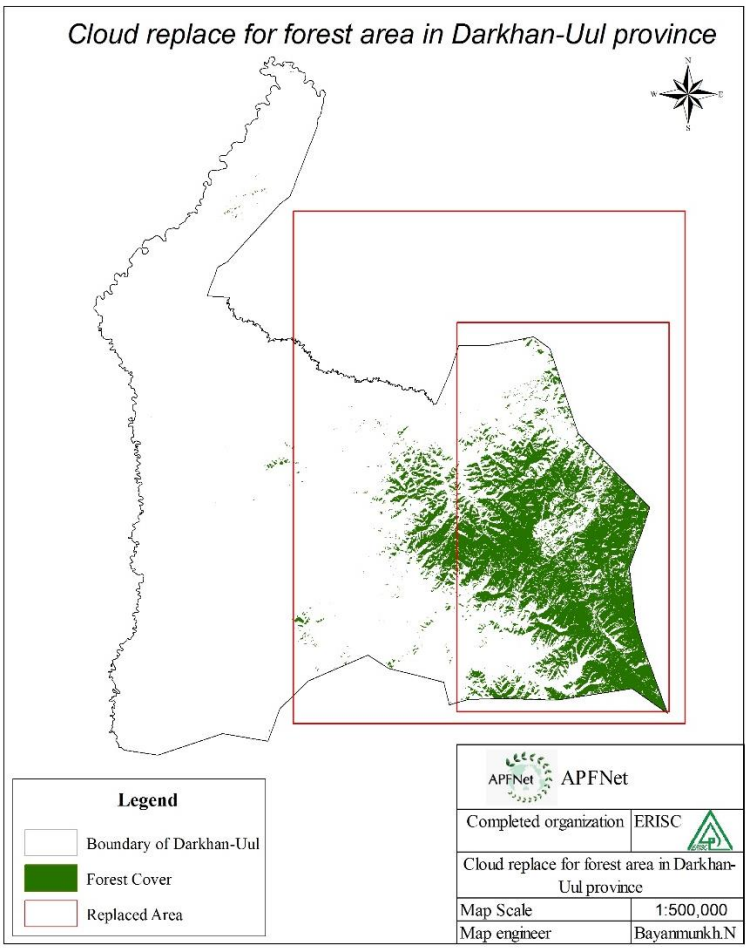
Forest fund of Darkhan-uul aimag made a Forest taxation in 2006. The forest fund performance developed from next forest taxation in 2013. Total forest fund area of the Darkhan-uul province is 82 thousand hectares and from that forest, covered area is 66.2 thousand hectares as 80.7%. 64.8 thousand hectare as 97.9% of forest-covered area is natural forest and left 1.3thousand hectare is shrub and 0.16 thousand hectare Nurse forest. Total reserve of forest fund is 4.6 million cubic meter. The dominant tree species are *Pinus* 11.8 thousand hectares, *Betula platyphylla* 51.1 thousand hectares, *Populus tremula* 1.1 thousand hectares, *Shrub* 0.8 thousand hectares.



Picture 65. Forest taxation map of Darkhan-Uul province



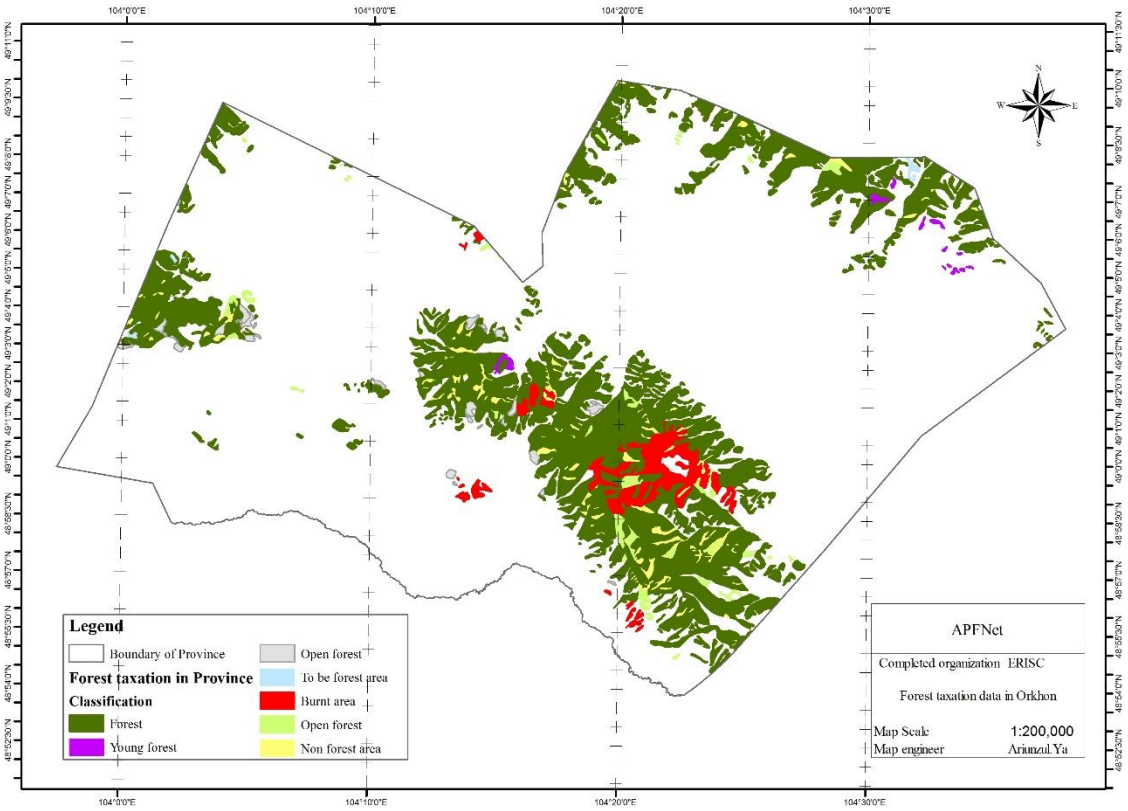
Picture 66. Forest dispersion map by 15 years in Darkhan-Uul province.



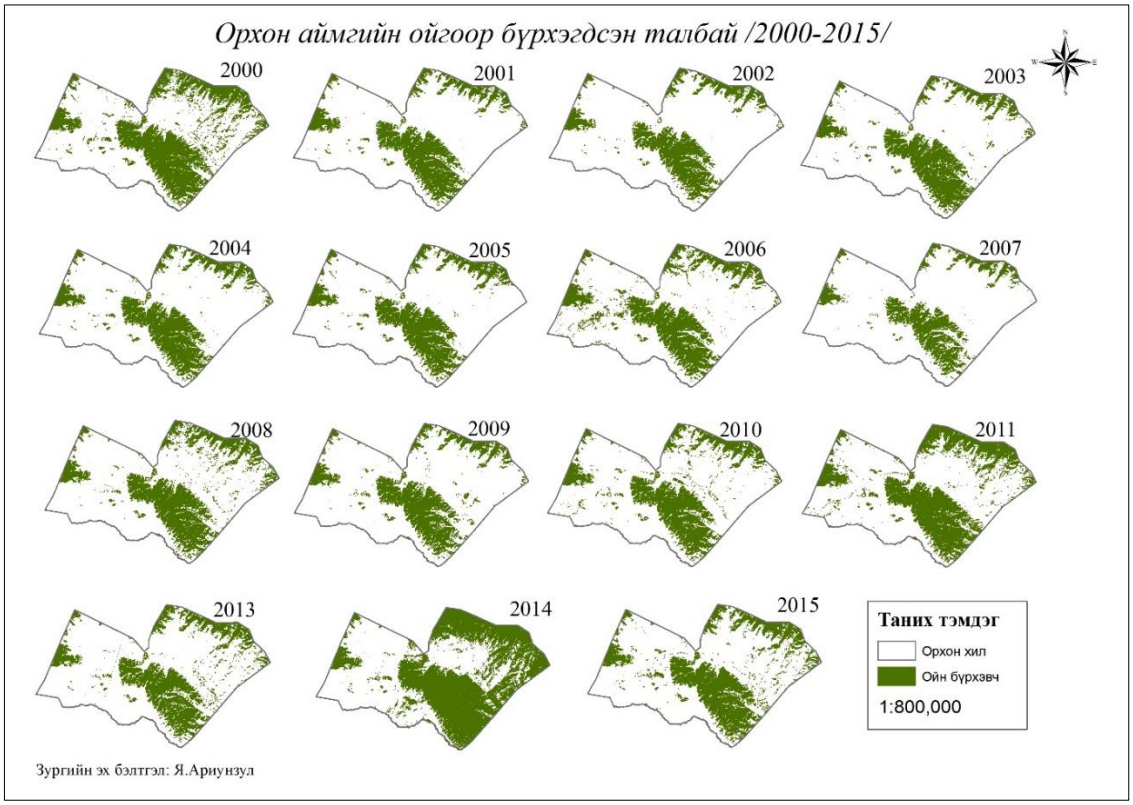
Picture 67. Forest dispersion map which shows cloud replacement

2.6.16. Forest dispersion map of Orkhon province

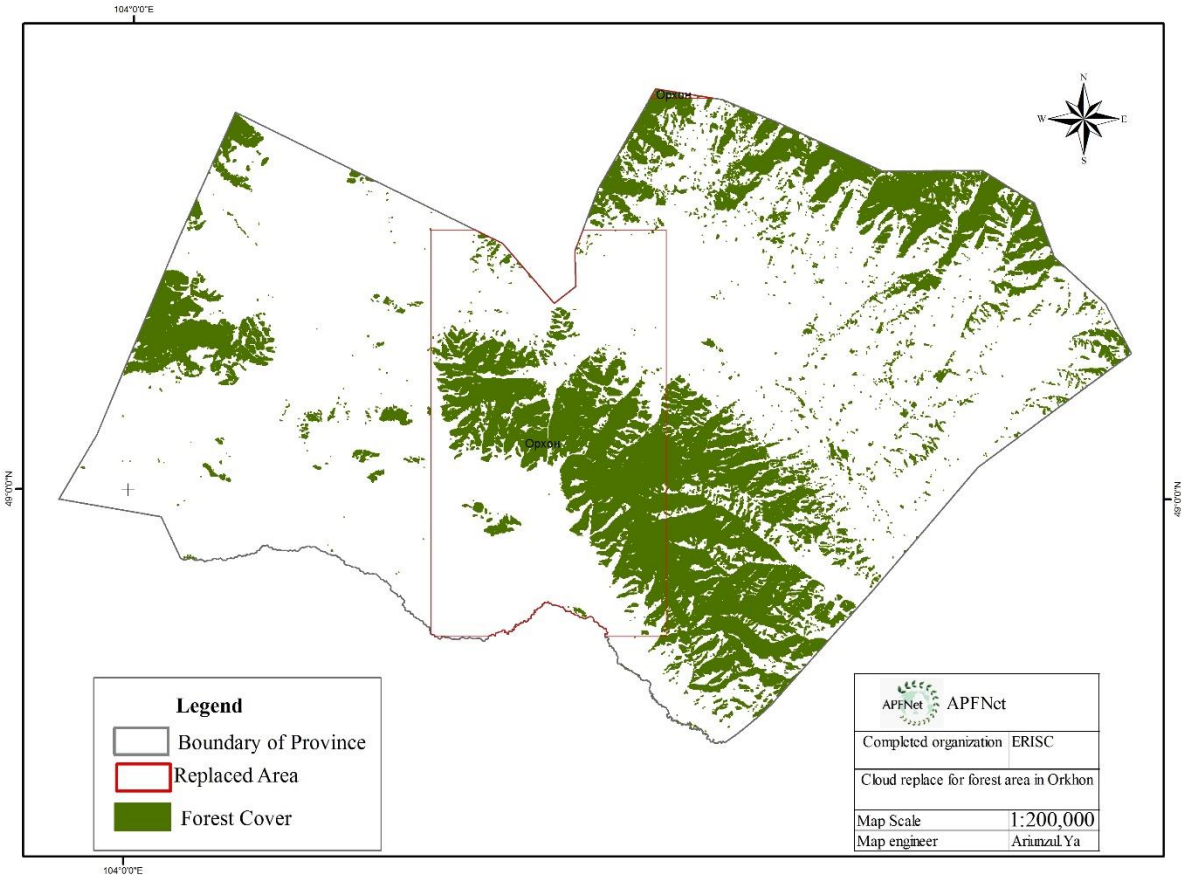
Forest fund of Orkhon aimag made a Forest taxation in 2001. The forest fund performance developed from next forest taxation in 2001. Total forest fund area of the Orkhon province is 17.8 thousand hectares and from that forest, covered area is 15.6 thousand hectares as 87.6%. 100% of forest-covered area is natural forest. Total reserve of forest fund is 1.6 million cubic meter. The dominant tree species are *Larch* 14.1 thousand hectares, *Betula platyphylla* 1.5 thousand hectares.



Picture 68. Forest taxation map of Orkhon province



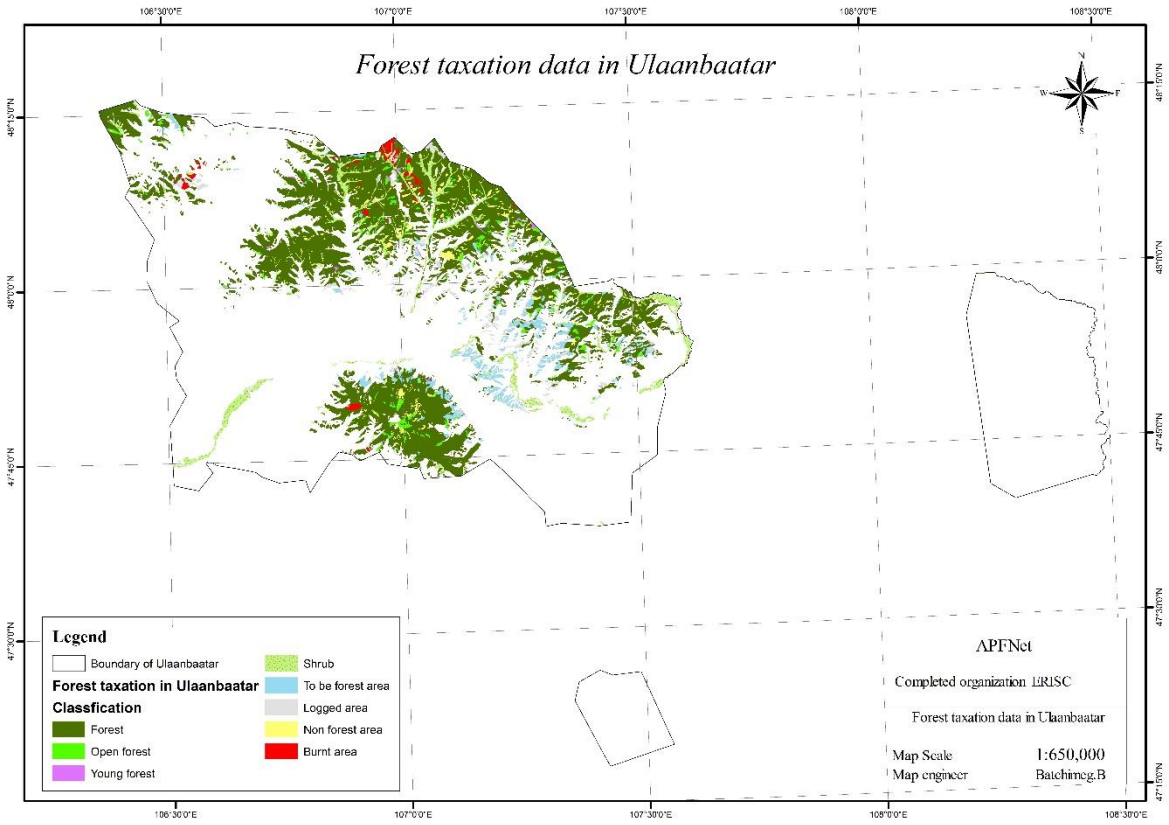
Picture 69. Forest dispersion map by 15 years in Orkhon province.



Picture 70. Forest dispersion map which shows cloud replacement

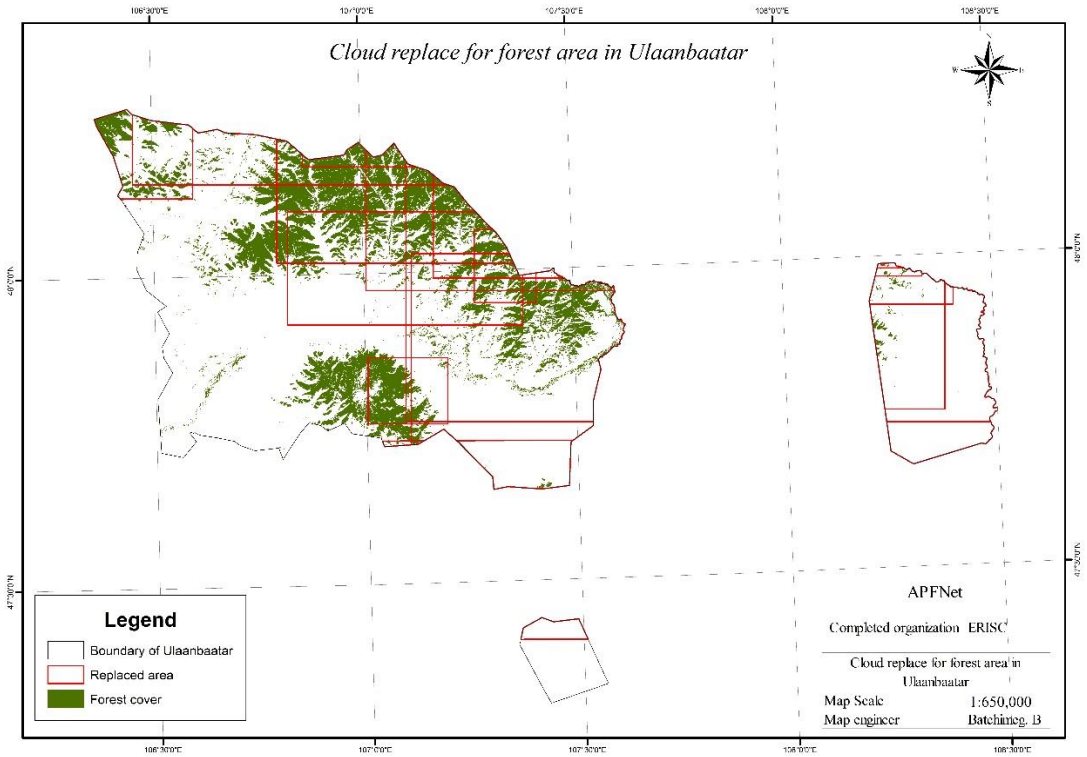
2.6.17. Forest dispersion map of Ulaanbaatar province

Forest fund of Ulaanbaatar aimag made a Forest taxation in 1998. The forest fund performance developed from next forest taxation in 2008. Total forest fund area of the Darkhan-uul province is 116 thousand hectares and from that forest, covered area is 93.6 thousand hectares as 87.6%. 87.1 thousand hectare as 93.1% of forest-covered area is natural forest and left 6.5 thousand hectare is shrub and 0.02 thousand hectare Nurse forest. Total reserve of forest fund is 10.9 million cubic meter. The dominant tree species are Larch 49.6 thousand hectares, *Pinus* 9.9 thousand hectares, Cedar 13.8 thousand hectares, spruce 1.6 thousand hectares, *Betula platyphylla* 7.3 thousand hectares, *Shrub* 4.3 thousand hectares.



Picture 71. Forest taxation map of Ulaanbaatar province

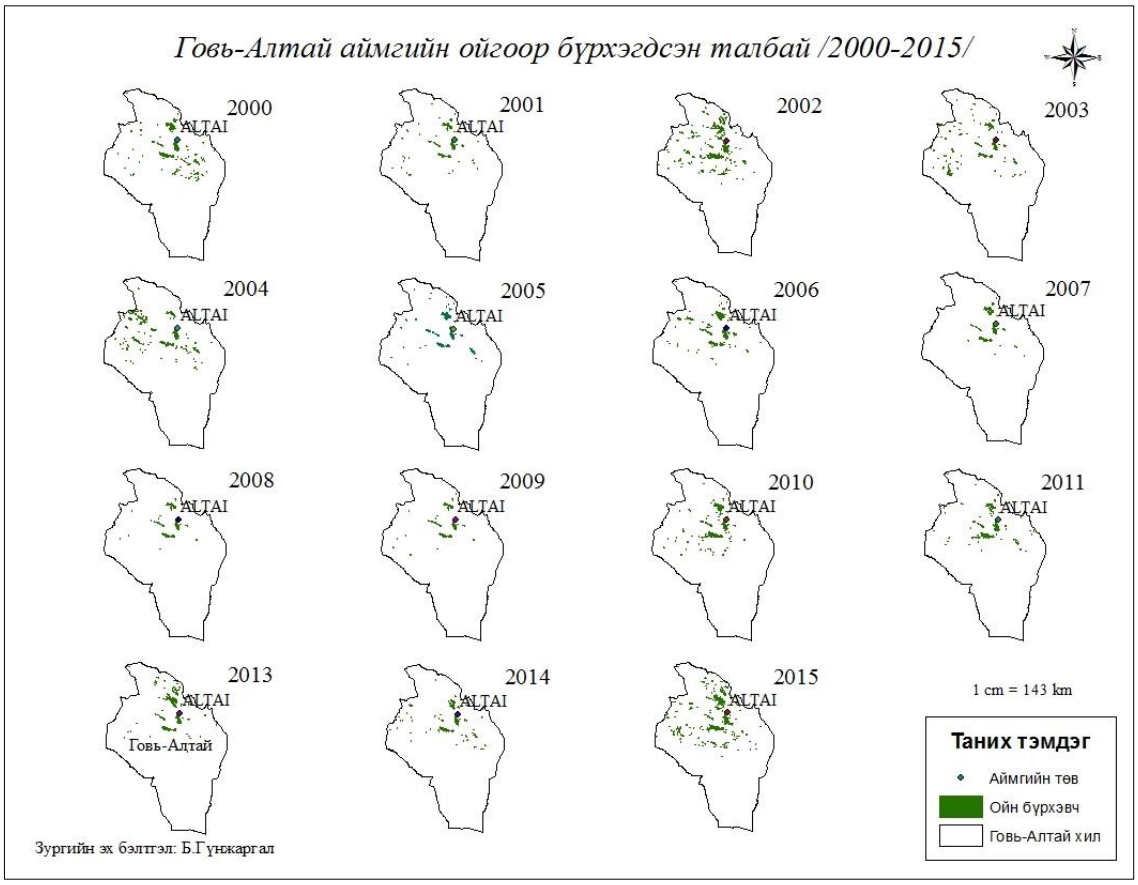
Picture 72. Forest dispersion map by 15 years in Ulaanbatar province.



Picture 73. Forest dispersion map that shows cloud replacement

2.6.18. Forest dispersion map of Gobi-Altai province

The forest fund of Gobi-Altai identified to performance developed from next forest taxation in 2005. Total forest fund area of the Gobi-Altai province is 9.4 thousand hectares and from that forest, covered area is 9.1 thousand hectares as 96.8%. 9.1 thousand hectares as 100 % of forest-covered area is natural forest. The dominant tree species are Larch 8.6 thousand hectares, Poplar 0.5 thousand hectares.



Picture 74. Forest dispersion map by 15 years in Gobi-Altai province.

2.6.18. Mongolian forest distribution map produced from Forest Index in Landsat data

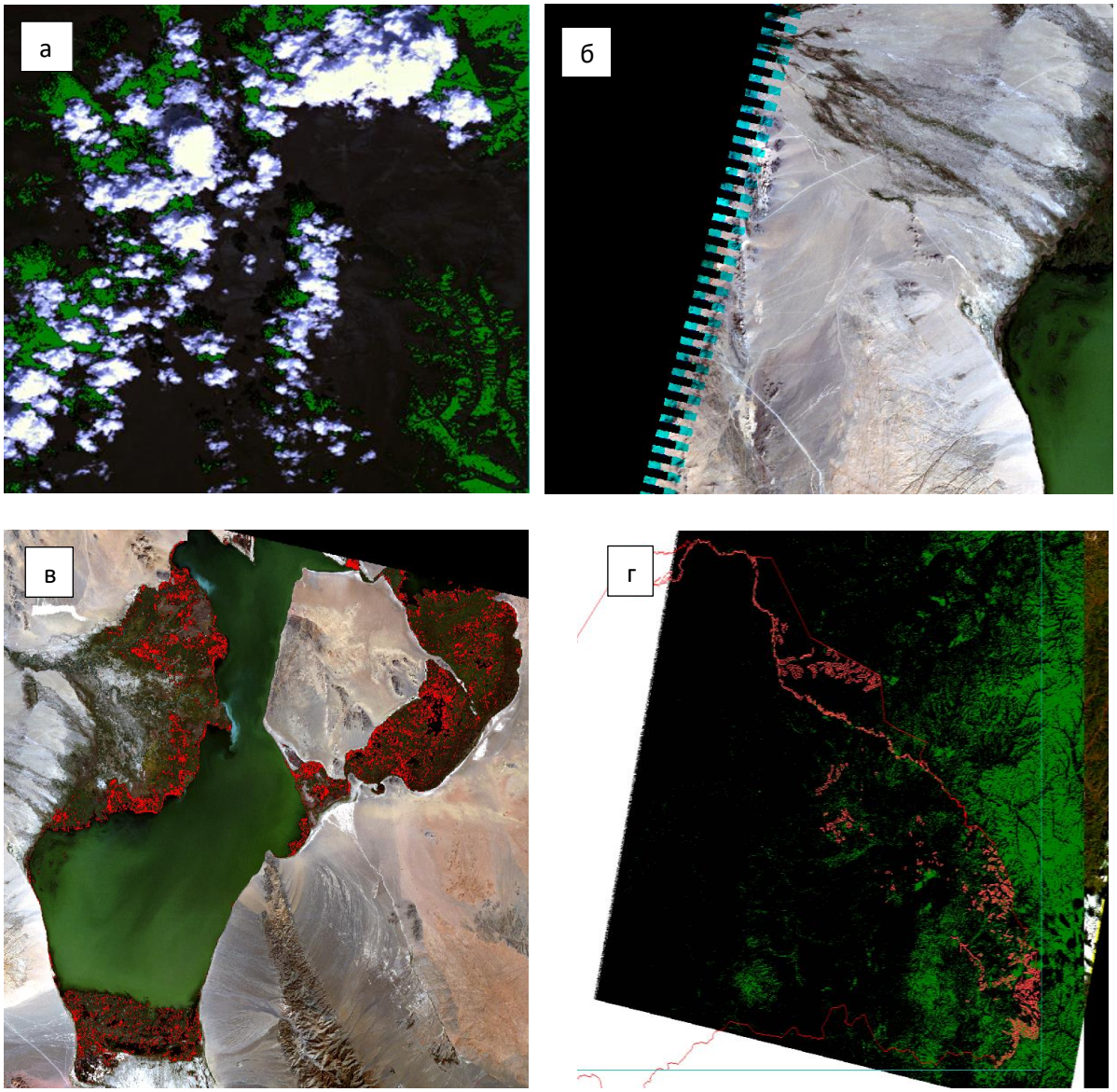
Mongolian forest fund calculated 10.4 million hectares from Leso Project of Russia in 1956, 15.2 million hectares from Russian Mongolian remote sensing research in 1974, 18.2 million hectares from State taxation of forest Research Organization in 2006. Mongolian forest usually grows as scattered in north part of state such as Khangai, Khentii, Khuvsgul mountain and their division. South part of state has saxual forest. Mongolian forest fund distributed by whole landscape covers 18454.6 thousand hectare area in 31st December 2015. It takes 11.8 percent of the whole landscape. The Mongolian forest resource is 1243.4 million cubic meters. Forest resource percentage of that 78.6% are larex, 9.3% are cedar, 6.18% are betula, 4.9% are pine tree, 0.27% are shrub, 0.23% are spruce, 0.2% are aspen, 0.14% are saxual forest, 0.05% are poplar, 0.019% are fir tree, 0.002% are variety of poplar and 0.007% are ulmus.

Forest index has L factor which subtracted water body from the forest value. That is why Landsat forest index is differentiated from the MODIS data, it can identify forest from the water. Although, it cannot identify cloud shadow from the forest.

If the data include cloud shadow, we deleted them manually. Cloud shadow is identifying like a forest in non-forest area. We checked up forest vector layered with the raw data, if it has cloud shadow or not. This research shows us cloud follows forest. It was usually cloud occurs in forested area. There were difficulties such as forested area occurs cloud shadow in every year. Cloud shadow occurred in non-forest area will be removed, occurred in forested area will be replaced by cloudless data forest, if there was not any replacement of certain year we replaced another year. Replacement means if there was a cloud shadow we replaced by a cloudless scene with overlapped part or replace by another year data.

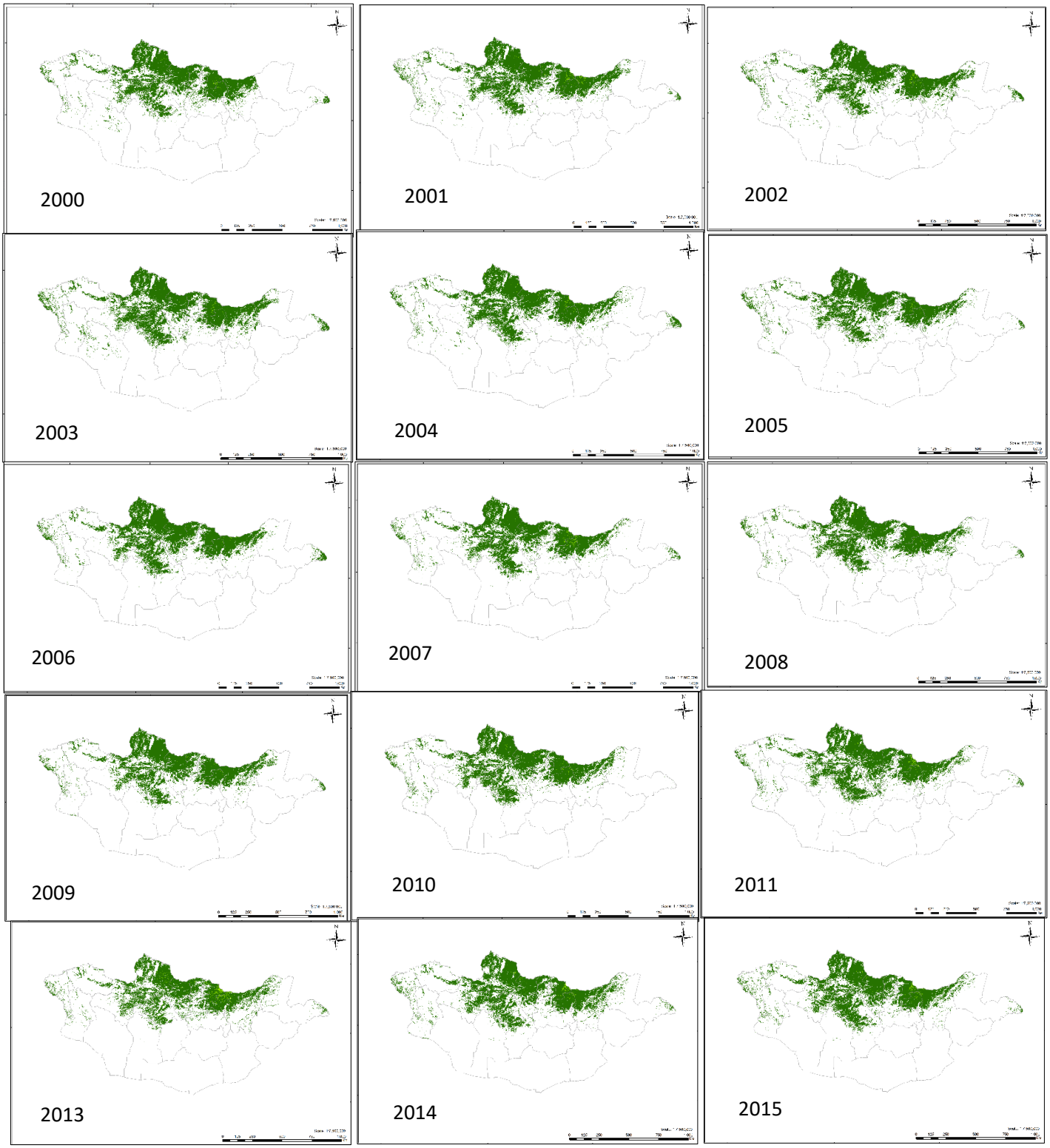
In addition, scene boundary is one of the problematic thing that identified as a forest. We deleted manually all scene boundaries.

Additionally, pluvious year wetland and meadow identified as a forest. For the Khovd province lake rush identified as a forest. In the Dornod province steppe meadow identified as a forest. For the Selenge and Bulgan province cropland identified as a forest. Project team checked up and repair those mistakes by layering all year province data. One more problem was the meadow area of the riverside in some pluvious year identified as a forest too. Those areas has not in situ research about forest or non-forest, then we kept those areas in that condition. In small area research that problem can be solved easily.



Picture 75. а) Cloud shadow б) Scene boundary в) Lake rush г) Steppe meadow

Mongolian forest cover map by 15 years in following map

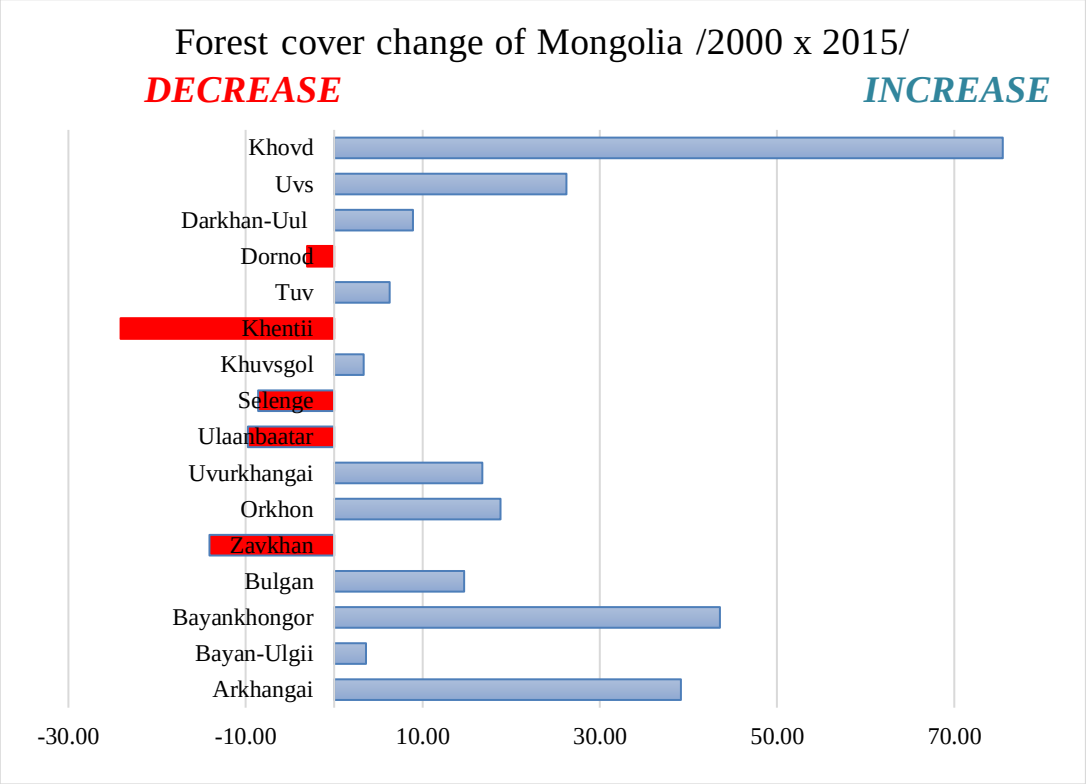


Picture 76. Mongolian forest cover /2000-2015/

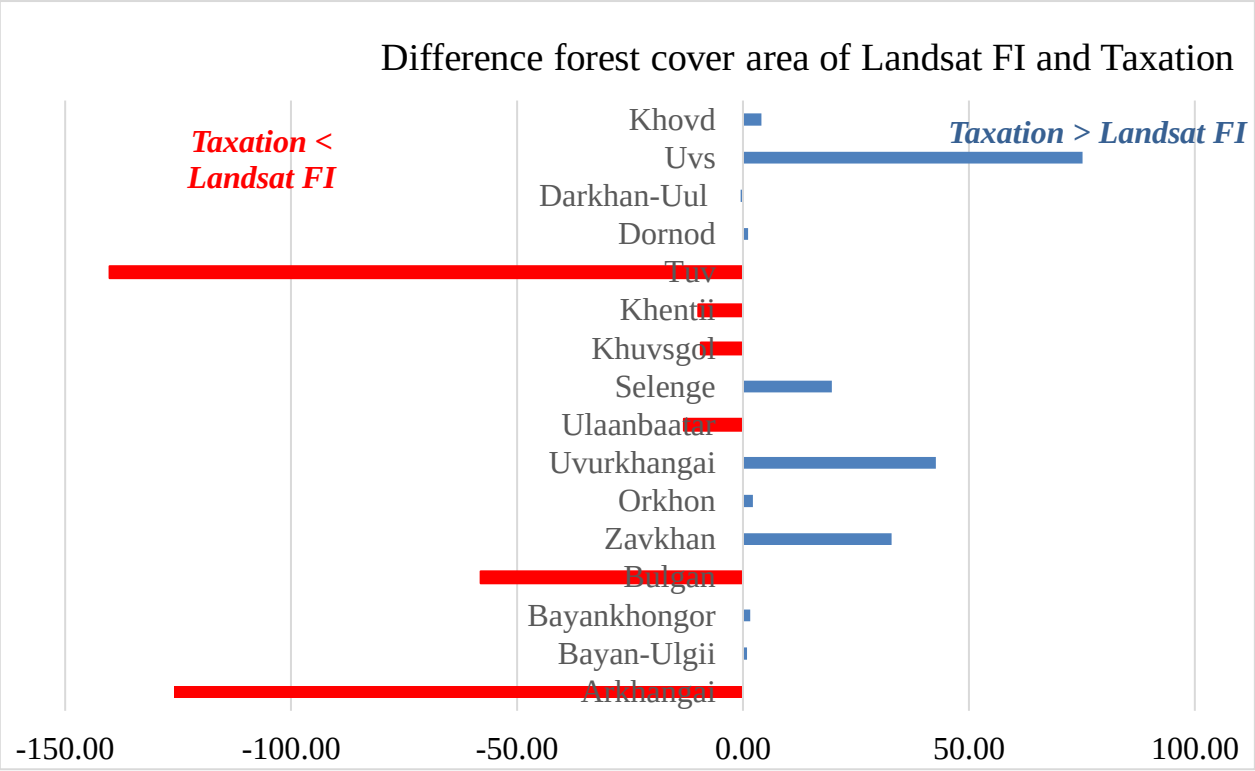
№	Name	Landsat forest cover /Average/ha	Woodland %	Taxation Year	Taxation data ha	Woodland %	Difference	Landsat forest cover /That Year/ha	Difference	Trend	Increase area ha	Decrease area ha	Average Dinamic ha	Difference ha	Dinamic %	Increase %	Decrease %	Difference %	Trend
1	Arkhangai	821,298.50	14.85	2008	799.40	14.45	0.40	925.16	-125.76	Бага	217377	92863	155120	124514	32.66	52.24	13.09	39.14	Increase
2	Bayan-Ulgii	59,108.61	1.27	2008	42.30	0.91	0.36	41.43	0.87	Их	20,310.00	18,186.00	19,248.00	2,124.00	32.56	34.36	30.77	3.59	Increase
3	Bayankhongor	25,053.14	0.22	2015	29.80	0.26	-0.04	28.16	1.64	Их	13,631.00	2,721.00	8,176.00	10,910.00	32.63	54.41	10.86	43.55	Increase
4	Bulgan	1,333,812.44	27.37	2010	1,315.00	26.98	0.39	1373.06	-58.06	Бага	318,519.00	122,812.00	220,665.50	195,707.00	16.54	23.88	9.21	14.67	Increase
5	Zavkhan	397,072.76	4.82	2013	456.80	5.54	-0.72	423.90	32.90	Их	105,836.00	161,730.00	133,783.00	-55,894.00	33.69	26.65	40.73	-14.08	Decrease
6	Orkhon	13,941.78	16.52	2010	15.60	18.48	-1.96	13.44	2.16	Их	3,264.00	646.00	1,955.00	2,618.00	14.02	23.41	4.63	18.78	Increase
7	Uvurkhangai	122,911.06	1.95	2008	134.60	2.14	-0.19	91.89	42.71	Их	40,751.00	20,193.00	30,472.00	20,558.00	24.79	33.15	16.43	16.73	Increase
8	Ulaanbaatar	88,379.95	18.70	2008	87.10	18.51	0.19	100.17	-13.07	Бага	6,528.00	15,134.00	10,831.00	-8,606.00	12.26	7.39	17.12	-9.74	Decrease
9	Selenge	1,477,514.49	35.90	2008	1,397.40	33.96	1.95	1377.73	19.67	Их	160,830.00	287,592.00	224,211.00	-126,762.0	15.17	10.89	19.46	-8.58	Decrease
10	Khuvsgol	3,013,598.18	29.95	2012	3,152.50	31.33	-1.38	3161.82	-9.32	Бага	529,068.00	428,665.00	478,866.50	100,403.00	15.89	17.56	14.22	3.33	Increase
11	Khentii	925,879.55	11.53	2013	989.70	12.32	-0.79	999.59	-9.89	Бага	240,088.00	463,329.00	351,708.50	-223,241.0	37.99	25.93	50.04	-24.11	Decrease
12	Tuv	932,655.85	12.60	2013	957.20	12.93	-0.33	1097.38	-140.18	Бага	193,853.00	135,414.00	164,633.50	58,439.00	17.65	20.79	14.52	6.27	Increase
13	Dornod	119,181.05	1.42	2012	75.40	0.61	0.81	74.29	1.11	Их	9,382.80	13,024.00	11,203.40	-3,641.20	9.40	7.87	10.93	-3.06	Decrease
14	Darkhan-Uul	53,941.01	16.47	2013	64.80	19.79	-3.32	65.30	-0.50	Бага	8,669.00	3,871.00	6,270.00	4,798.00	11.62	16.07	7.18	8.89	Increase
15	Uvs	107,268.16	1.54	2011	197.30	2.84	-1.29	122.21	75.09	Их	46,820.00	18,695.00	32,757.50	28,125.00	30.54	43.65	17.43	26.22	Increase
16	Khovd	11915.5568	0.16	2011	12.40	0.16	-0.01	8.289	4.11	Их	12,639.00	3,646.00	8,142.50	8,993.00	68.34	106.07	30.60	75.47	Increase
17	Mongolia	9,491,616.55	6.11		10,386.90	6.64	-0.37		0.11	Бага	1,927,565.80	1,788,521.00	1,858,043.40	139,044.80	25.36 19.58	31.52 20.31	19.20 18.8	12.32 1.5	Increase

Table 9. Mongolian forest cover area performance

Graph 12. Mongolian forest dynamic change from 2000 to 2015



Graph 13. Difference between Forest index and taxation data

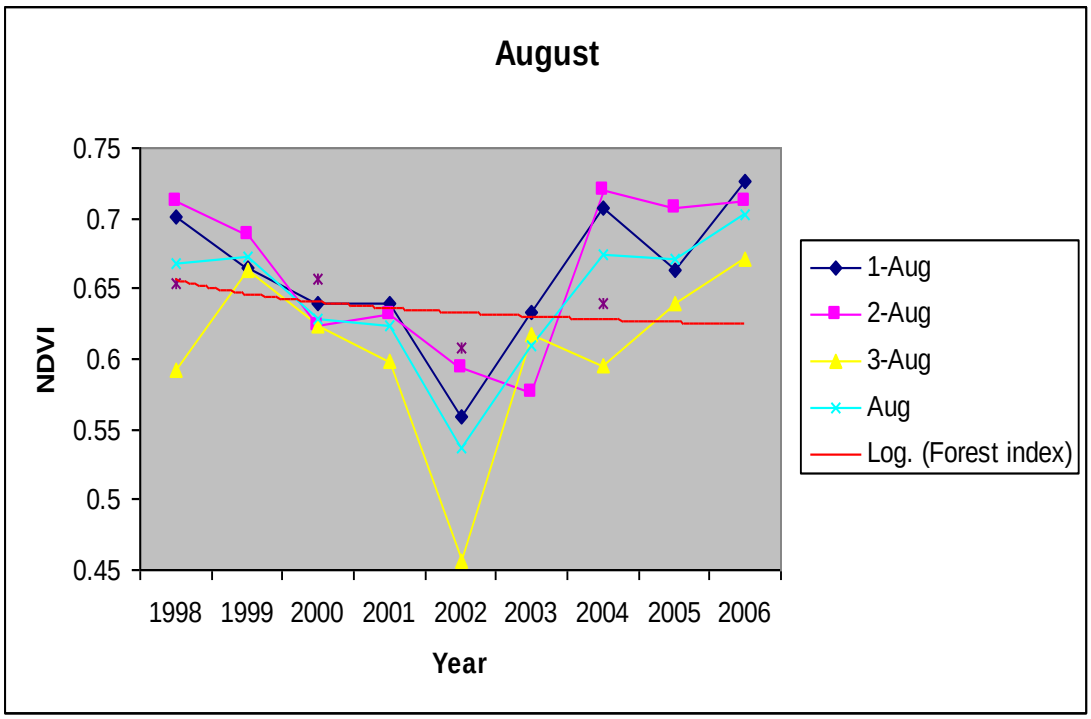


2.6.19. Mongolian forest distribution map on NDVI of the MODIS satellite data

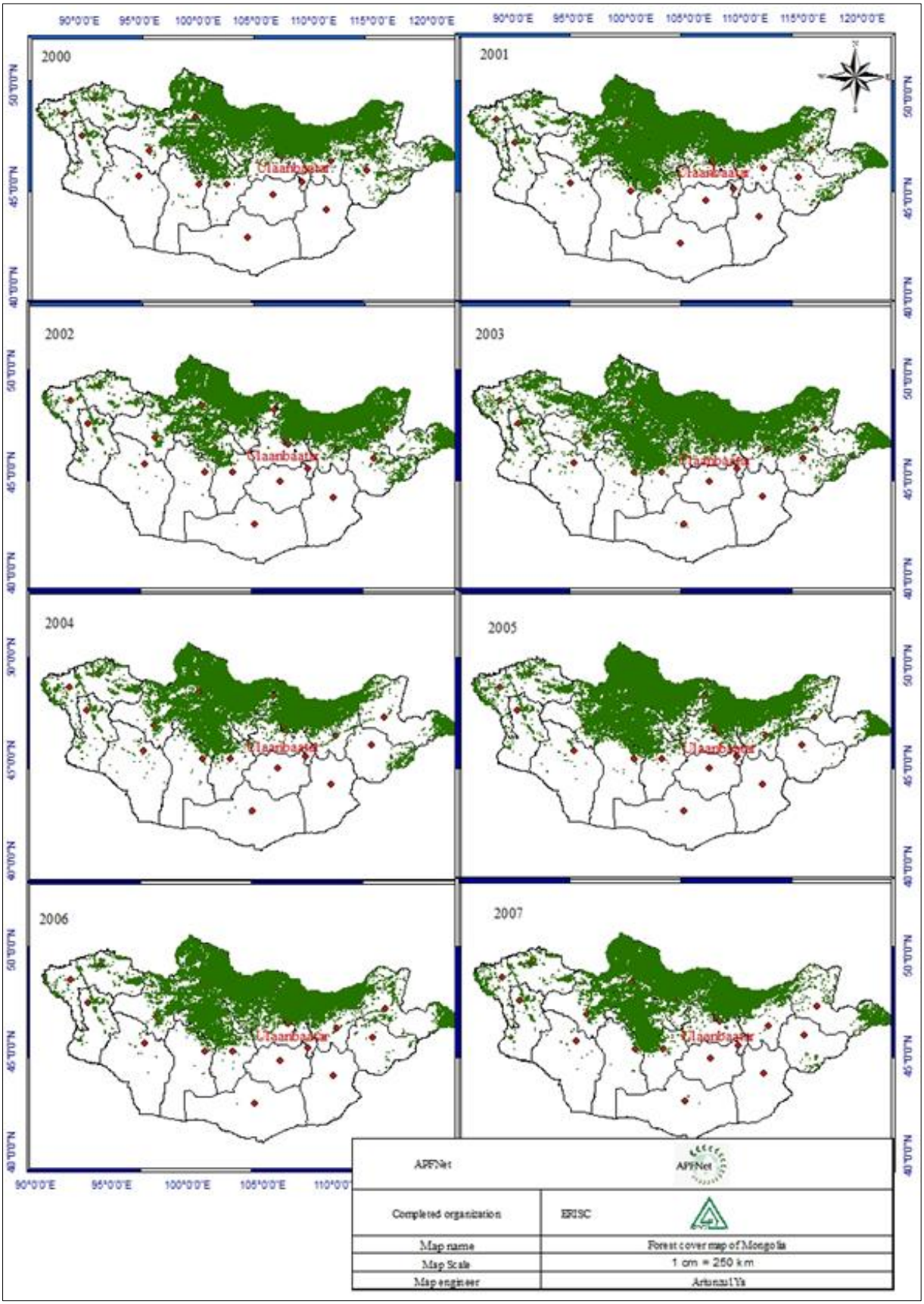
MODIS satellite data:

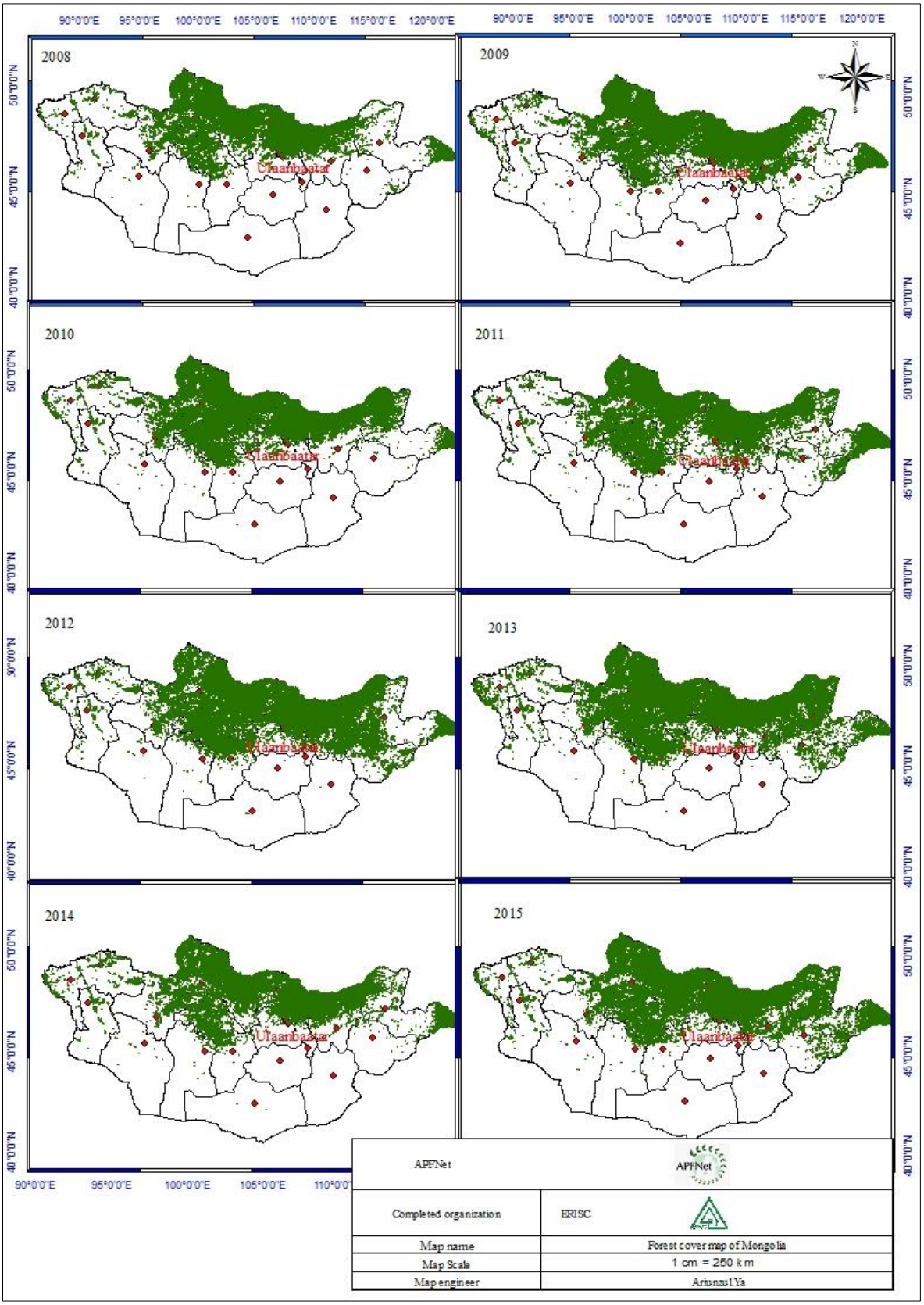
We used MODIS (Moderate Resolution Imaging Spectroradiometer) satellite 16 days NDVI data from 2000 to 2015. The NDVI value of the MOD13 enhanced vegetation indexing 16 days data from 2000 to 2015 used in this research. The NDVI threshold for forest taken by 0.65 (from Ariunzul.Ya Doctoral thesis in 2008). In that research, calculated monthly forest index from 1998 to 2006 then compared average of three-ten days period of each month in ten years vegetation of NDVI.

Graph 14. NDVI threshold of August for define forest cover



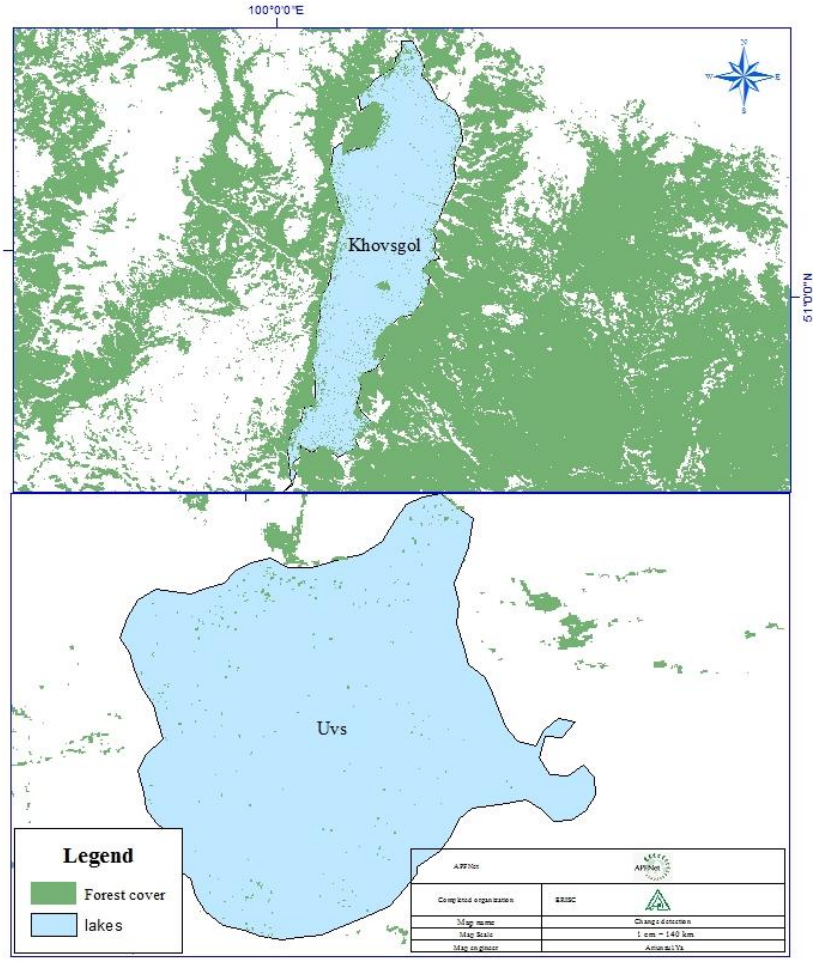
Mongolian forest cover defined by NDVI with threshold 0.65 of MODIS satellite data as shown in Picture 75.


2000
2001
2002
2003
2004
2005
2006
2007
Ulaanbaatar
APFNet
Completed organization
ERISC
Map name
Forest cover map of Mongolia
Map Scale
1 cm = 250 km
Map engineer
Artsenul Ya

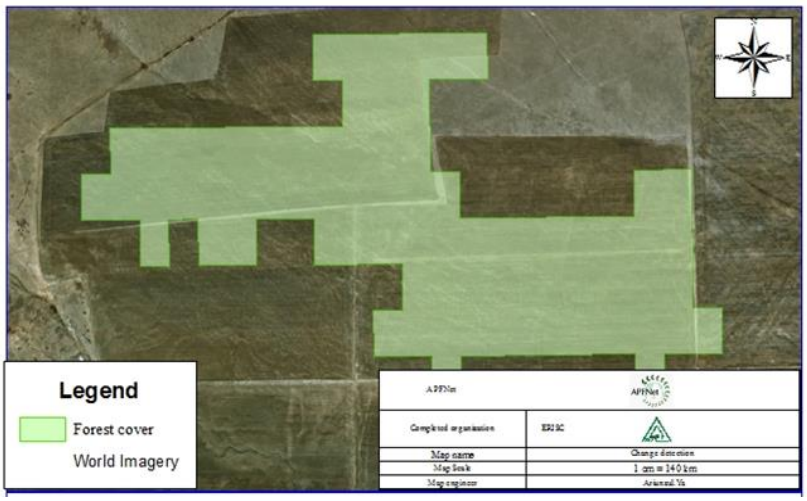


Picture 77. Forest cover mapping by NDVI of MODIS satellite data from 2000 to 2015

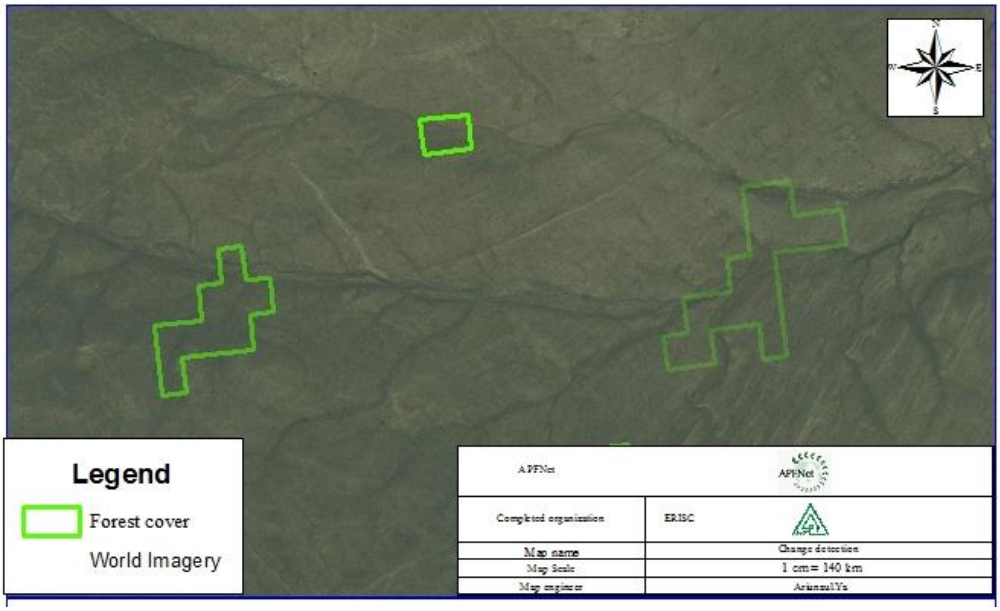
MODIS data has a risk to identify water body, cropland area, meadow, wetland of riverside as a forest.



Picture 78. The mistake detected with water body as a forest in MODIS data



Picture 79. The mistake detected with cropland as a forest in MODIS data



Picture 80. The mistake detected with meadow and pasture as a forest in MODIS data

2.7. ACTIVITY LEVEL FOUR

FOREST COVER CHANGE DETECTION

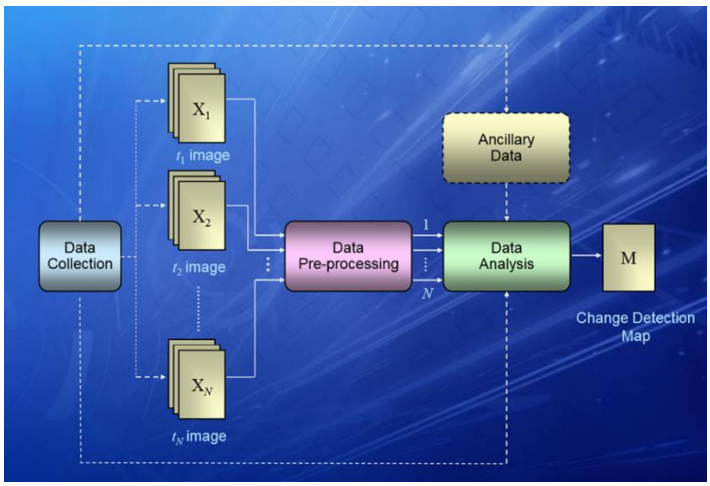
2.7.1. Calculate change detection for forest cover

The determination of chronological forest cover from satellite data in same area has give knowledge about how that area changed in 15 years. There has two type of change. First change is forest cover area changed into the other land cover type such as shrub, pasture or meadow etc. The second change is forest index value change, which is connected with forest biomass and also may affect by data period. If there was value of the forest index changed in same period, may express the area has occurred forest scarced or insected or fired.

Our project studied forest cover change by area. In other word, historical forest detection area changed into the nonforest area we calculate as a forest decrease and vice versa. Two type of forest change detection made by our project, the first Landsat satellite forest index calculated forest area change and MODIS satellite NDVI calculated forest cover change.

We calculated change detection between maximum likelihood classification forest cover area and forest index calculated forest cover area in two pilot community forest area. The forest cover change detection made the approach of Francesca Bovolo, and Lorenzo Bruzzone of Trento Univirsity, Italia (F. Bovolo, L. Bruzzone, 2015).

Schema 5. Approach of forest change detection



2.7.2. Change detection of forest cover from the forest index of Landsat satellite data

The forest cover change detection from the Landsat satellite data made the approach of Francesca Bovolo, and Lorenzo Bruzzone of Trento Univirsity, Italia (F. Bovolo, L. Bruzzone, 2015). It means forest cover change detection map created from difference between 2000 Mongolian forest cover area and 2015-forest cover area. However, table and graph shows yearly difference of forest cover area. Forest increase notified in riverside and distant place from the public. Whereas forest decrease notifies on deepest part of forest and public place. Some province shown increasement and decreasement.

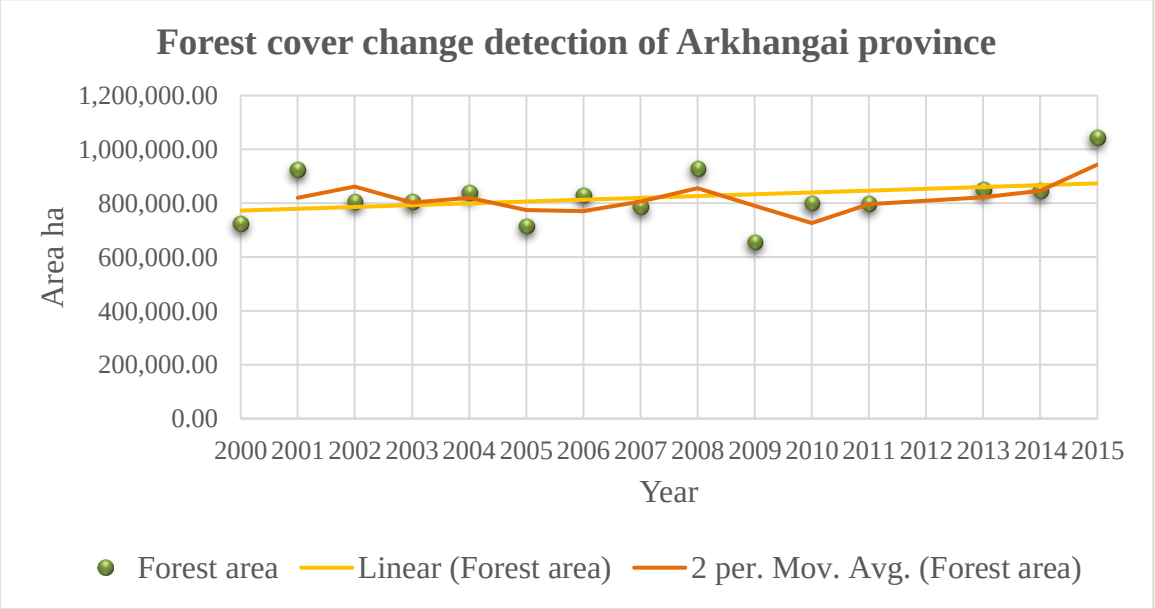
2.7.3. Arkhangai province forest cover change

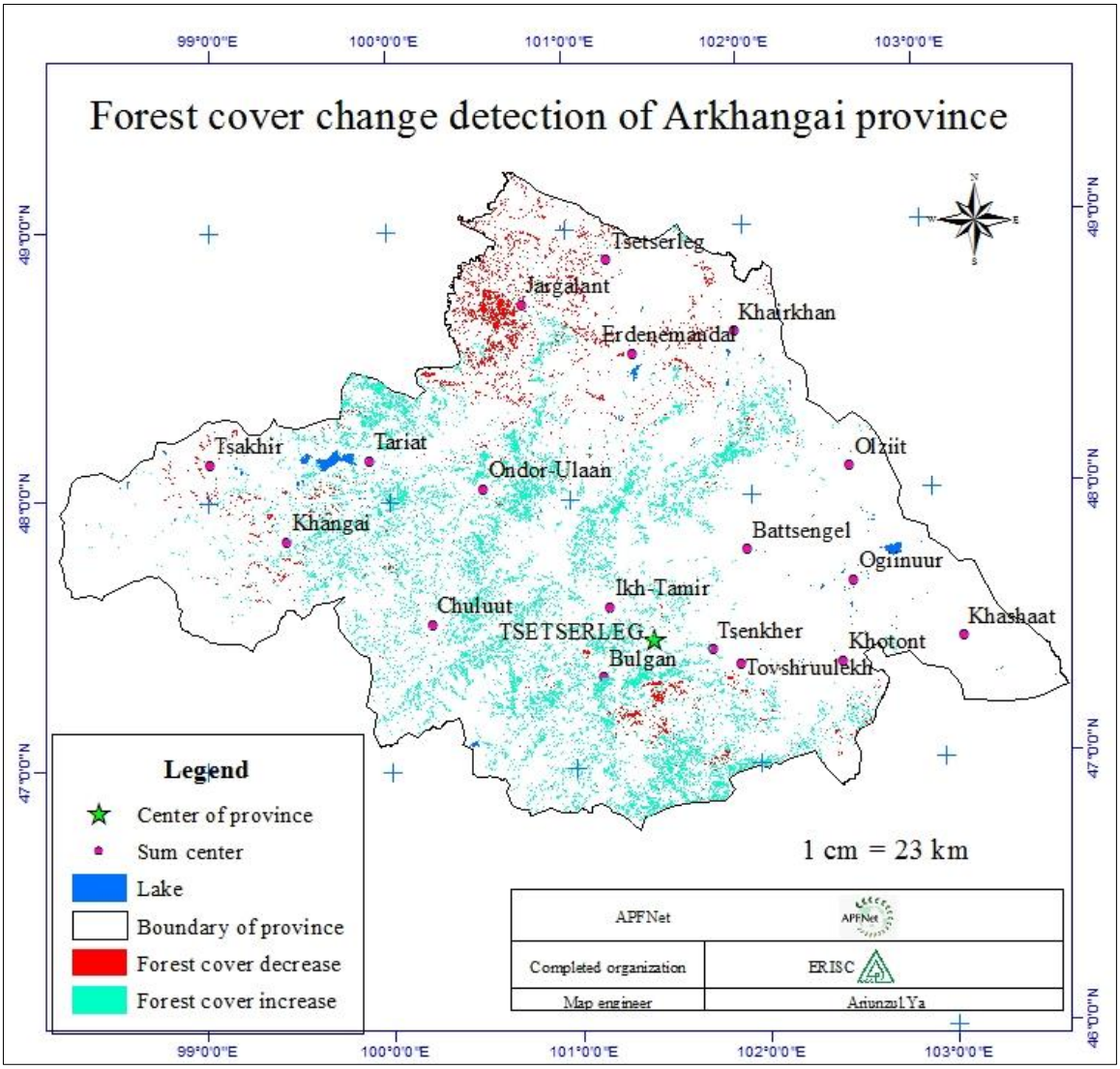
Arkhangai has 5531.4 thousand hectares area. Taxation data of FRDC shows 14.45 percent of the province landscape covered by forest which means 799.4 thousand hectare area is natural forest. Forest fund area determined by taxation data in 1995-1996 and 2008. The Arkhangai province forest cover area increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Arkhangai province has 821.3 thousand hectares and it is 14.9% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2008 by 125.8 thousand hectare which means 16.7% of the province total ladscape as 925.2 thousand hectares.

Table 10. Arkhangai province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	720274.03	13.02			
2001	920672.56	16.64			
2002	802680.21	14.51			
2003	803337.75	14.52			
2004	835793.09	15.11			
2005	712559.93	12.88			
2006	827935.14	14.97			
2007	785375.32	14.20	5,531,382.0		
2008	925162.03	16.73		799,400.0	125,762.0
2009	654168.23	11.83			
2010	798750.74	14.44			
2011	796169.92	14.39			
2013	849062.01	15.35			
2014	844790.14	15.27			
2015	1042746.40	18.85			
Average	821298.50	14.85			

Graph 15. Arkhangai province forest cover change





Picture 81. Arkhangai province forest cover change

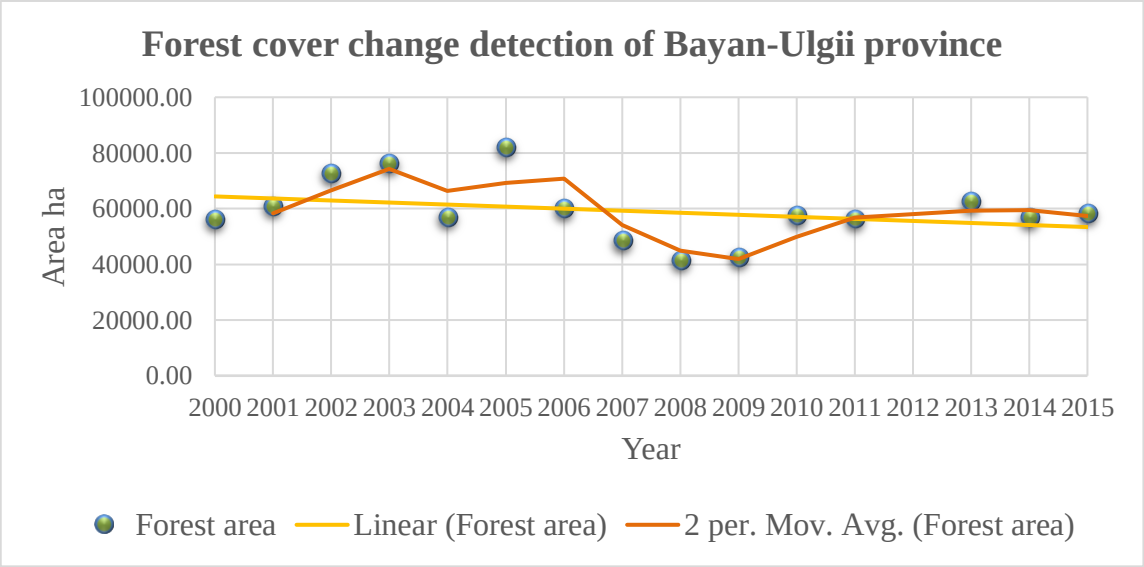
2.7.4. Bayan-Ulgii province forest cover change

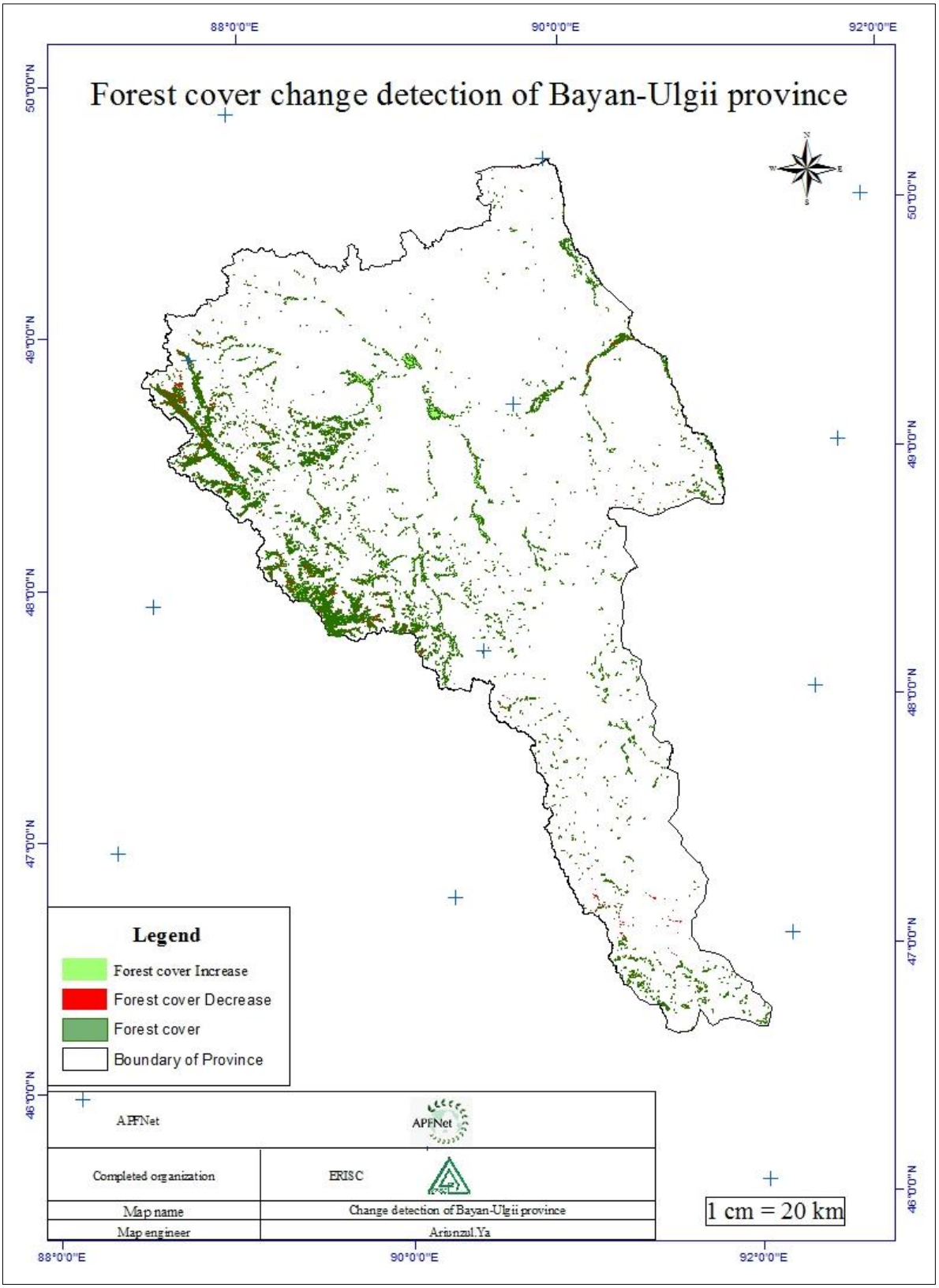
Bayan-Ulgii has 4670.5 thousand hectares area. Taxation data of FRDC shows 0.9 percent of the province landscape covered by forest which means 42.3 thousand hectare area is natural forest. Forest fund area determined by taxation data in 1985 and 2008. The Bayan-Ulgii province forest cover area decreased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Bayan-Ulgii province has 59.1 thousand hectares and it is 1.27% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2008 by 0.9 thousand hectare which means 0.89% of the province total ladscape as 41.4 thousand hectares.

Table 11. Bayan-Ulgii province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Bayan-Ulgii	Taxation Data	Difference
2000	56023.44513	1.20			
2001	60731.82397	1.30			
2002	72462.52485	1.55			
2003	76076.64986	1.63			
2004	56707.93314	1.21			
2005	81804.62146	1.75			
2006	59792.41946	1.28			
2007	48291.50327	1.03	4670489.00 ha		
2008	41427.08547	0.89		42300.00 ha	-872.91ha
2009	42337.10231	0.91			
2010	57447.83571	1.23			
2011	56205.86693	1.20			
2013	62416.55037	1.34			
2014	56684.76759	1.21			
2015	58219.02955	1.25			
Average	59108.6106	1.27			

Graph 16. Bayan-Ulgii province forest cover change





Picture 82. Bayan-Ulgii province forest cover change

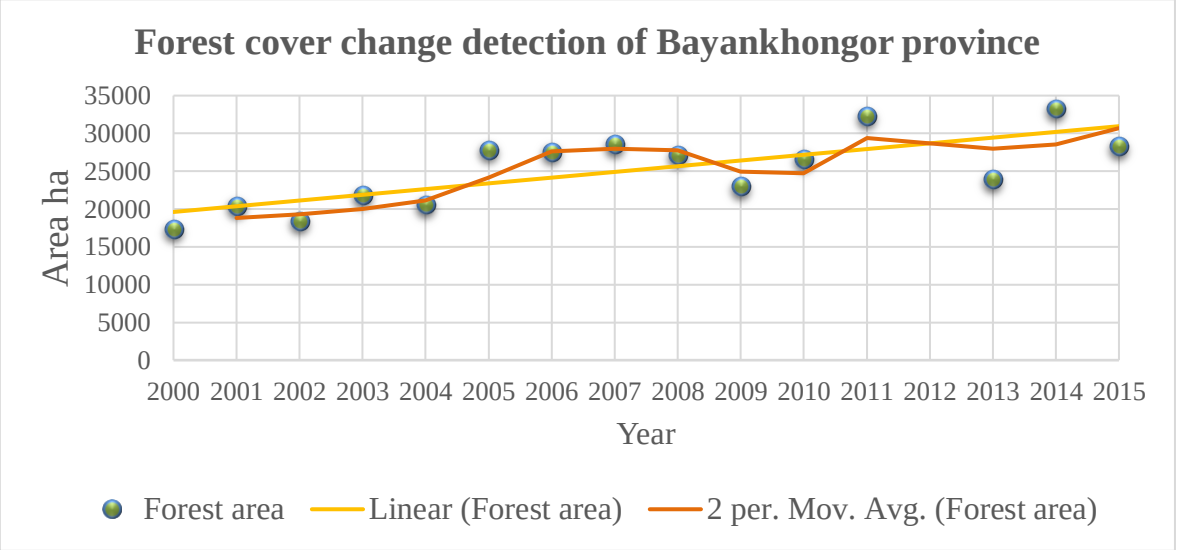
2.7.5. Bayankhongor province forest cover change

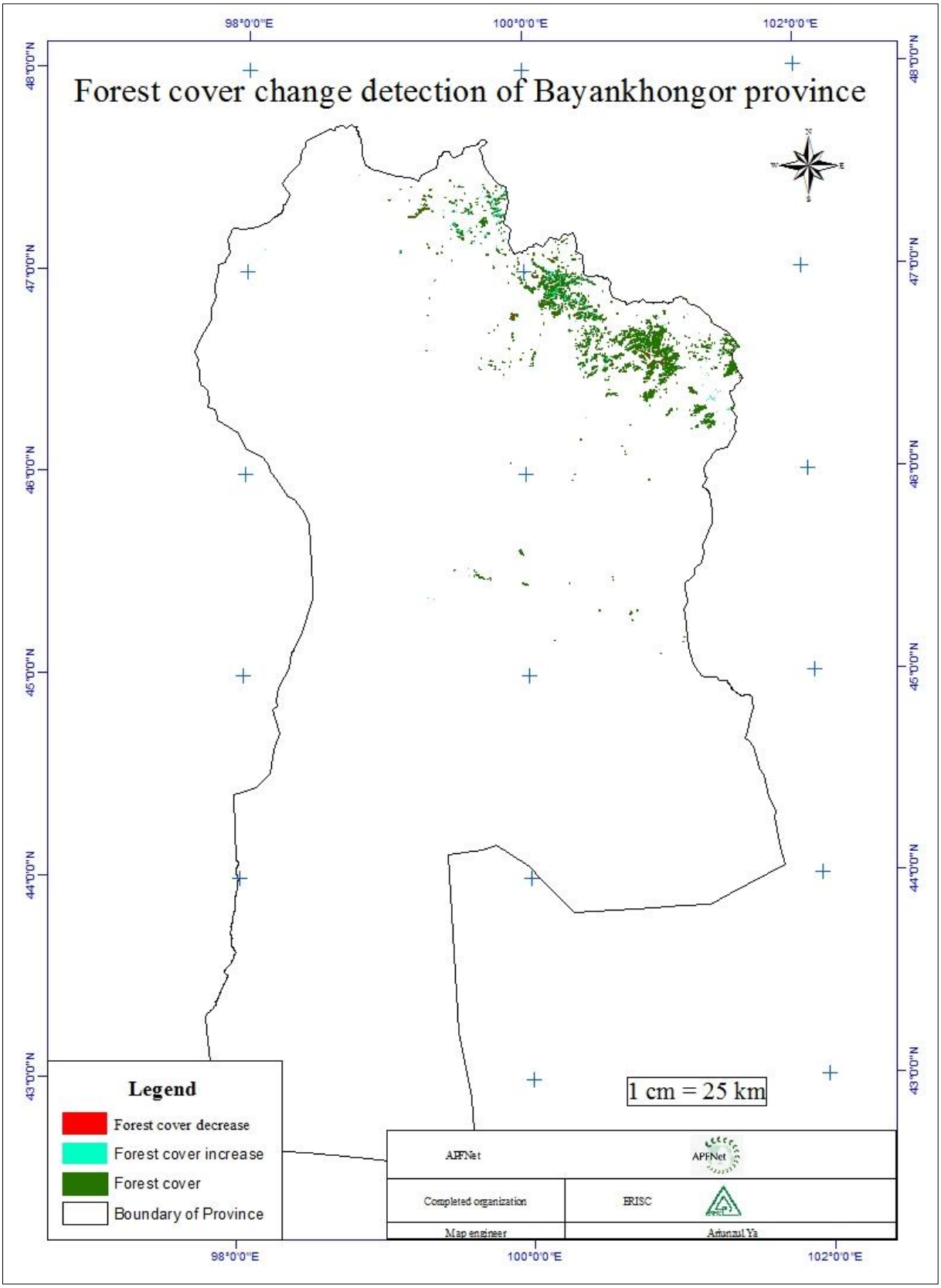
Bayankhongor has 11597.7 thousand hectares area. Taxation data of FRDC shows 0.26 percent of the province landscape covered by forest which means 29.8 thousand hectare area is natural forest. Forest fund area determined by taxation data in 1991, 2006 and 2015. The Bayankhongor province forest cover area increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Bayankhongor province has 25.1 thousand hectares and it is 0.22% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2015 by 1.7 thousand hectare which means 0.24% of the province total ladscape as 28.2 thousand hectares.

Table 12. Bayankhongor province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	17278.95422	0.15	11597780.0	29800.00	-1641.02
2001	20347.38738	0.18			
2002	18299.53206	0.16			
2003	21732.09198	0.19			
2004	20490.73676	0.18			
2005	27778.30737	0.24			
2006	27506.25022	0.24			
2007	28487.89732	0.25			
2008	27028.34557	0.23			
2009	22860.14975	0.20			
2010	26589.25158	0.23			
2011	32205.03597	0.28			
2013	23812.32242	0.21			
2014	33221.80402	0.29			
2015	28158.9755	0.24			
Average	25053.13614	0.22			

Graph 17. Bayankhongor province forest cover change





Picture 83. Bayankhongor province forest cover change

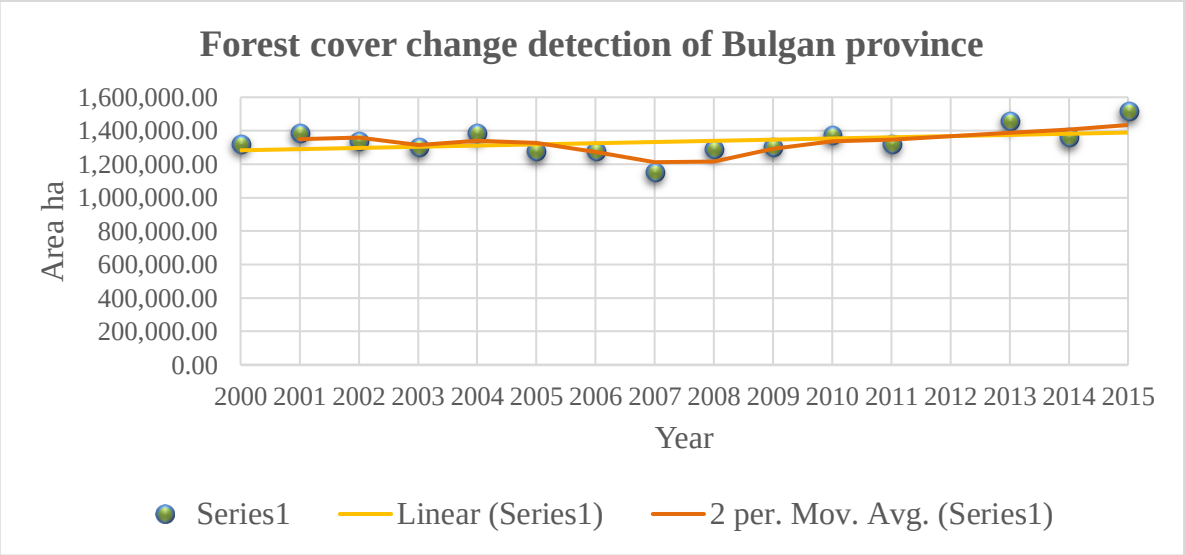
2.7.6. Bulgan province forest cover change

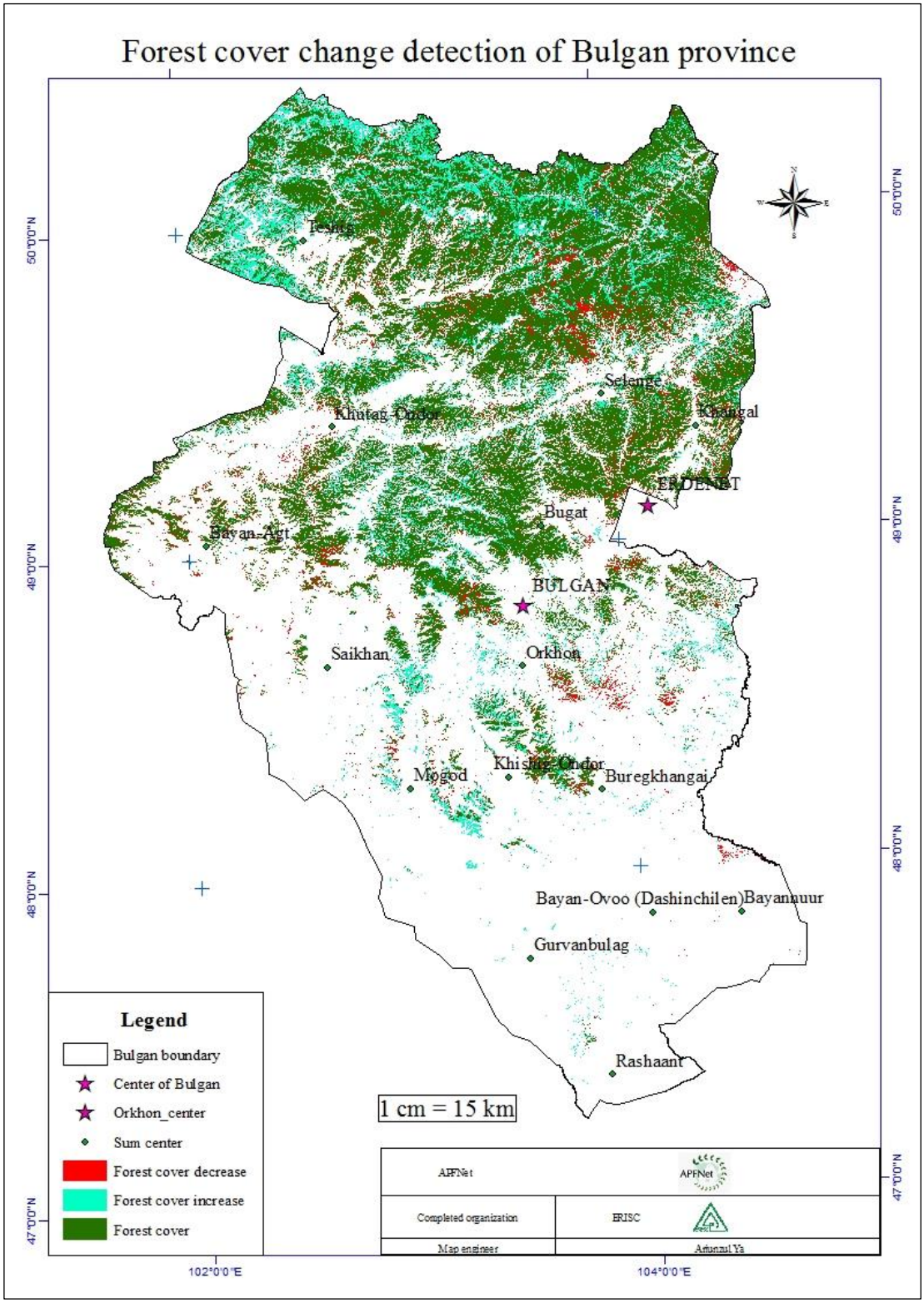
Bulgan has 4873.3 thousand hectares area. Taxation data of FRDC shows 26.9 percent of the province landscape covered by forest which means 1315.0 thousand hectare area is natural forest. Forest fund area determined by taxation data in 1997-1999 and 2010. The Bulgan province forest cover area slightly increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Bulgan province has 1333 thousand hectares and it is 27.37% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2010 by 58.1 thousand hectare which means 28.18% of the province total ladscape as 1373.1 thousand hectares.

Table 13. Bulgan province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	1,317,250.36	27.03	4873300.00	1315000.0	58056.4
2001	1,382,965.84	28.38			
2002	1,333,833.51	27.37			
2003	1,297,319.94	26.62			
2004	1,381,600.94	28.35			
2005	1,271,702.16	26.10			
2006	1,274,954.88	26.16			
2007	1,148,624.60	23.57			
2008	1,285,273.88	26.37			
2009	1,298,464.79	26.64			
2010	1,373,056.43	28.18			
2011	1,318,392.16	27.05			
2013	1,455,073.76	29.86			
2014	1,355,874.03	27.82			
2015	1,512,799.35	31.04			
Average	1,333,812.44	27.37			

Graph 18. Bulgan province forest cover change





Picture 84. Bulgan province forest cover change

Forest cover in south part of the Khangal, Selenge, Bayan-Agt and Teshig soum of Bulgan province has decreased, north part of Teshig soum and state boundary has increased.

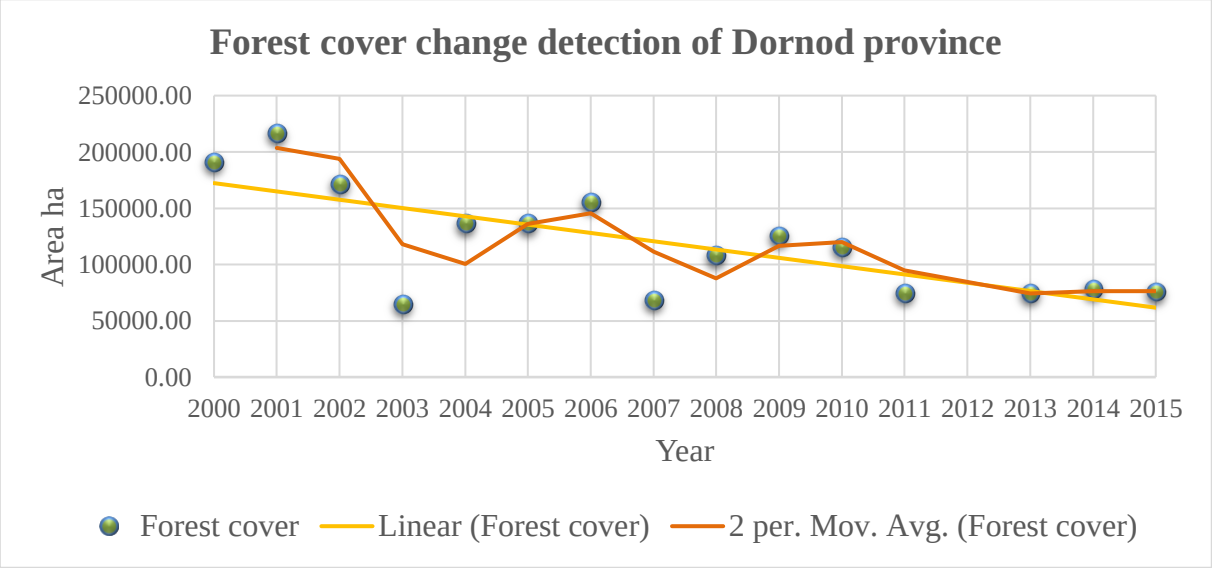
2.7.7. Dornod province forest cover change

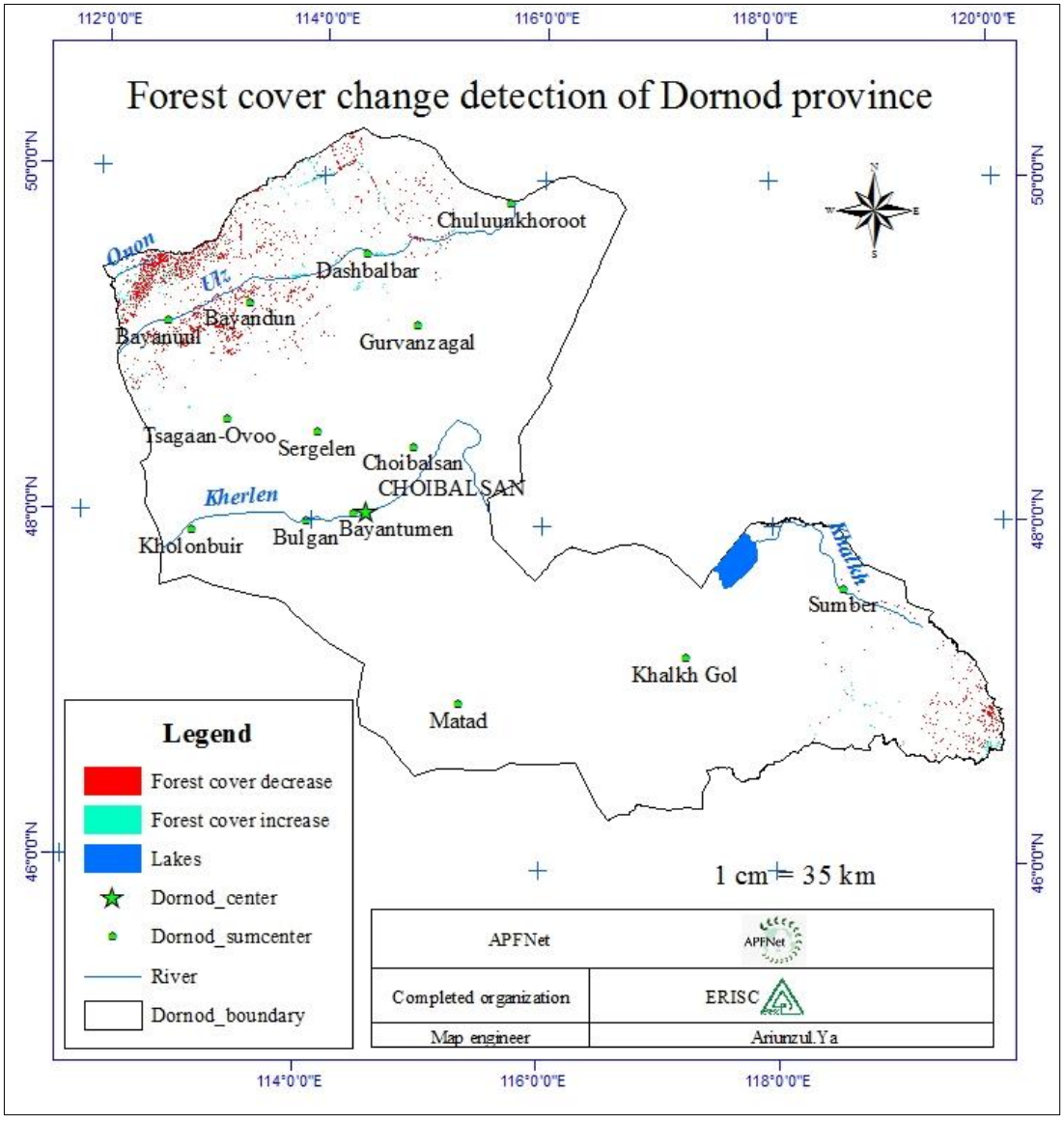
Dornod has 12359.7 thousand hectares area. Taxation data of FRDC shows 0.61 percent of the province landscape covered by forest which means 75.4 thousand hectare area is natural forest. Forest fund area determined by taxation data in 2003 and 2012. The Dornod province forest cover area decreased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Dornod province has 175 thousand hectares and it is 1.42% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2013 by 76.9 thousand hectare which means 1.23% of the province total ladscape as 152.4 thousand hectares.

Table 14. Dornod province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	190,722.00	2.44			
2001	216,337.44	1.75			
2002	171,212.35	1.60			
2003	170,607.35	1.38			
2004	135,256.89	1.09			
2005	163,106.38	1.32			
2006	155,155.09	1.26			
2007	185,148.08	1.50	12,359,743.00		
2008	215,339.04	1.74			
2009	223,529.22	1.81			
2010	146,758.22	1.19			
2011	106,789.39	0.86		75,400.00	76,972.69
2013	152,372.69	1.23			
2014	152,372.69	1.23			
2015	104,377.48	0.84			
Average	175,025.20	1.42			

Graph 19. Dornod province forest cover change





Picture 85. Dornod province forest cover change

Nomrog national reservation land of Khalkhgol soum of Dornod province has bit increasement and other area forest cover has decreased.

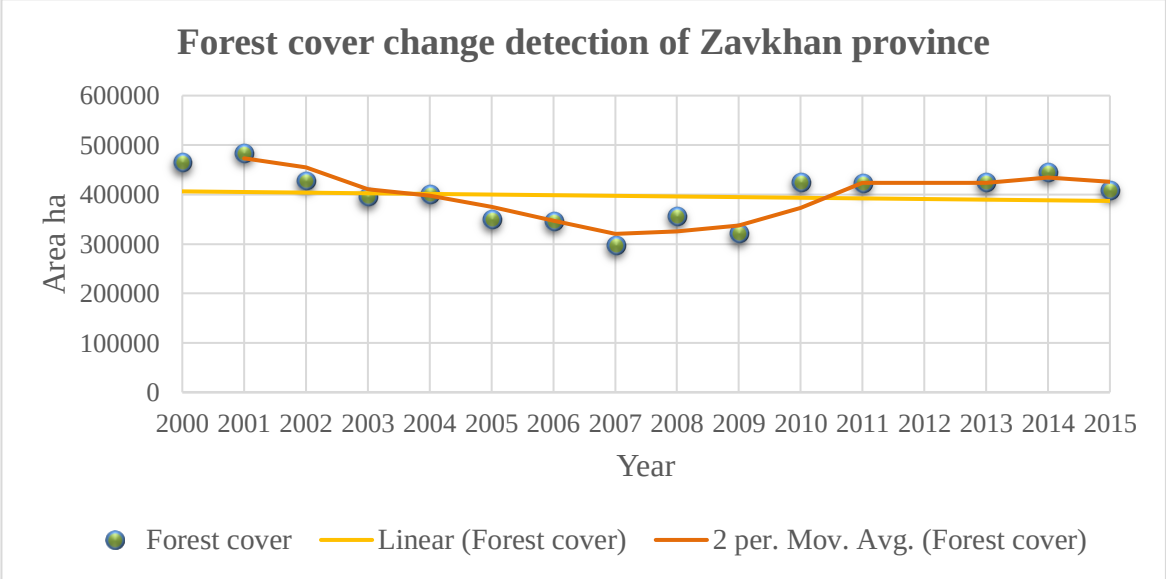
2.7.8. Zavkhan province forest cover change

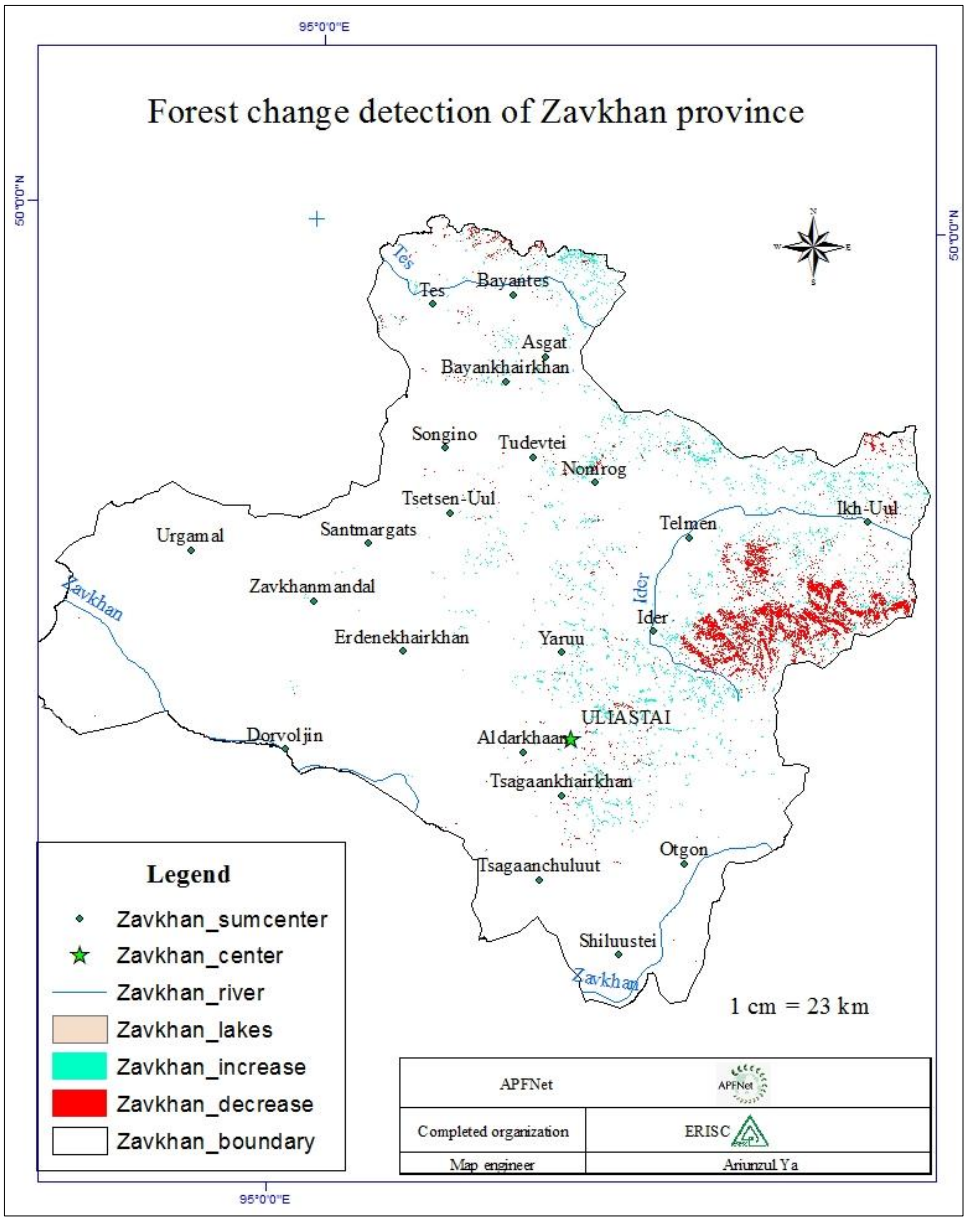
Zavkhan has 8245.6 thousand hectares area. Taxation data of FRDC shows 5.54 percent of the province landscape covered by forest which means 456.8 thousand hectare area is natural forest. Forest fund area determined by taxation data in 2006 and 2013. The Zavkhan province forest cover area decreased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Zavkhan province has 397.07 thousand hectares and it is 4.82% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2013 by 32.9 thousand hectare which means 5.14% of the province total ladscape as 423.9 thousand hectares.

Table 15. Zavkhan province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	464,011.82	5.63	8,245,566.00		
2001	482,503.51	5.85			
2002	426,594.27	5.17			
2003	394,219.38	4.78			
2004	400,030.32	4.85			
2005	349,455.83	4.24			
2006	344,965.65	4.18			
2007	295,815.17	3.59			
2008	355,222.20	4.31			
2009	319,838.53	3.88			
2010	424,925.22	5.15			
2011	422,197.62	5.12			
2013	423,895.85	5.14		456,800.00	-32,904.15
2014	444,302.65	5.39			
2015	408,113.40	4.95			
Average	397,072.76	4.82			

Graph 20. Zavkhan province forest cover change





Picture 86. Zavkhan province forest cover change

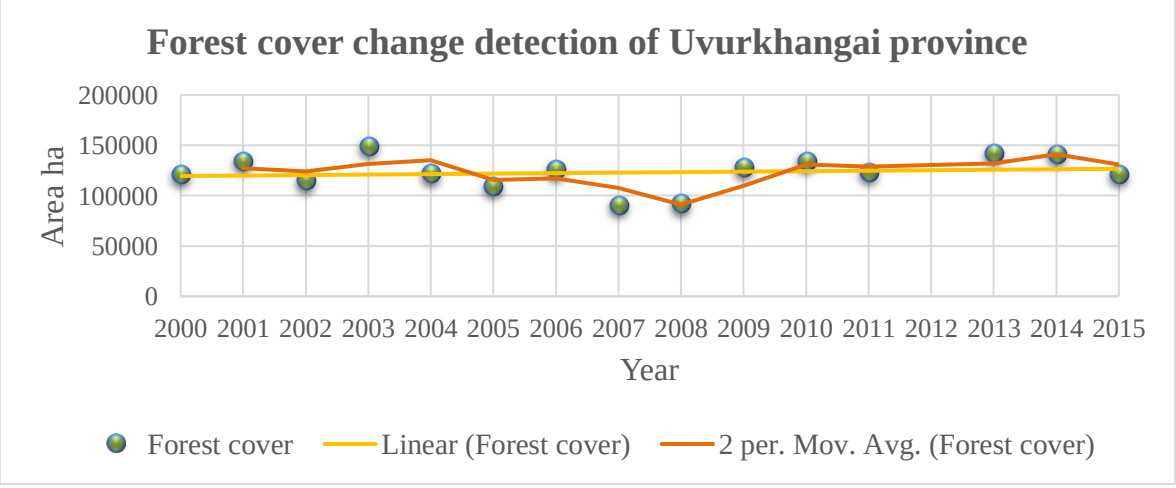
2.7.9. Uvurkhangai province forest cover change

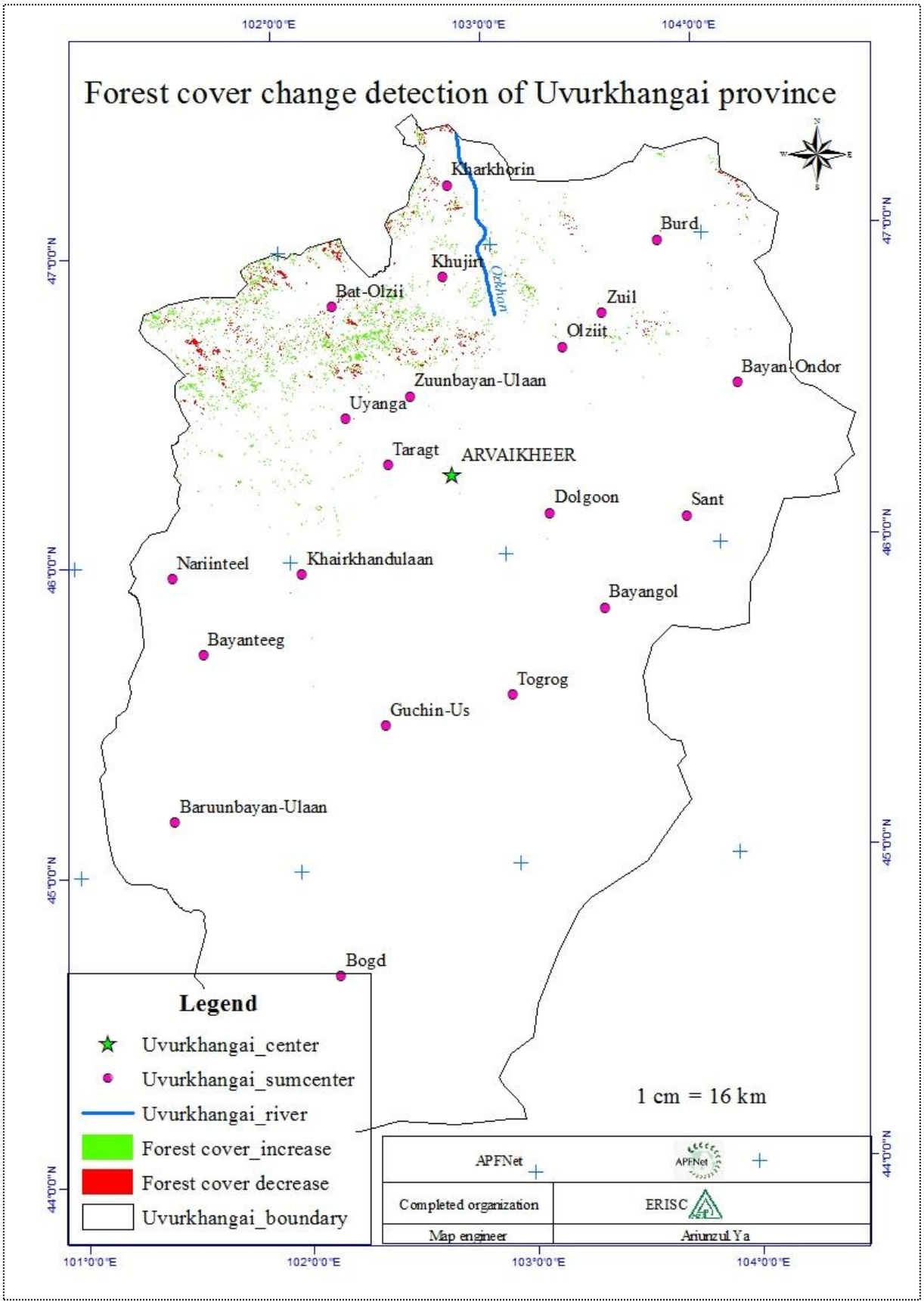
Uvurkhangai has 6289.5 thousand hectares area. Taxation data of FRDC shows 2.14 percent of the province landscape covered by forest which means 134.6-thousand-hectare area is natural forest. Forest fund area determined by taxation data in 1997 and 2008. The Uvurkhangai province forest cover area slightly increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Uvurkhangai province has 122.9 thousand hectares and it is 1.95% of the province landscape. The forest cover area of Landsat data is lower than FRDC taxation data of the 2008 by 42.7 thousand hectare which means 1.46% of the province total ladscape as 91.9 thousand hectares.

Table 16. Uvurkhangai province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	120,165.20	1.91			
2001	133,854.84	2.13			
2002	114,467.10	1.82			
2003	148,813.53	2.37			
2004	121,547.96	1.93			
2005	109,297.48	1.74			
2006	125,393.77	1.99			
2007	90,250.37	1.43	6,289,533.00		
2008	91,890.09	1.46		134,600.00	-42,709.91
2009	127,682.56	2.03			
2010	134,249.60	2.13			
2011	123,157.88	1.96			
2013	141,294.11	2.25			
2014	140,735.16	2.24			
2015	120,866.33	1.92			
Average	122,911.06	1.95			

Graph 21. Uvurkhangai province forest cover change





Picture 87. Uvurkhangai province forest cover change

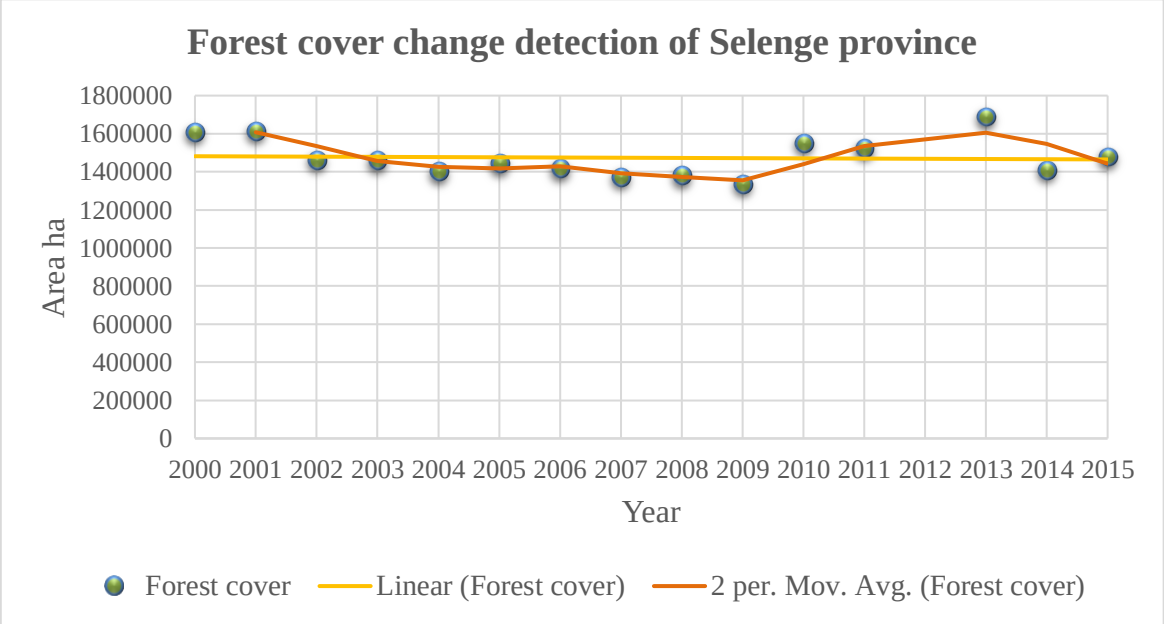
2.7.10. Selenge province forest cover change

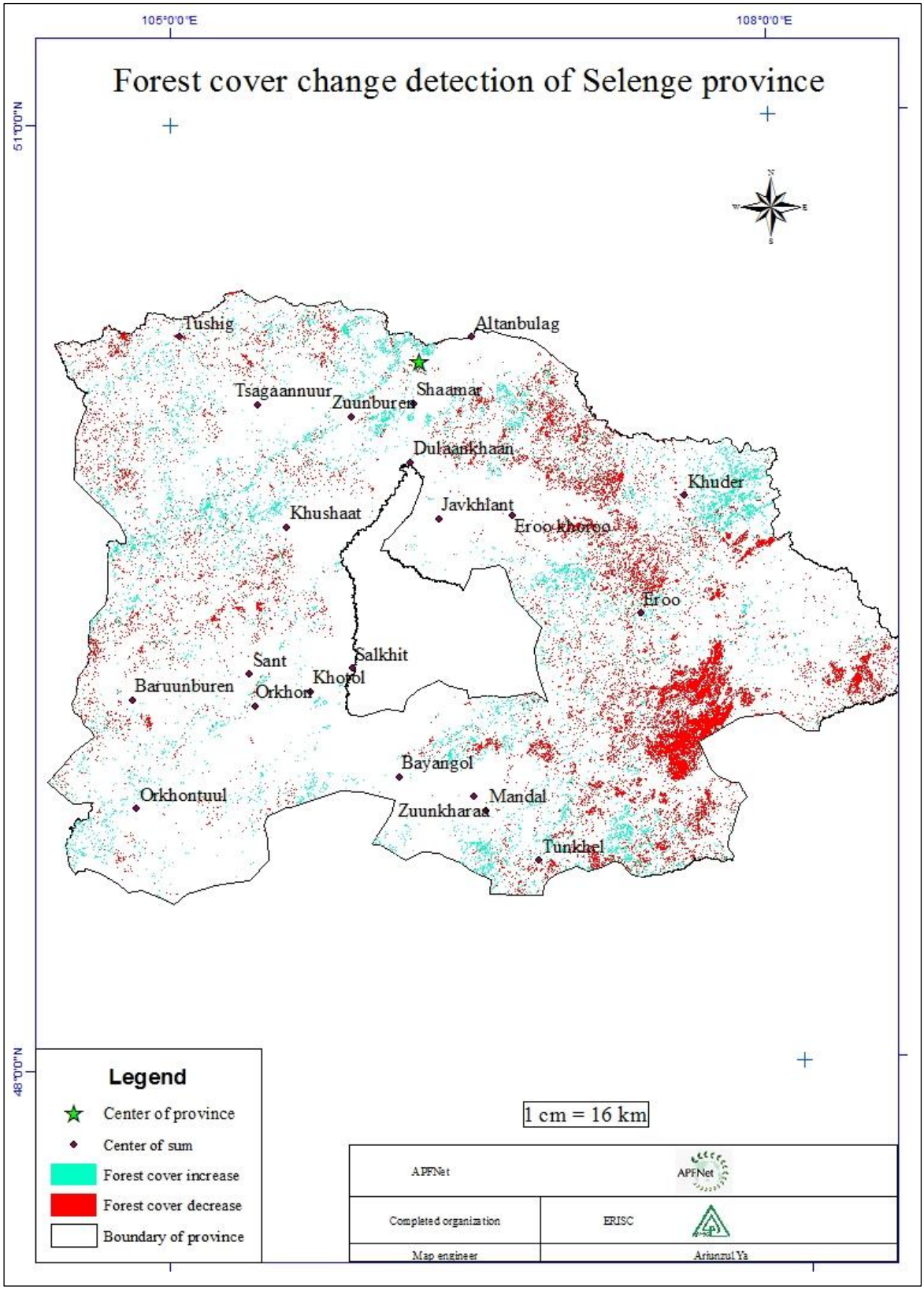
Selenge has 4115.3 thousand hectares area. Taxation data of FRDC shows 33.96 percent of the province landscape covered by forest which means 1397.4 thousand hectare area is natural forest. Forest fund area determined by taxation data in 1992-1994 and 2008-2009. The Selenge province forest cover area decreased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Selenge province has 1477.5 thousand hectares and it is 35.9% of the province landscape. The forest cover area of Landsat data is lower than FRDC taxation data of the 2009 by 64.8 thousand hectare which means 32.38% of the province total ladscape as 1332.5 thousand hectares.

Table 17. Selenge province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	1,604,191.97	38.98			
2001	1,610,886.10	39.14			
2002	1,459,577.06	35.47			
2003	1,455,757.10	35.37			
2004	1,397,090.51	33.95			
2005	1,439,984.62	34.99			
2006	1,415,317.59	34.39			
2007	1,370,206.82	33.30	4,115,263.00		
2008	1,377,734.25	33.48			
2009	1,332,553.52	32.38		1,397,400.00	-64,846.48
2010	1,548,509.81	37.63			
2011	1,520,723.27	36.95			
2013	1,687,672.30	41.01			
2014	1,407,158.33	34.19			
2015	1,535,354.19	37.31			
Average	1,477,514.49	35.90			

Graph 22. Selenge province forest cover change





Picture 88. Selenge province forest cover change

Zuunburen, Khushaat and Tsagaannuur soums forest cover slightly increased and Mandal, Tunkhel, Yoroo and Dulaankhaan soum forest cover has great decrease.

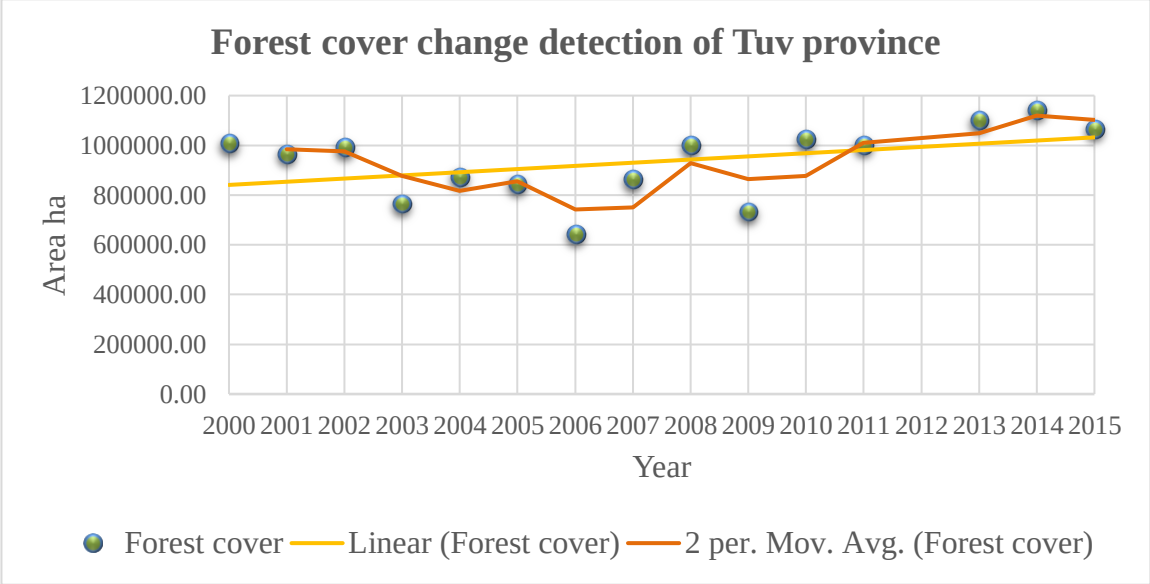
2.7.11. Tuv province forest cover change

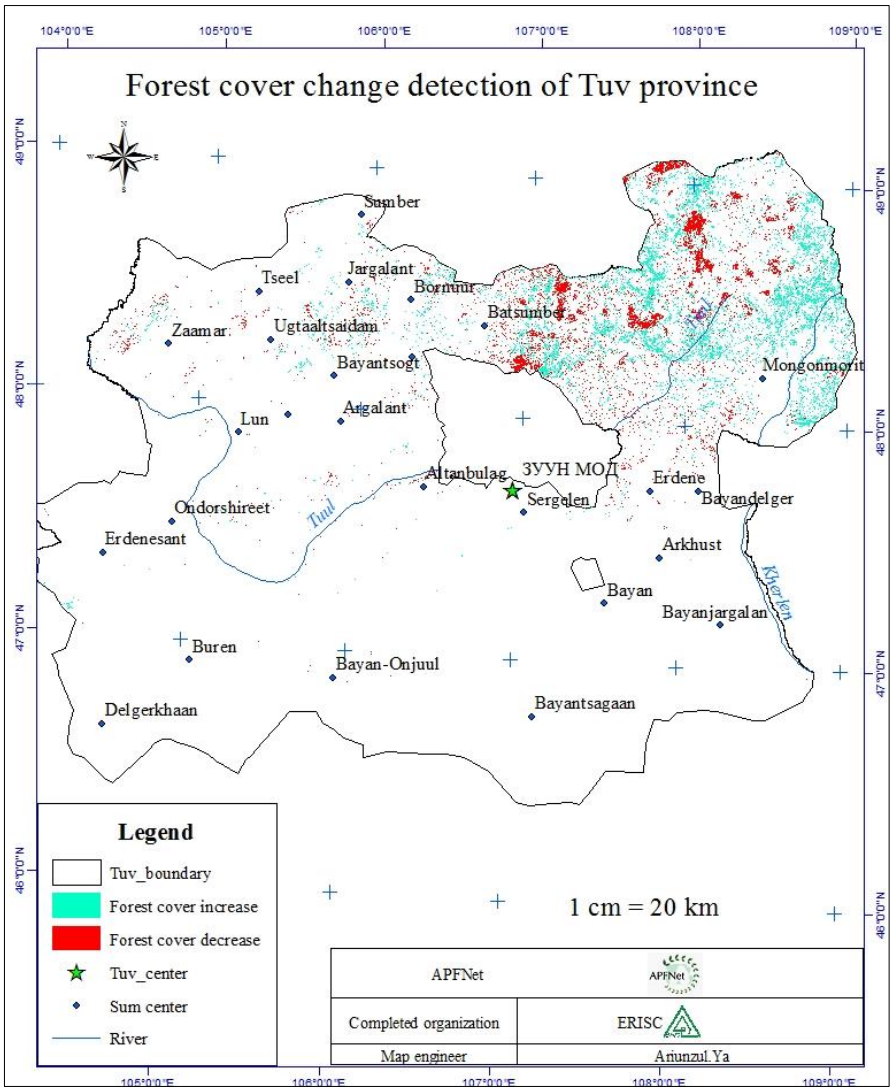
Tuv has 7404.2 thousand hectares area. Taxation data of FRDC shows 12.9 percent of the province landscape covered by forest which means 957.2 thousand hectare area is natural forest. Forest fund area determined by taxation data in 2007 and 2013. The Tuv province forest cover area decreased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Tuv province has 932.6 thousand hectares and it is 12.6% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2013 by 140.2 thousand hectare which means 14.82% of the province total ladscape as 1097.4 thousand hectares.

Table 18. Tuv province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	1,005,940.21	13.59	7,404,237.00		
2001	963,246.35	13.01			
2002	988,092.67	13.34			
2003	763,997.57	10.32			
2004	870,756.88	11.76			
2005	842,220.06	11.37			
2006	642,084.42	8.67			
2007	860,736.48	11.62			
2008	997,879.04	13.48			
2009	731,500.61	9.88			
2010	1,020,505.24	13.78			
2011	999,287.73	13.50			
2013	1,097,378.10	14.82		957,200.00	140,178.10
2014	1,141,840.97	15.42			
2015	1,064,371.40	14.38			
Average	932,655.85	12.60			

Graph 23. Tuv province forest cover change





Picture 89. Tuv province forest cover change

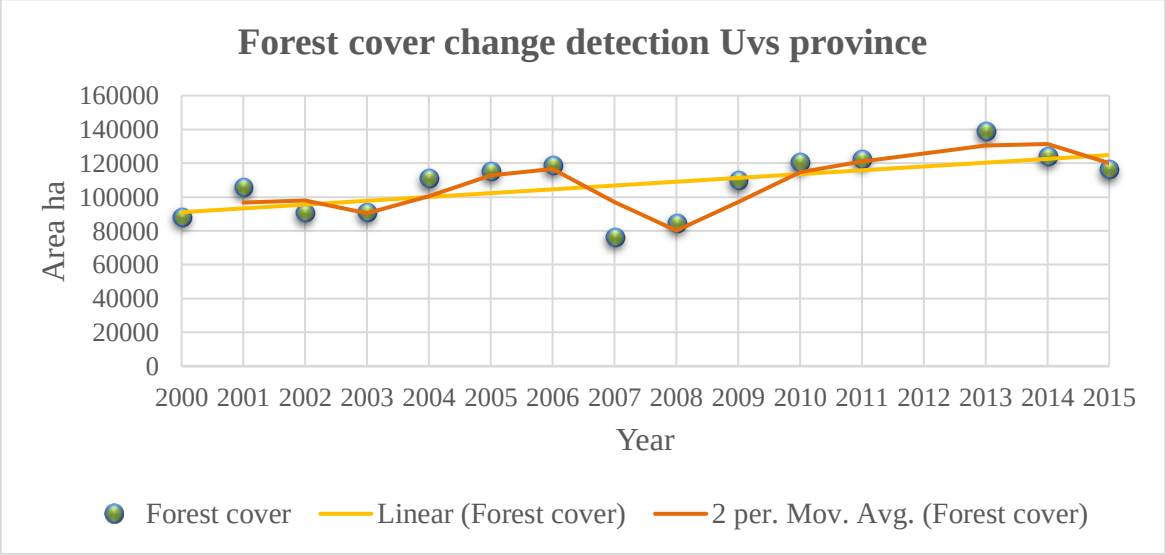
2.7.12. Uvs province forest cover change

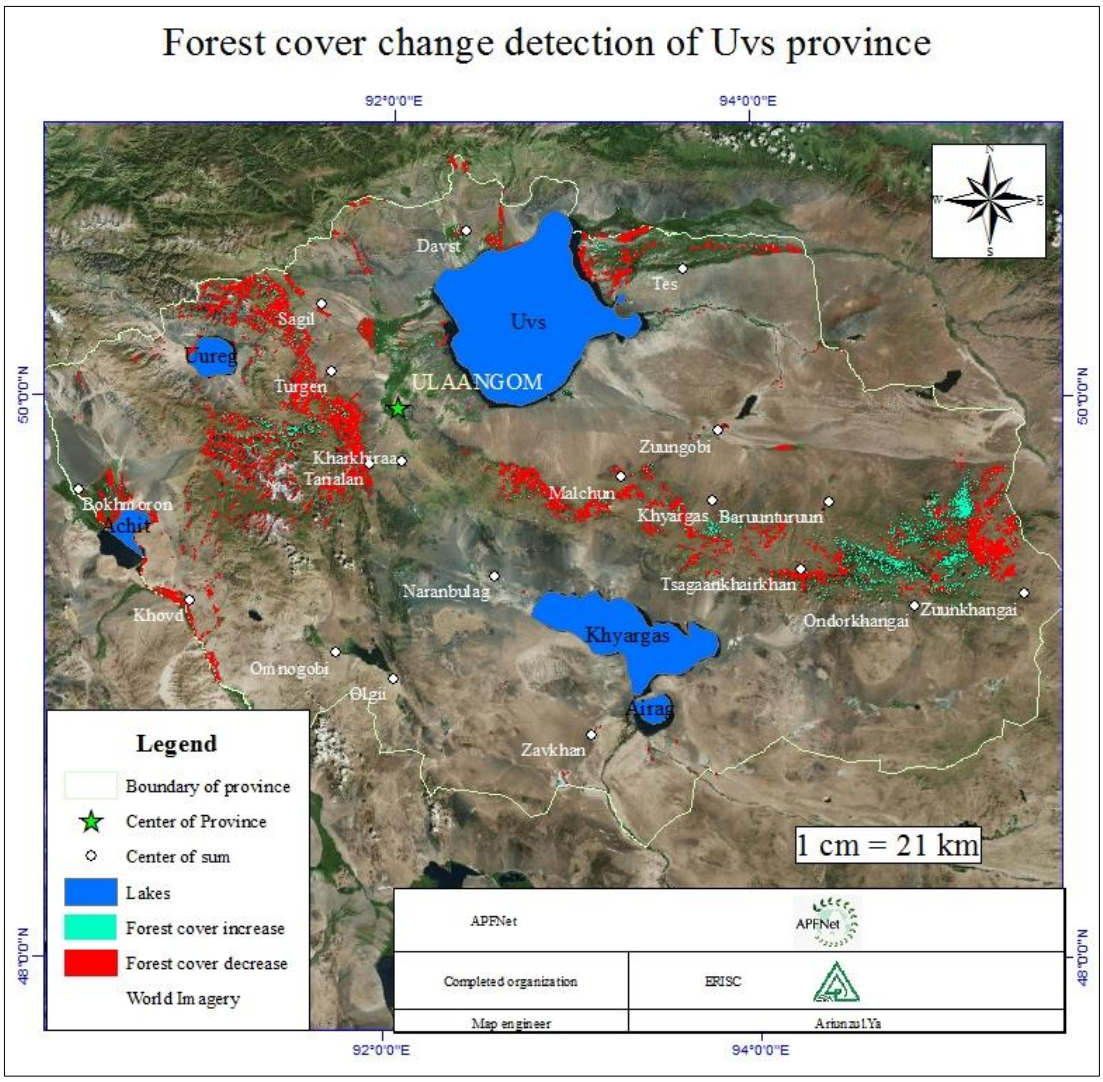
Uvs has 6958.6 thousand hectares area. Taxation data of FRDC shows 2.8 percent of the province landscape covered by forest which means 197.3 thousand hectare area is natural forest. Forest fund area determined by taxation data in 1990 and 2011. The Uvs province forest cover area increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Uvs province has 107.3 thousand hectares and it is 1.54% of the province landscape. The forest cover area of Landsat data is lower than FRDC taxation data of the 2011 by 75 thousand hectare which means 1.76% of the province total ladscape as 122.2 thousand hectares.

Table 19. Uvs province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	87,755.38	1.26	6,958,539.00		
2001	105,411.54	1.51			
2002	90,386.62	1.30			
2003	90,579.22	1.30			
2004	110,720.46	1.59			
2005	114,918.21	1.65			
2006	118,383.40	1.70			
2007	75,860.23	1.09			
2008	84,518.78	1.21			
2009	109,652.11	1.58			
2010	119,921.21	1.72			
2011	122,206.31	1.76		197300.0	-75,093.69
2013	138,817.66	1.99			
2014	123,918.97	1.78			
2015	115,972.34	1.67			
Average	107,268.16	1.54			

Graph 24. Uvs province forest cover change





Picture 90. Uvs province forest cover change

Ondorkhangai, Zuunkhangai, Baruunturuun and Turgen soum's forest cover has increased and Sagil, Turgen, Tarialan, Naranbualg, Malchin, Tes and Zuunkhangai soum forest cover has decreased.

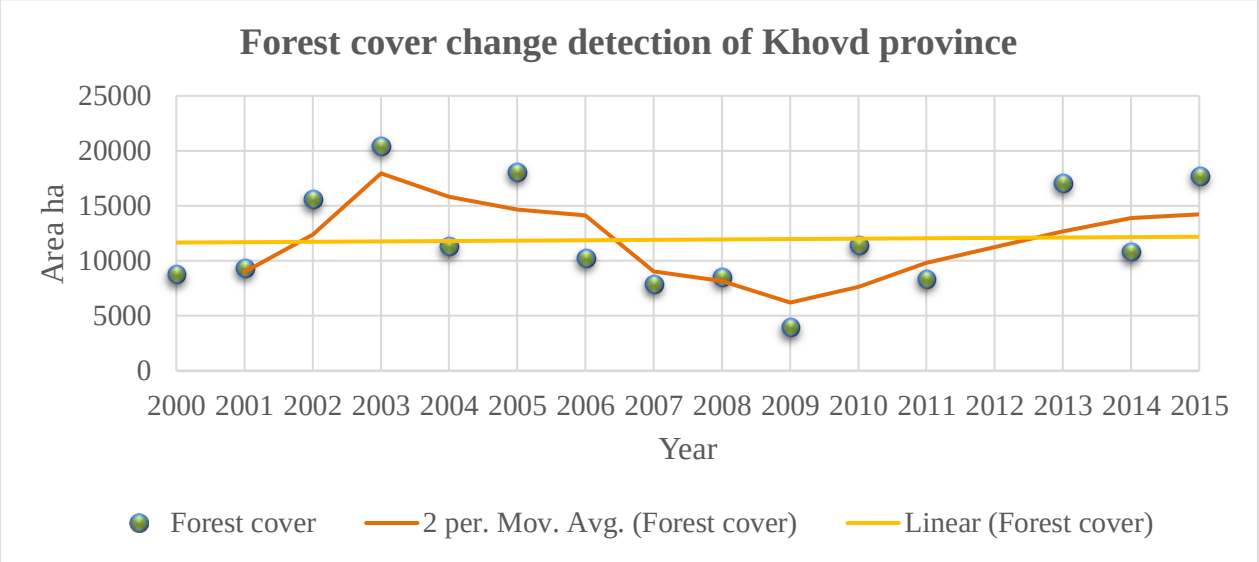
2.7.13. Khovd province forest cover change

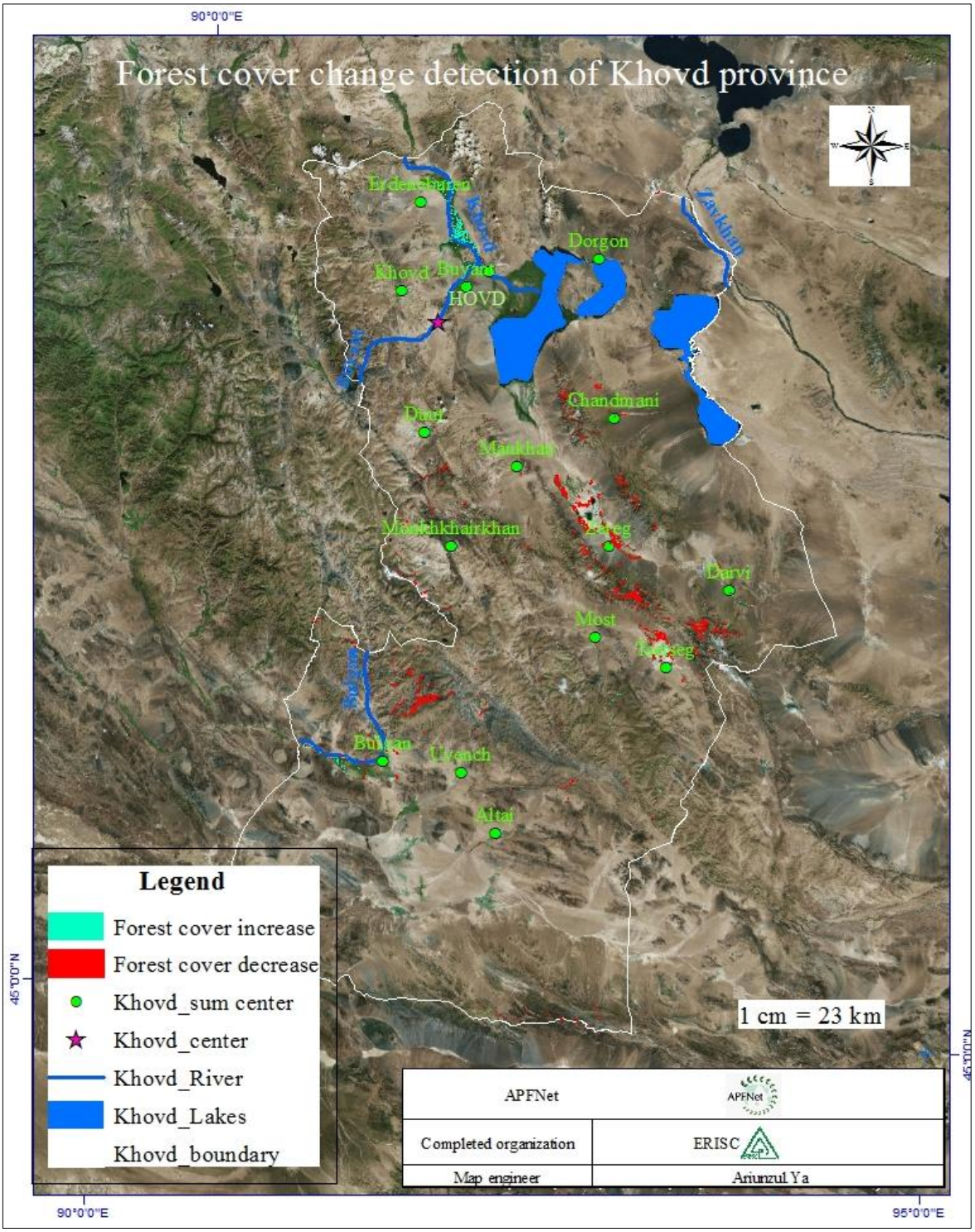
Khovd has 7606 thousand hectares area. Taxation data of FRDC shows 0.16 percent of the province landscape covered by forest which means 12.4 thousand hectare area is natural forest. Forest fund area determined by taxation data in 2011. The Khovd province forest cover area decreased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Khovd province has 11.9 thousand hectares and it is 0.16% of the province landscape. The forest cover area of Landsat data is lower than FRDC taxation data of the 2011 by 4.1 thousand hectare which means 0.11% of the province total ladscape as 8.3 thousand hectares.

Table 20. Khovd province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	8,693.16	0.11	7,606,038.00		
2001	9,268.60	0.12			
2002	15,535.80	0.20			
2003	20,365.74	0.27			
2004	11,253.13	0.15			
2005	18,035.36	0.24			
2006	10,189.86	0.13			
2007	7,844.96	0.10			
2008	8,506.95	0.11			
2009	3,909.08	0.05			
2010	11,343.87	0.15			
2011	8,289.58	0.11		12400.00	-4,110.42
2013	17,022.13	0.22			
2014	10,794.78	0.14			
2015	17,680.35	0.23			
Average	11,915.56	0.16			

Graph 25. Khovd province forest cover change





Picture 91. Khovd province forest cover change

Khovd riverside rush slightly increased of Erdeneburen soum of Khovd and other part forest cover decreased.

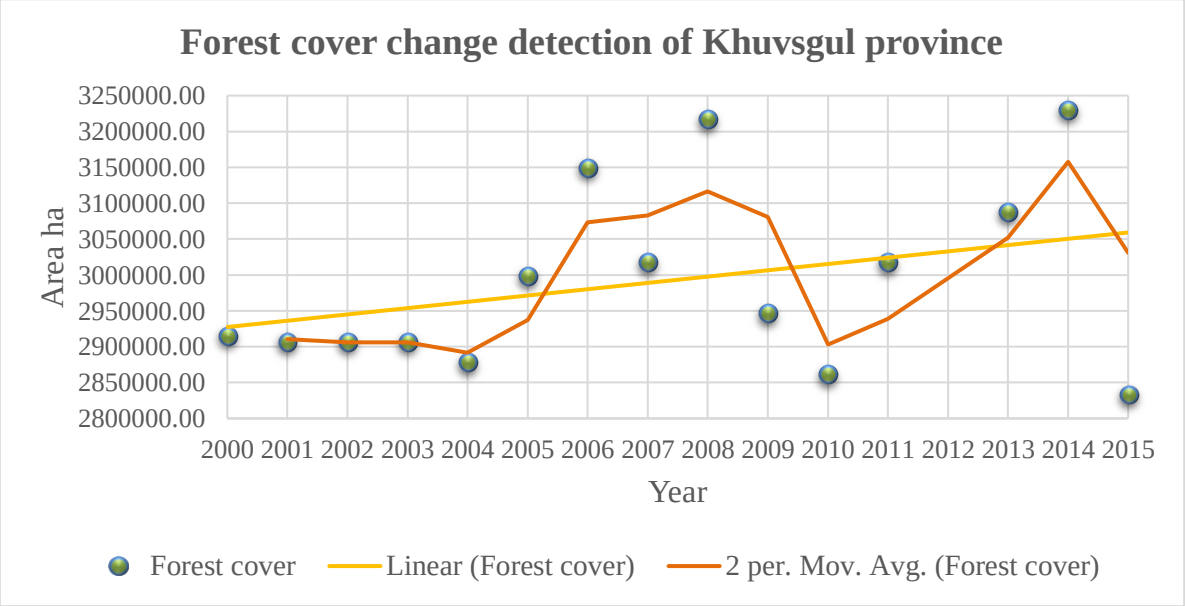
2.7.14. Khuvsgul province forest cover change

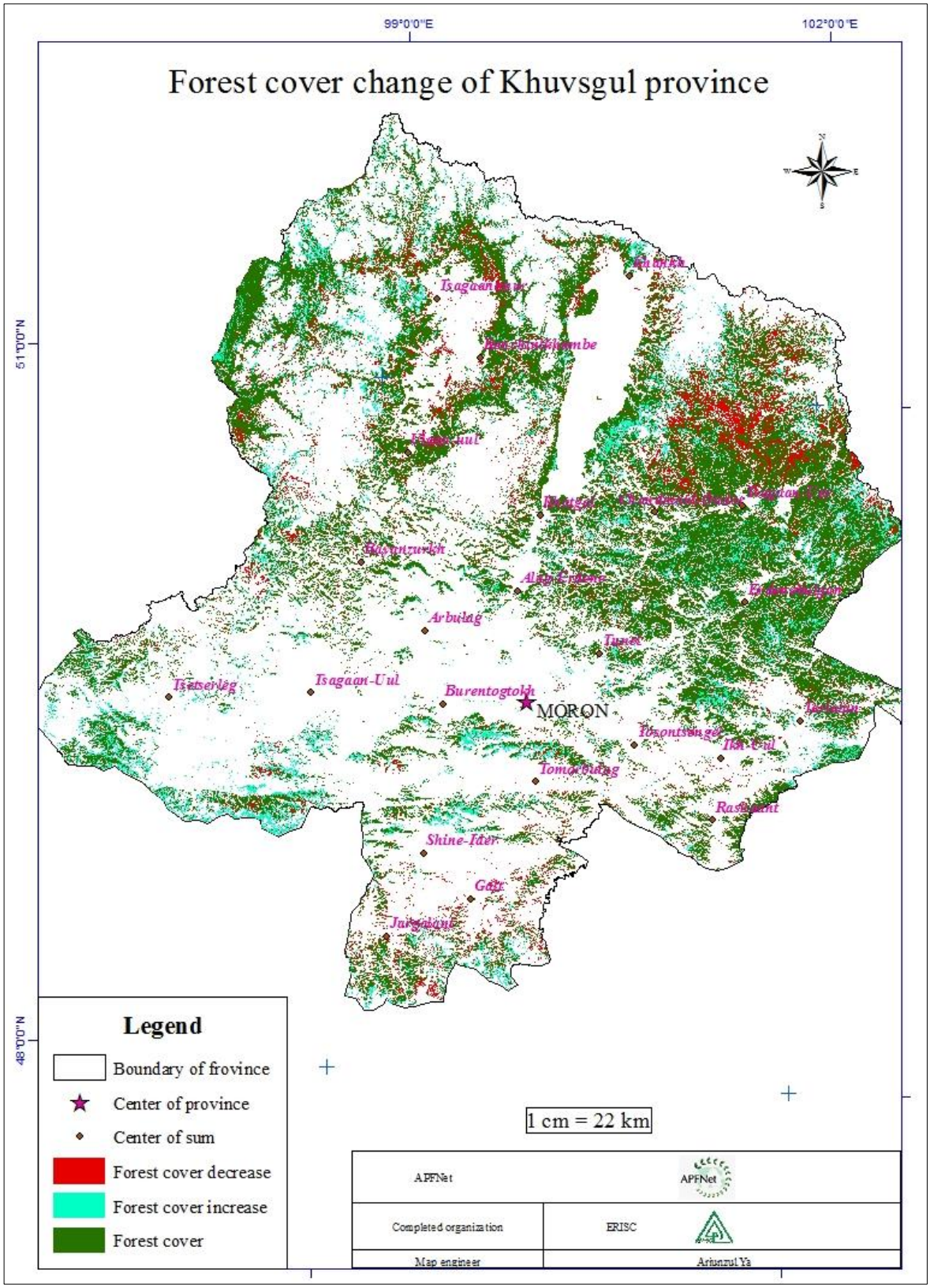
Khuvsgul has 10062.9 thousand hectares area. Taxation data of FRDC shows 31.3 percent of the province landscape covered by forest which means 3152.5 thousand hectare area is natural forest. Forest fund area determined by taxation data in 2000-2003 and 2012. The Khuvsgul province forest cover area increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Khuvsgul province has 3013.6 thousand hectares and it is 29.95% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2013 by 9.3 thousand hectare which means 31.42% of the province total ladscape as 3161.8 thousand hectares.

Table 21. Khuvsgul province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	2,914,553.27	28.96	10,062,882.00		
2001	2,947,767.11	29.29			
2002	2,905,992.39	28.88			
2003	2,905,992.39	28.88			
2004	2,877,602.46	28.60			
2005	2,997,552.09	29.79			
2006	3,149,560.55	31.30			
2007	3,070,485.19	30.51			
2008	3,216,448.35	31.96			
2009	2,945,494.96	29.27			
2010	2,860,388.96	28.43			
2011	3,016,532.72	29.98			
2013	3,161,824.59	31.42		3,152,500.0	9,324.59
2014	3,228,735.92	32.09			
2015	3,005,041.79	29.86			
Average	3,013,598.18	29.95			

Graph 26. Khuvsgul province forest cover change





Picture 92. Khuvsgul province forest cover change

Tsagaan-Uur, CHandmani-Undur and Khankh soum forest cover decreased and Tsagaannuur soum and state boundary forest cover increased.

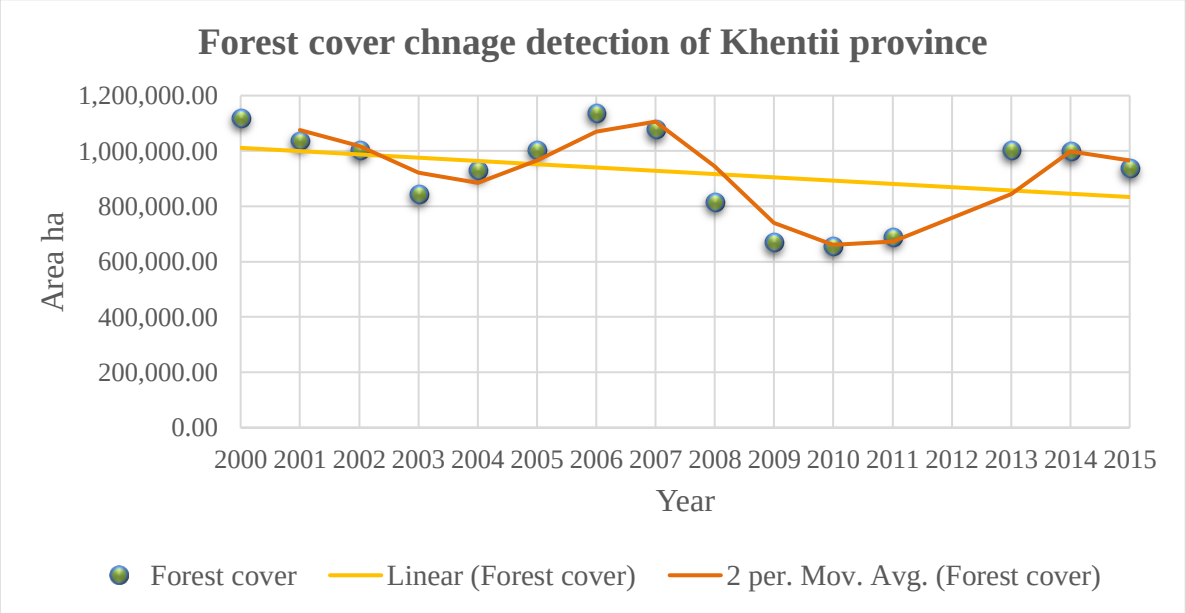
2.7.15. Khentii province forest cover change

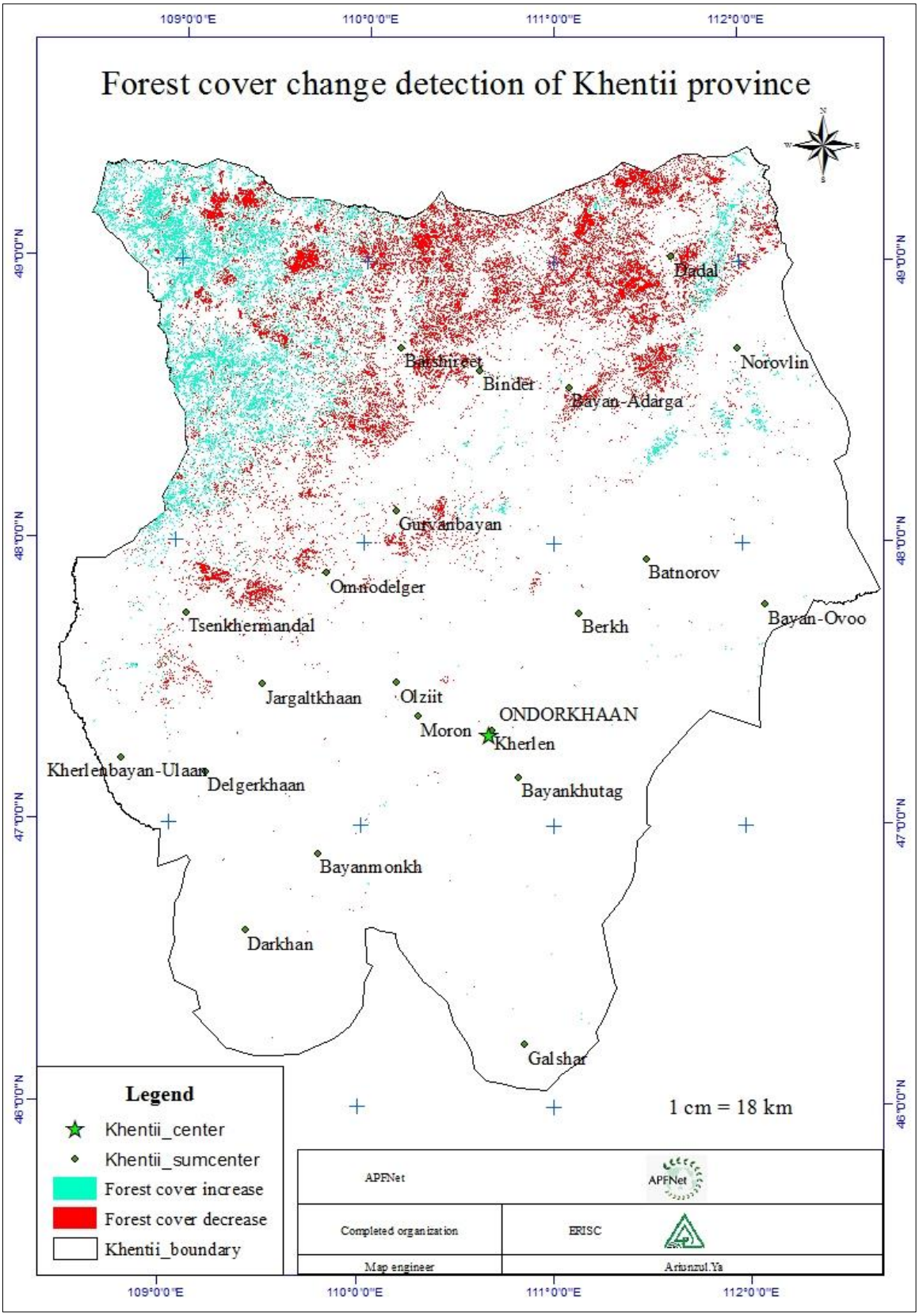
Khentii has 8032.5 thousand hectares area. Taxation data of FRDC shows 12.32 percent of the province landscape covered by forest which means 989.7 thousand hectare area is natural forest. Forest fund area determined by taxation data in 2004-2005 and 2013. The Khentii province forest cover area decreased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Khentii province has 925.9 thousand hectares and it is 11.53% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2013 by 9.9 thousand hectare which means 12.44% of the province total ladscape as 999.6 thousand hectares.

Table 22. Khentii province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	1,115,381.89	13.89			
2001	1,034,922.69	12.88			
2002	1,000,159.11	12.45			
2003	841,909.78	10.48			
2004	927,027.54	11.54			
2005	1,003,137.25	12.49			
2006	1,135,663.94	14.14			
2007	1,076,210.10	13.40	8,032,508.00		
2008	812,756.52	10.12			
2009	666,769.52	8.30			
2010	654,495.90	8.15			
2011	688,779.92	8.57			
2013	999,588.38	12.44		989,700.00	9,888.38
2014	997,007.75	12.41			
2015	934,383.02	11.63			
Average	925,879.55	11.53			

Graph 27. Khentii province forest cover change





Picture 93. Khentii province forest cover change

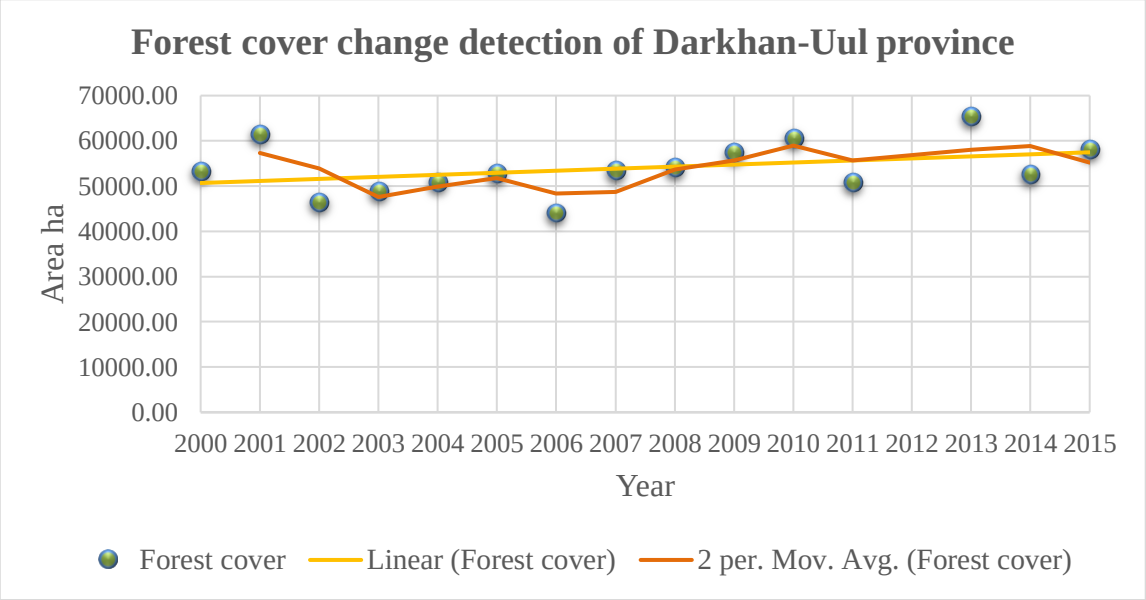
2.7.16. Darkhan-Uul province forest cover change

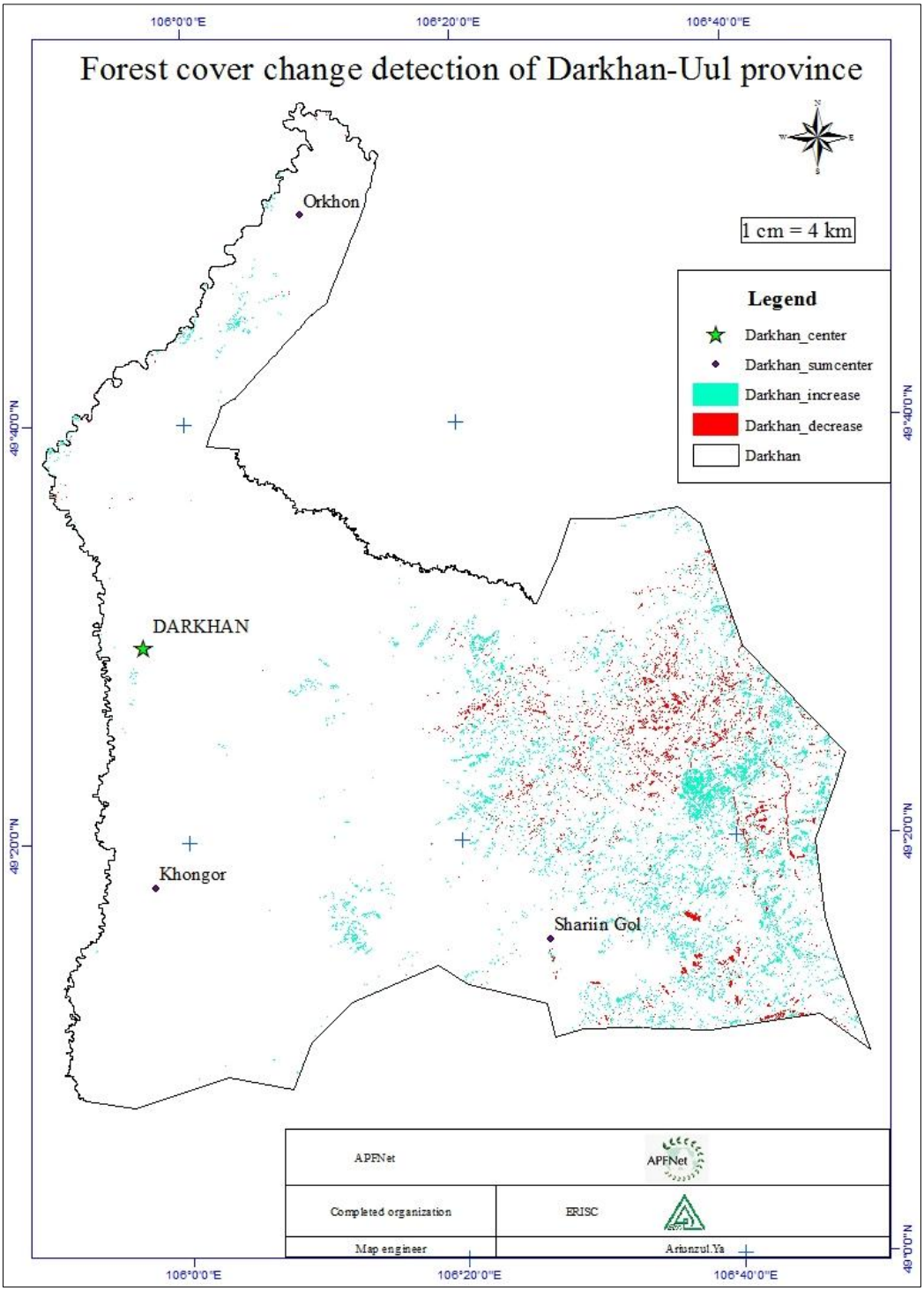
Darkhan-Uul has 327.5 thousand hectares area. Taxation data of FRDC shows 19.8 percent of the province landscape covered by forest which means 64.8 thousand hectare area is natural forest. Forest fund area determined by taxation data in 2006 and 2013. The Darkhan-Uul province forest cover area increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Darkhan-Uul province has 53.9 thousand hectares and it is 16.47% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2013 by 0.5 thousand hectare which means 19.9% of the province total ladscape as 65.3 thousand hectares.

Table 23. Darkhan-Uul province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	53,182.51	16.24	327,500.00		
2001	61,478.75	18.77			
2002	46,353.85	14.15			
2003	48,833.22	14.91			
2004	50,832.32	15.52			
2005	52,737.42	16.10			
2006	44,023.44	13.44			
2007	53,293.71	16.27			
2008	54,003.43	16.49			
2009	57,344.49	17.51			
2010	60,555.92	18.49			
2011	50,680.77	15.48			
2013	65,301.74	19.94		64,800.0	501.74
2014	52,507.13	16.03			
2015	57,986.42	17.71			
Average	53,941.01	16.47			

Graph 28. Darkhan-Uul province forest cover change





Picture 94. Darkhan-Uul province forest cover change

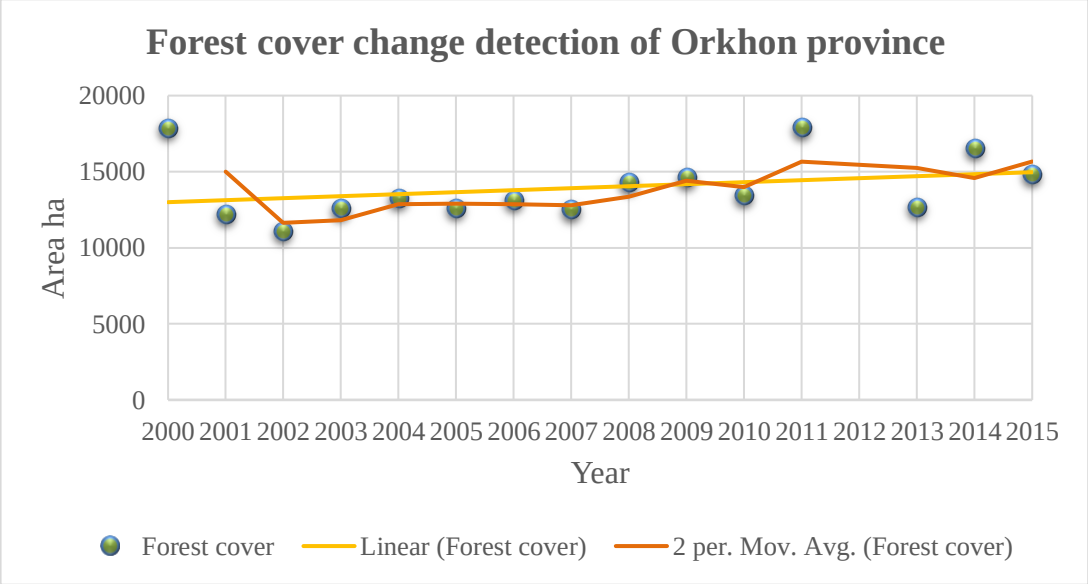
2.7.17. Orkhon province forest cover change

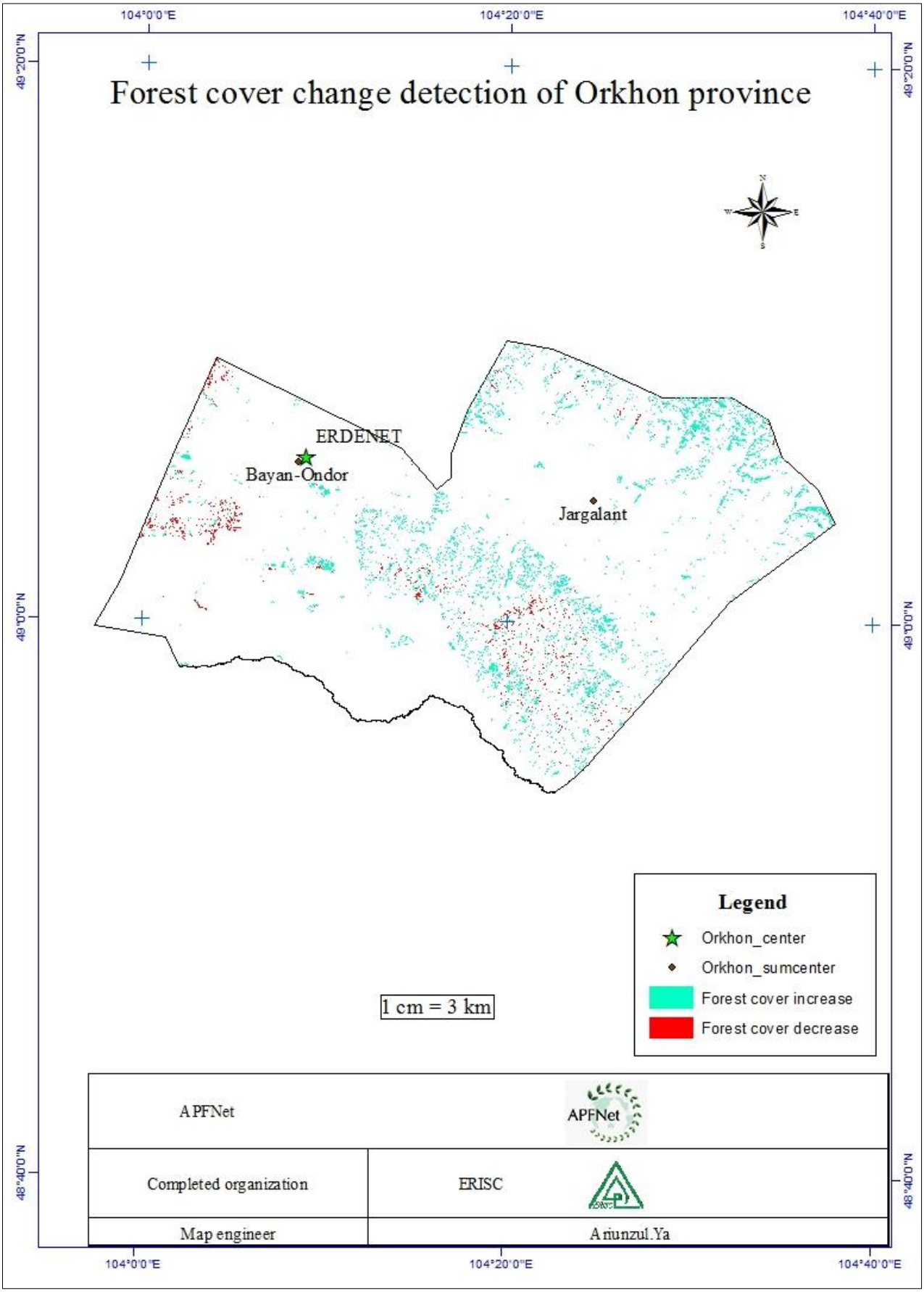
Orkhon has 84.4 thousand hectares area. Taxation data of FRDC shows 18.4 percent of the province landscape covered by forest which means 15.6 thousand hectare area is natural forest. Forest fund area determined by taxation data in 2001 and 2010. The Orkhon province forest cover area increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Orkhon province has 13.9 thousand hectares and it is 16.52% of the province landscape. The forest cover area of Landsat data is lower than FRDC taxation data of the 2010 by 4.4 thousand hectare which means 15.92% of the province total ladscape as 13.4 thousand hectares.

Table 24. Orkhon province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	17,830.37	21.13	84,400.00		
2001	12,190.08	14.44			
2002	11,084.31	13.13			
2003	12,547.55	14.87			
2004	13,201.91	15.64			
2005	12,594.31	14.92			
2006	13,098.03	15.52			
2007	12,469.58	14.77			
2008	14,271.53	16.91			
2009	14,566.87	17.26			
2010	13,437.27	15.92		17.800.0	-4,362.73
2011	17,882.12	21.19			
2013	12,636.43	14.97			
2014	16,508.95	19.56			
2015	14,807.47	17.54			
Average	13,941.78	16.52			

Graph 29. Orkhon province forest cover change





Picture 95. Orkhon province forest cover change

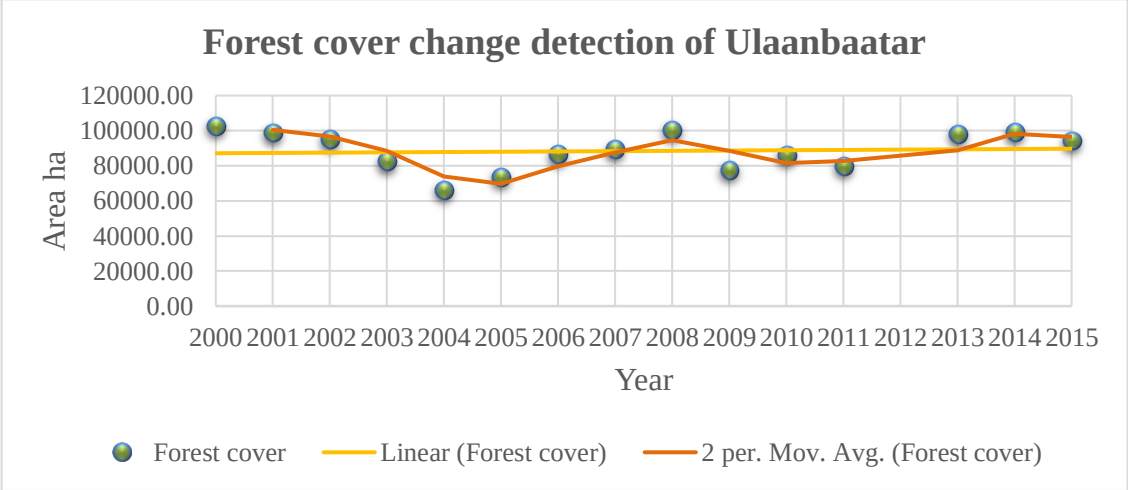
2.7.18. Ulaanbaatar city forest cover change

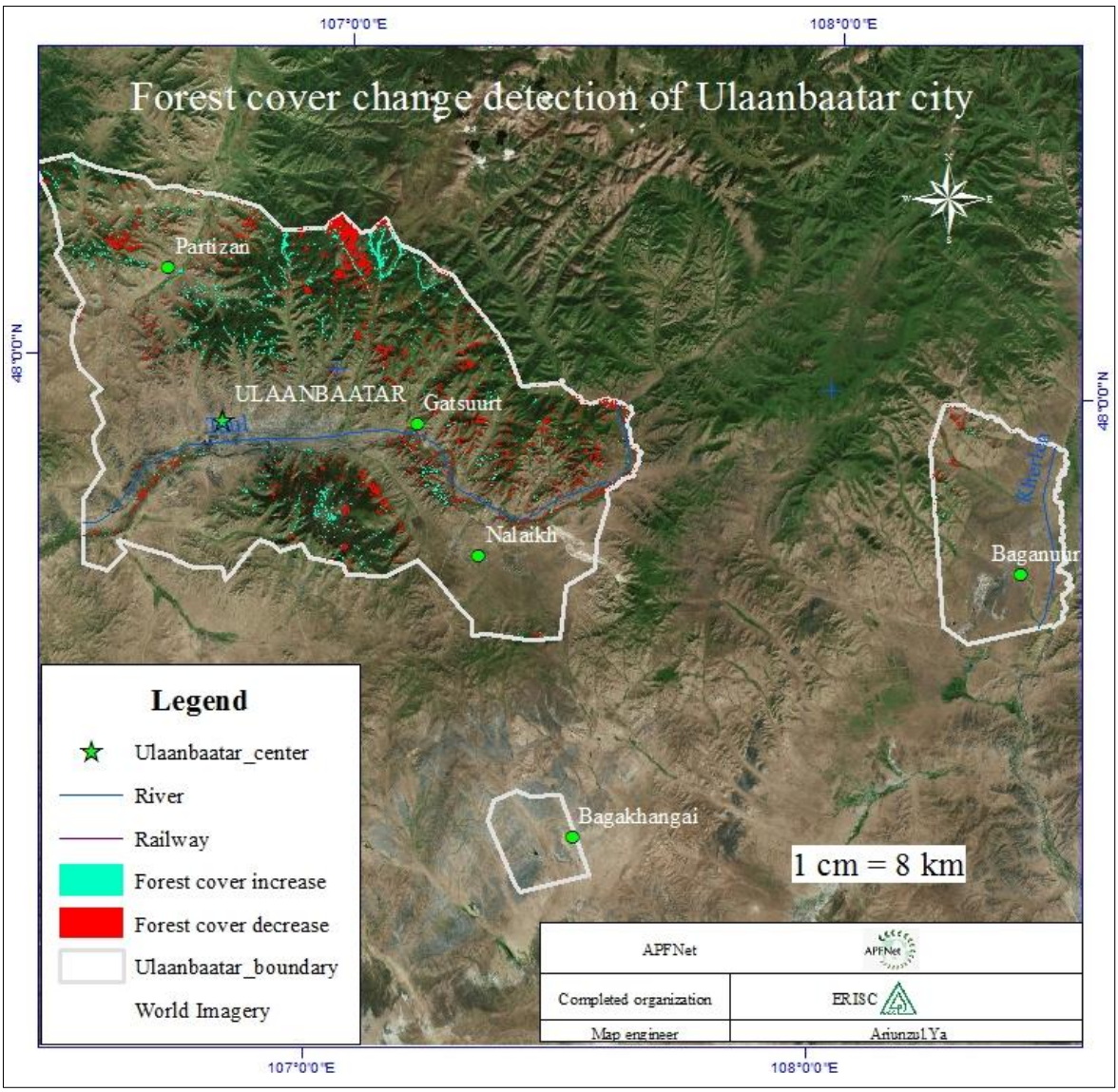
Ulaanbaatar city has 470.4 thousand hectares area. Taxation data of FRDC shows 18.51 percent of the province landscape covered by forest which means 87.1 thousand hectare area is natural forest. Forest fund area determined by taxation data in 1998 and 2008. The Ulaanbaatar city forest cover area decreased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Ulaanbaatar city has 88.3 thousand hectares and it is 18.7% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2018 by 13 thousand hectare which means 21.29% of the province total ladscape as 100.1 thousand hectares.

Table 25. Ulaanbaatar city forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province	Taxation Data /ha/	Difference /ha/
2000	102,449.33	21.78	470,440.00		
2001	98,459.15	20.93			
2002	94,750.17	20.14			
2003	82,091.52	17.45			
2004	66,021.00	14.03			
2005	73,418.14	15.61			
2006	85,937.37	18.27			
2007	89,188.08	18.96			
2008	100,173.97	21.29		87,100.00	13,073.97
2009	77,139.32	16.40			
2010	85,772.71	18.23			
2011	79,793.51	16.96			
2013	97,874.25	20.80			
2014	98,774.81	21.00			
2015	93,855.95	19.95			
Average	88,379.95	18.70			

Graph 30. Ulaanbaatar city forest cover change





Picture 96. Ulaanbaatar city forest cover change

The forest of the Ulaanbaatar city decrased by border and increased by center part. Other province's forest is decreased by center and increased by border. Natural reservation Bogdkhan mountain increased by peak part and decreased by north part.

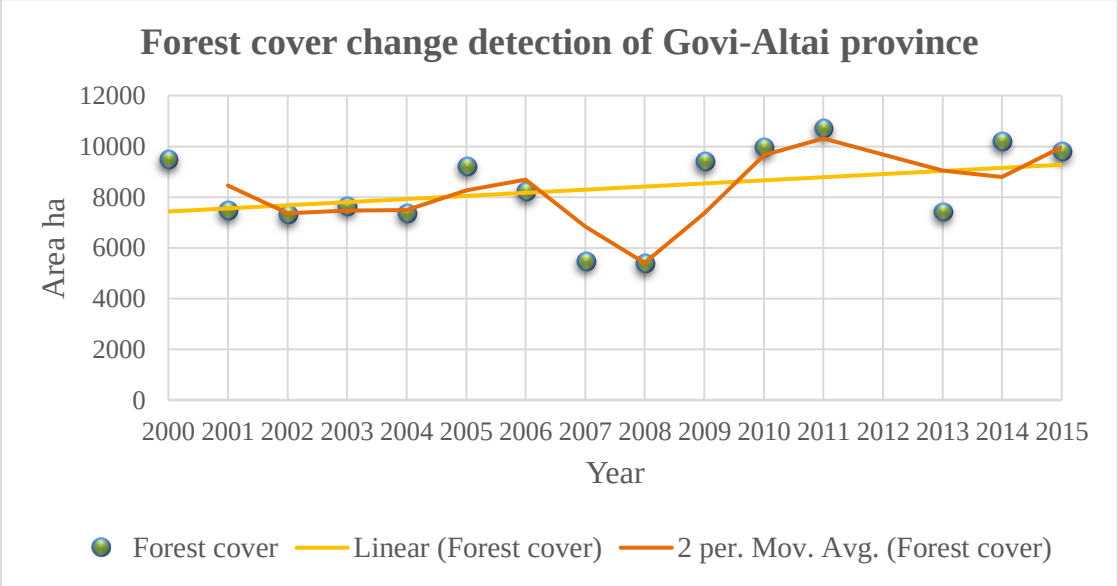
2.7.19. Gobi-Altai province forest cover change

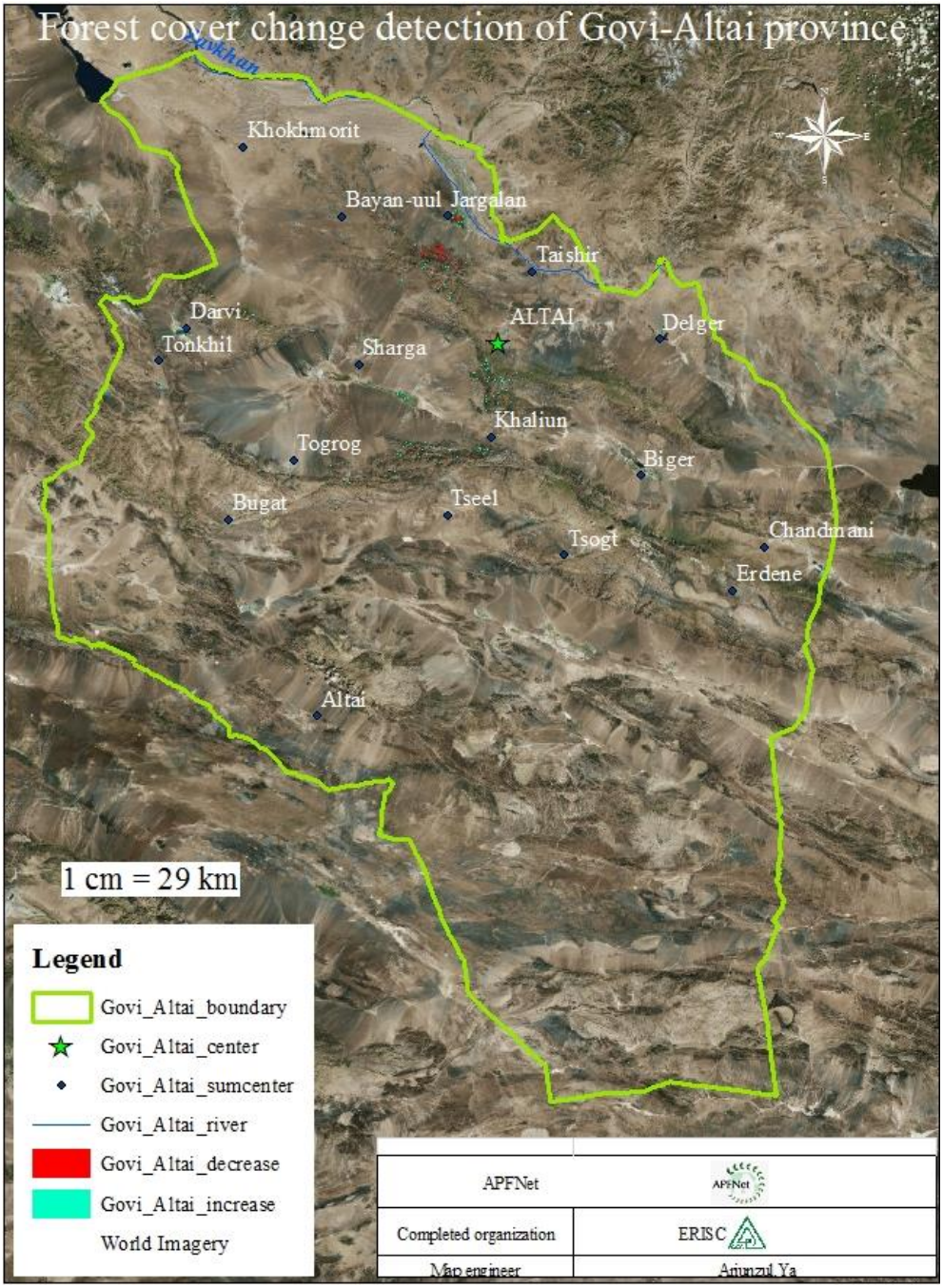
Gobi-Altai has 14144.7 thousand hectares area. Taxation data of FRDC shows 0.06 percent of the province landscape covered by forest which means 9.1 thousand hectare area is natural forest. Forest fund area determined by taxation data in 1990 and 2010. The Gobi-Altai province forest cover area increased from 2000 to 2015 by forest index of Landsat ETM and Landsat OLI data. The average of 15-year forest cover data, Gobi-Altai province has 8.3 thousand hectares and it is 0.06% of the province landscape. The forest cover area of Landsat data is greater than FRDC taxation data of the 2011 by 1.6 thousand hectare which means 0.08% of the province total ladscape as 10.7 thousand hectares.

Table 26. Gobi-Altai province forest cover change

Year	Forest cover /ha/	Woodland %	Area of Province /ha/	Taxation Data /ha/	Difference /ha/
2000	9474.62	0.07	14,144,767.0		
2001	7437.98	0.05			
2002	7293.19	0.05			
2003	7628.26	0.05			
2004	7332.47	0.05			
2005	9181.57	0.06			
2006	8213.21	0.06			
2007	5453.53	0.04			
2008	5358.95	0.04			
2009	9383.53	0.07			
2010	9936.22	0.07			
2011	10686.48	0.08		9100.0	-1586.48
2013	7407.04	0.05			
2014	10179.68	0.07			
2015	9774.81	0.07			
Average	8316.10	0.06			

Graph 31. Gobi-Altai province forest cover change



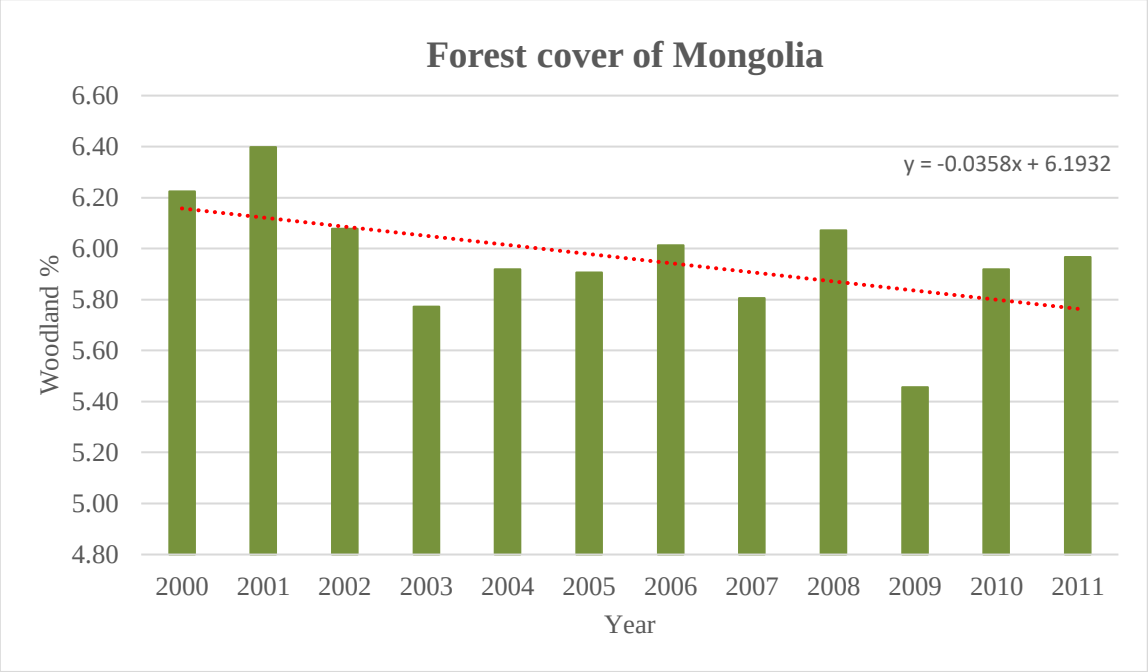


Picture 97. Gobi-Altai province forest cover change

Table 27. Mongolian forest cover area /2000-2015/

	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %	Forest cover ha	Woodland %
Year	Arkhangai	5531382.00	Bayan-Ulgii	4670489.00	Bayankhongor	11599780.00	Bulgan	4873300.00	Zavkhan	8,245,566.00	Orkhon	84400.00	Uvurkhangai	6289533.00	Ulaanbaatar	470440.00	Selenge	4,115,263.00	Khuvsgol	10,062,882.00	Khentii	8,032,508.00	Tuv	7,404,237.00	Dornod	12,359,743.00	Darkhan-Uul	327,500.00	Uvs	6,958,539.00	Khovd	7,606,038.00	Govi-Altai	14,144,767.00	Mongolia	156,511,391.00
2000	720,274.03	13.02	56023.44513	1.20	17,278.95	0.15	1,317,250.36	27.03	464,011.82	5.63	17,830.37	21.13	120,165.20	1.91	102,449.33	21.78	1,604,191.97	38.98	2,914,553.27	28.96	1,115,381.89	13.89	1,005,940.21	13.59	126,403.62	1.02	53,182.51	16.24	87,755.38	1.26	8,693.16	0.11	9474.62	0.07	9,740,860.13	6.22
2001	920,672.56	16.64	60731.82397	1.30	20,347.39	0.18	1,382,965.84	28.38	482,503.51	5.85	12,190.08	14.44	133,854.84	2.13	98,459.15	20.93	1,610,886.10	39.14	2,947,767.11	29.29	1,034,922.69	12.88	963,246.35	13.01	159,842.72	1.29	61,478.75	18.77	105,411.54	1.51	9,268.60	0.12	7437.98	0.05	10,011,987.01	6.40
2002	802,680.21	14.51	72462.52485	1.55	18,299.53	0.16	1,333,833.51	27.37	426,594.27	5.17	11,084.31	13.13	114,467.10	1.82	94,750.17	20.14	1,459,577.06	35.47	2,905,992.39	28.88	1,000,159.11	12.45	988,092.67	13.34	123,950.56	1.00	46,353.85	14.15	90,386.62	1.30	15,535.80	0.20	7293.19	0.05	9,511,512.89	6.08
2003	803,337.75	14.52	78076.64986	1.63	21,732.09	0.19	1,297,319.94	26.62	394,219.38	4.78	12,547.55	14.87	148,813.53	2.37	82,091.52	17.45	1,455,757.10	35.37	2,905,992.39	28.88	841,909.78	10.48	763,997.57	10.32	64,689.00	0.52	48,833.22	14.91	90,579.22	1.30	20,365.74	0.27	7628.26	0.05	9,035,890.70	5.77
2004	835,793.09	15.11	56707.93314	1.21	20,490.74	0.18	1,381,600.94	28.35	400,030.32	4.85	13,201.91	15.64	121,547.96	1.93	66,021.00	14.03	1,397,090.51	33.95	2,877,602.46	28.60	927,027.54	11.54	870,756.88	11.76	114,378.11	0.93	50,832.32	15.52	110,720.46	1.59	11,253.13	0.15	7332.47	0.05	9,262,387.76	5.92
2005	712,559.93	12.88	81804.62146	1.75	27,778.31	0.24	1,271,702.16	26.10	349,455.83	4.24	12,594.31	14.92	109,297.48	1.74	73,418.14	15.61	1,439,984.62	34.99	2,997,552.09	29.79	1,003,137.25	12.49	842,220.06	11.37	128,556.45	1.04	52,737.42	16.10	114,918.21	1.65	18,035.36	0.24	9181.57	0.06	9,244,933.80	5.91
2006	827,935.14	14.97	59792.41946	1.28	27,506.25	0.24	1,274,954.88	26.16	344,965.65	4.18	13,098.03	15.52	125,393.77	1.99	85,937.37	18.27	1,415,317.59	34.39	3,149,560.55	31.30	1,135,663.94	14.14	642,084.42	8.67	129,514.33	1.05	44,023.44	13.44	118,383.40	1.70	10,189.86	0.13	8213.21	0.06	9,412,534.25	6.01
2007	786,375.32	14.20	48291.50327	1.03	28,487.90	0.25	1,148,624.60	23.57	295,815.17	3.59	12,469.58	14.77	90,250.37	1.43	89,188.08	18.96	1,370,206.82	33.30	3,070,485.19	30.51	1,076,210.10	13.40	860,736.48	11.62	67,850.05	0.55	53,293.71	16.27	75,860.23	1.09	7,844.96	0.10	5453.53	0.04	9,086,443.59	5.81
2008	925,162.03	16.73	41427.00547	0.89	27,028.35	0.23	1,285,273.88	26.37	355,222.20	4.31	14,271.53	16.91	91,890.09	1.46	100,173.97	21.29	1,377,734.25	33.48	3,216,448.35	31.96	812,756.52	10.12	997,879.04	13.48	105,738.55	0.86	54,003.43	16.49	84,518.78	1.21	8,306.95	0.11	5358.95	0.04	9,503,393.94	6.07
2009	654,168.23	11.83	42337.10231	0.91	22,860.15	0.20	1,298,464.79	26.64	319,838.53	3.88	14,566.87	17.26	127,682.56	2.03	77,139.32	16.40	1,332,553.52	32.38	2,945,494.96	29.27	666,769.52	8.30	731,500.61	9.88	124,629.51	1.01	57,344.49	17.51	109,652.11	1.58	3,909.08	0.05	9383.53	0.07	8,538,294.89	5.46
2010	798,750.74	14.44	57447.83571	1.23	26,589.25	0.23	1,373,056.43	28.18	424,925.22	5.15	13,437.27	15.92	134,249.60	2.13	85,772.71	18.23	1,548,509.81	37.63	2,860,388.96	28.43	654,495.50	8.15	1,020,505.24	13.78	62,767.11	0.51	60,555.92	18.49	119,921.21	1.72	11,343.87	0.15	9936.22	0.07	9,262,653.28	5.92
2011	796,169.92	14.39	56205.86693	1.20	32,205.04	0.28	1,318,392.16	27.05	422,197.62	5.12	17,882.12	21.19	123,157.88	1.96	79,793.51	16.96	1,520,723.27	36.95	3,016,532.72	29.98	688,779.92	8.57	999,287.73	13.50	74,292.00	0.60	50,680.77	15.48	122,206.31	1.76	8,289.58	0.11	10686.48	0.08	9,337,482.89	5.97
2013	849,062.01	15.35	62416.55037	1.34	23,812.32	0.21	1,455,073.76	29.86	423,895.85	5.14	12,636.43	14.97	141,294.11	2.25	97,874.25	20.80	1,687,672.30	41.01	3,161,824.59	31.42	999,588.38	12.44	1,097,378.10	14.82	74,292.00	0.60	65,301.74	19.94	138,817.66	1.99	17,022.13	0.22	7407.04	0.05	10,315,369.23	6.59
2014	844,790.14	15.27	56684.76759	1.21	33,221.80	0.29	1,355,074.03	27.82	444,302.65	5.39	16,508.95	19.56	140,735.16	2.24	98,774.81	21.00	1,407,158.33	34.19	3,238,735.92	32.09	997,007.75	12.41	1,141,840.97	15.42	77,926.52	0.63	52,507.13	16.03	123,918.97	1.78	10,794.78	0.14	10179.68	0.07	10,040,962.37	6.42
2015	914,528.64	16.53	58219.02955	1.25	28,158.98	0.24	1,512,799.35	31.04	408,113.40	4.95	14,807.47	17.54	120,866.33	1.92	93,855.95	19.95	1,477,427.45	35.90	3,005,041.79	29.86	934,383.02	11.63	1,064,362.37	14.38	75,165.00	0.61	57,986.42	17.71	115,972.34	1.67	17,680.35	0.23	9774.81	0.07	9,909,142.69	6.33
Average	812,750.65	14.69	59,108.61	1.27	25,053.14	0.22	1,333,812.44	27.37	397,072.76	4.82	13,941.78	16.52	122,911.06	1.95	88,379.95	18.70	1,473,652.71	35.81	3,013,598.18	29.95	925,879.55	11.53	932,655.25	12.60	100,666.37	0.81	53,941.01	16.47	107,268.16	1.54	11,915.56	0.16	8316.10	0.06	9,480,923.29	6.06
Taxation Data	799.40	14.45	42.30	0.91	29.80	0.26	1,315.00	26.98	456.80	5.54	15.60	18.48	134.60	2.14	87.10	18.51	1,397.40	33.96	3,152.50	31.33	988.70	12.32	957.20	12.93	75.40	0.61	64.80	19.79	197.30	2.8	12.40	0.16	9,100.00	0.06		
Increase area	217,377.00	26.75	20,310.00	34.36	13631.00	54.41	318,519	23.88	105,836.00	26.65	3,264.00	23.41	40,751.00	33.15	6,328.00	7.39	160,830.00	10.91	529,068.00	17.56	240,088.00	25.93	193,853.00	20.79	33,809.00	33.59	8,669.00	16.07	46,820.00	43.65	12,639.00	106.07	5,962.00	71.69	1,964,951.0	20.73
Decrease area	92,863.00	11.43	18,186.00	30.77	2,721.00	10.86	122,812	9.21	161,730.00	40.73	646.00	4.63	20,193.00	16.43	15,134.00	17.12	287,592.00	19.52	428,665.00	14.22	463,329.00	50.04	135,414.00	14.52	85,194.00	84.63	3,871.00	7.18	18,695.00	17.43	3,646.00	30.60	3,626.00	43.60	1,877,929.0	19.81
Average	155,120.00	19.09	19,248.00	32.56	8,176.00	32.63	220,665.50	16.54	133,783.00	33.69	1,955.00	14.02	30,472.00	24.79	10,831.00	12.26	224,211.00	15.21	478,866.50	15.89	351,708.50	37.99	164,633.50	17.65	59,501.50	59.11	6,270.00	11.62	32,757.50	30.54	8,142.50	68.34	4,794.00	57.65	87,022.00	0.92
Difference	124,514.00	Increase	2,124.00	Increase	10,910.00	Increase	195,707.00	Increase	-55,894.00	Decrease	2,618.00	Increase	20,558.00	Decrease	-8,606.00	Decrease	-126,762.00	Decrease	100,403.00	Increase	-223,241.00	Decrease	58,439.00	Decrease	-51,385.00	Decrease	4,798.00	Decrease	28,125.00	Increase	8,993.00	Increase	2,336.00	Increase	87,022.0	Decrease

Graph 32. Mongolian forest cover area /2000-2011/



Graph 33. Mongolian forest cover area /2013-2015/

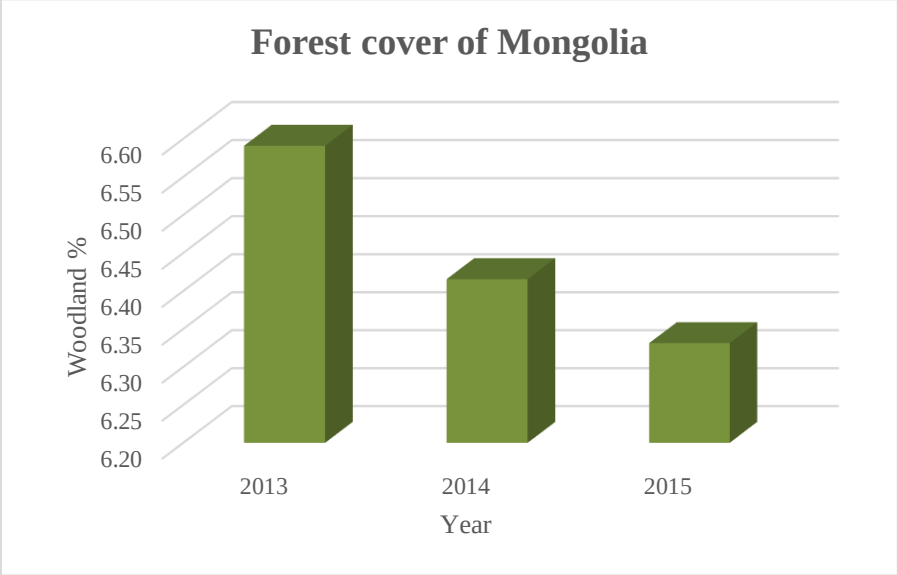
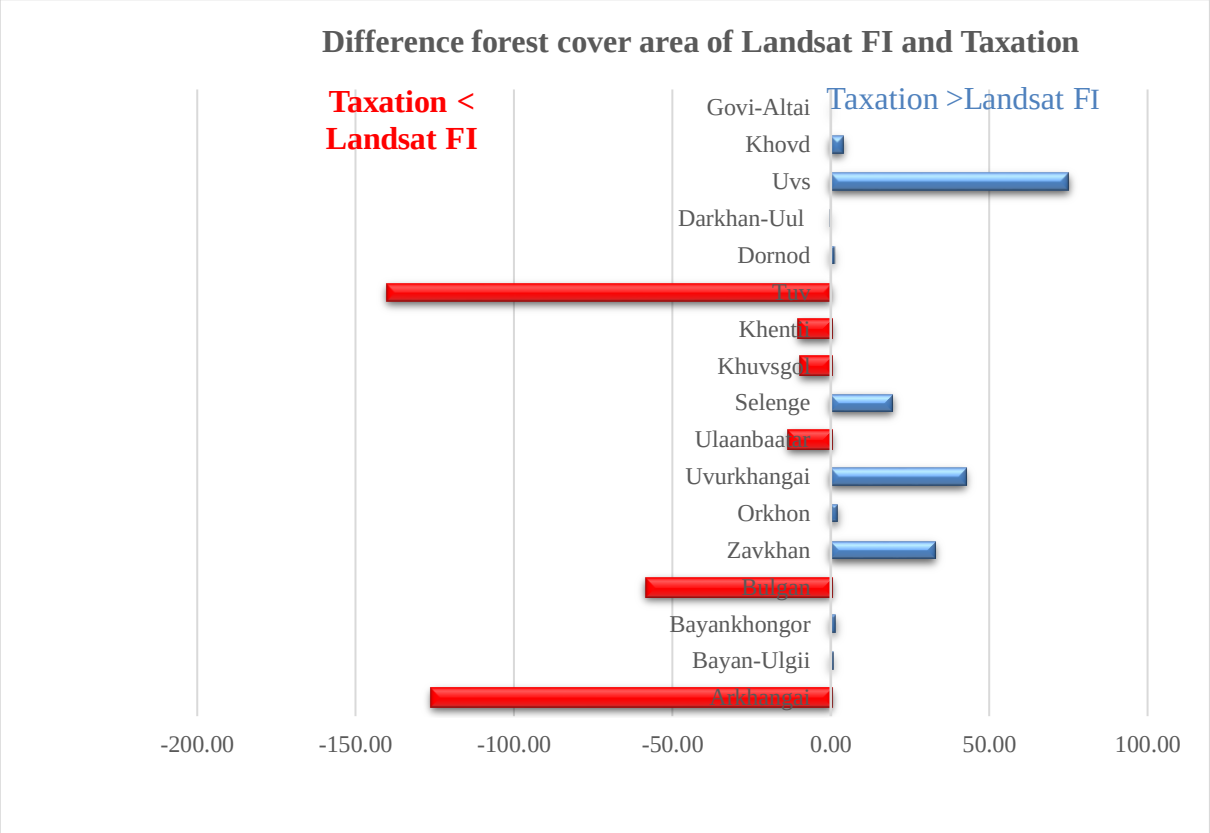


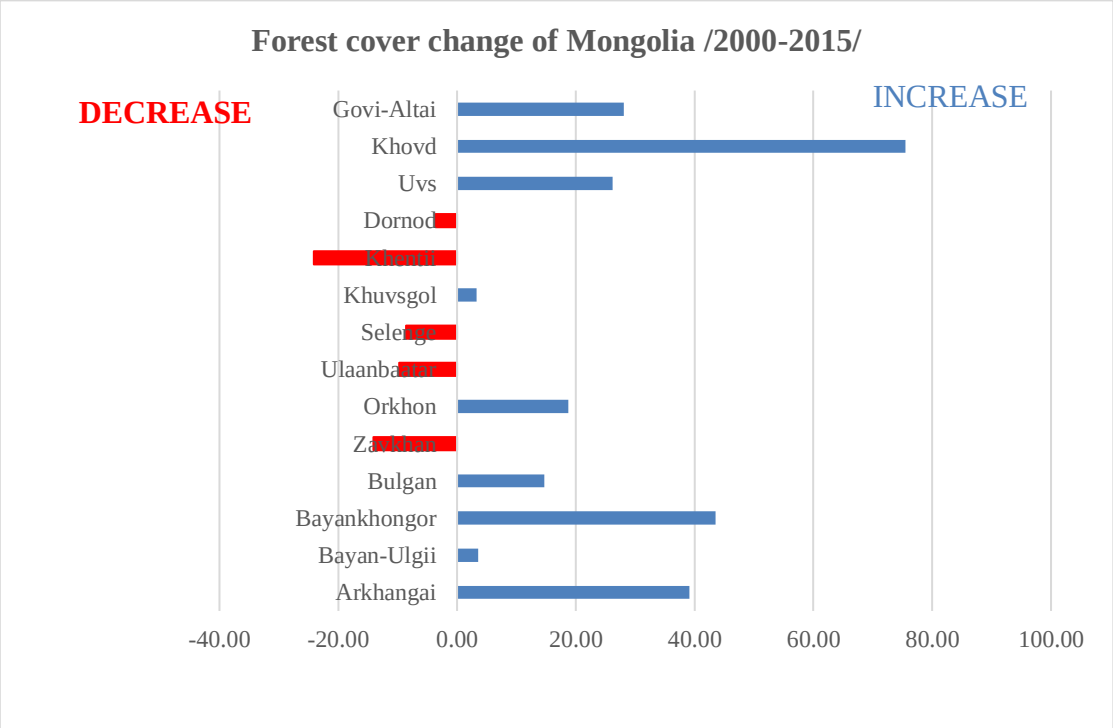
Table 28. Mongolian forest cover area /2000-2015/

№	Name	Landsat forest cover /Average/ha	Woodland %	Taxation Year	Taxation data ha	Woodland %	Difference	Landsat forest cover /That Year/ha	Difference	Trend	Increase area ha	Decrease area ha	Average Dinamic ha	Difference ha	Dinamic %	Increase %	Decrease %	Difference %	Trend
1	Arkhangai	812,750.65	14.85	2008	799.40	14.45	0.40	925.16	-125.76	Бага	217377	92863	155120	124514	32.66	52.24	13.09	39.14	Increase
2	Bayan-Ulgii	59,108.61	1.27	2008	42.30	0.91	0.36	41.43	0.87	Их	20,310.00	18,186.00	19,248.00	2,124.00	32.56	34.36	30.77	3.59	Increase
3	Bayankhongor	25,053.14	0.22	2015	29.80	0.26	-0.04	28.16	1.64	Их	13,631.00	2,721.00	8,176.00	10,910.00	32.63	54.41	10.86	43.55	Increase
4	Bulgan	1,333,812.44	27.37	2010	1,315.00	26.98	0.39	1373.06	-58.06	Бага	318,519.00	122,812.00	220,665.50	195,707.00	16.54	23.88	9.21	14.67	Increase
5	Zavkhan	397,072.76	4.82	2013	456.80	5.54	-0.72	423.90	32.90	Их	105,836.00	161,730.00	133,783.00	-55,894.00	33.69	26.65	40.73	-14.08	Decrease
6	Orkhon	13,941.78	16.52	2010	15.60	18.48	-1.96	13.44	2.16	Их	3,264.00	646.00	1,955.00	2,618.00	14.02	23.41	4.63	18.78	Increase
7	Uvurkhangai	122,911.06	1.95	2008	134.60	2.14	-0.19	91.89	42.71	Их	40,751.00	20,193.00	30,472.00	20,558.00	24.79	33.15	16.43	16.73	Increase
8	Ulaanbaatar	88,379.95	18.70	2008	87.10	18.51	0.19	100.17	-13.07	Бага	6,528.00	15,134.00	10,831.00	-8,606.00	12.26	7.39	17.12	-9.74	Decrease
9	Selenge	1,477,514.49	35.90	2008	1,397.40	33.96	1.95	1377.73	19.67	Их	160,830.00	287,592.00	224,211.00	-126,762.00	15.17	10.89	19.46	-8.58	Decrease
10	Khuvsgol	3,013,598.18	29.95	2012	3,152.50	31.33	-1.38	3161.82	-9.32	Бага	529,068.00	428,665.00	478,866.50	100,403.00	15.89	17.56	14.22	3.33	Increase
11	Khentii	925,879.55	11.53	2013	989.70	12.32	-0.79	999.59	-9.89	Бага	240,088.00	463,329.00	351,708.50	-223,241.00	37.99	25.93	50.04	-24.11	Decrease
12	Tuv	932,655.85	12.60	2013	957.20	12.93	-0.33	1097.38	-140.18	Бага	193,853.00	135,414.00	164,633.50	58,439.00	17.65	20.79	14.52	6.27	Increase
13	Dornod	100,666.37	1.42	2012	75.40	0.61	0.81	74.29	1.11	Их	9,382.80	13,024.00	11,203.40	-3,641.20	11.13	9.32	12.94	-3.62	Decrease
14	Darkhan-Uul	53,941.01	16.47	2013	64.80	19.79	-3.32	65.30	-0.50	Бага	8,669.00	3,871.00	6,270.00	4,798.00	11.62	16.07	7.18	8.89	Increase
15	Uvs	107,268.16	1.54	2011	197.30	2.84	-1.29	122.21	75.09	Их	46,820.00	18,695.00	32,757.50	28,125.00	30.54	43.65	17.43	26.22	Increase
16	Khovd	11,915.56	0.16	2011	12.40	0.16	-0.01	8.289	4.11	Их	12,639.00	3,646.00	8,142.50	8,993.00	68.34	106.07	30.60	75.47	Increase
17	Govi-Altai	8,316.10	0.06	2005	9.10	0.06	0.00	9.181	-0.08	Бага	5,962.00	3,626.00	4,794.00	2,336.00	57.65	71.69	43.60	28.09	Increase
18	Mongolia	9,484,785.68	6.06		10,386.90	6.06	-0.35		-10.39	Бага	1,933,527.80	1,792,147.00	1,862,837.40	141,380.80	27.36 19.64	33.97 20.39	20.76 18.9	13.21 1.5	Increase

Graph 34. The difference of forest cover data between satellite data and taxation data

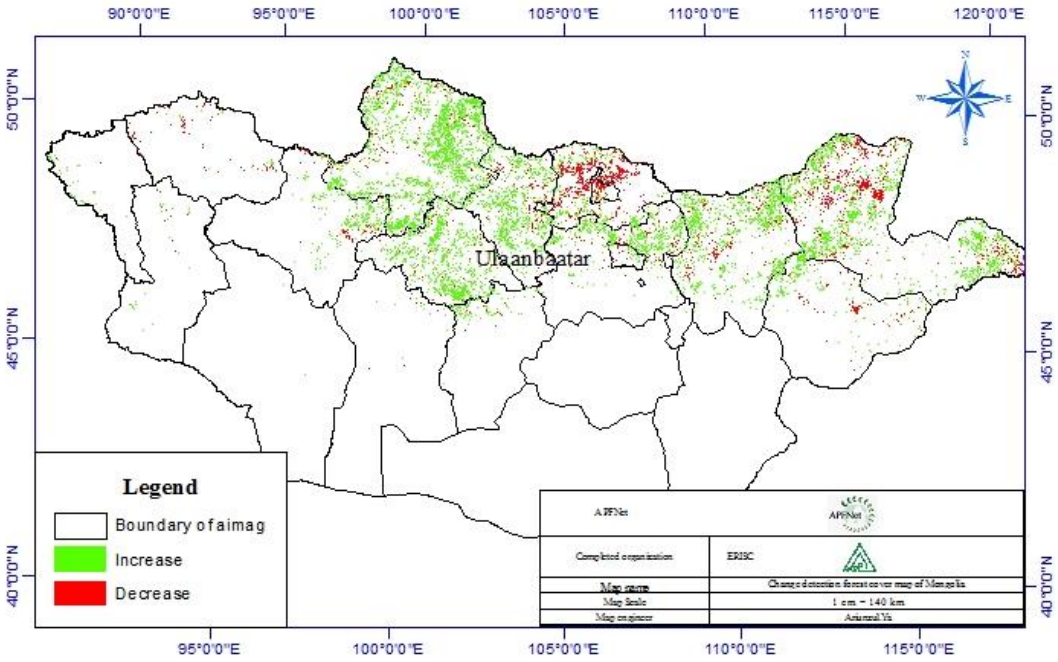


Graph 35. Mongolian forest cover area changes 2000-2015



2.7.19. Forest cover change from NDVI of MODIS satellite data

Forest cover change calculated in NDVI value of 16th of August each year by 15 year of MODIS satellite data with threshold 0.65.



Picture 98. Forest cover change in MODIS satellite data from 2000 to 2015

Red part is decreased forest part from 2000 and green part is increased forest part from 2000. As shown Picture 95 Selenge, Khentii, DOrnod and Zavkhan province forest decreased and Khuvsgul, Arkhangai, Bulgan and Orkhon province forest increased.

Graph 36. Forest cover defined in MODIS satellite data (2000-2015)

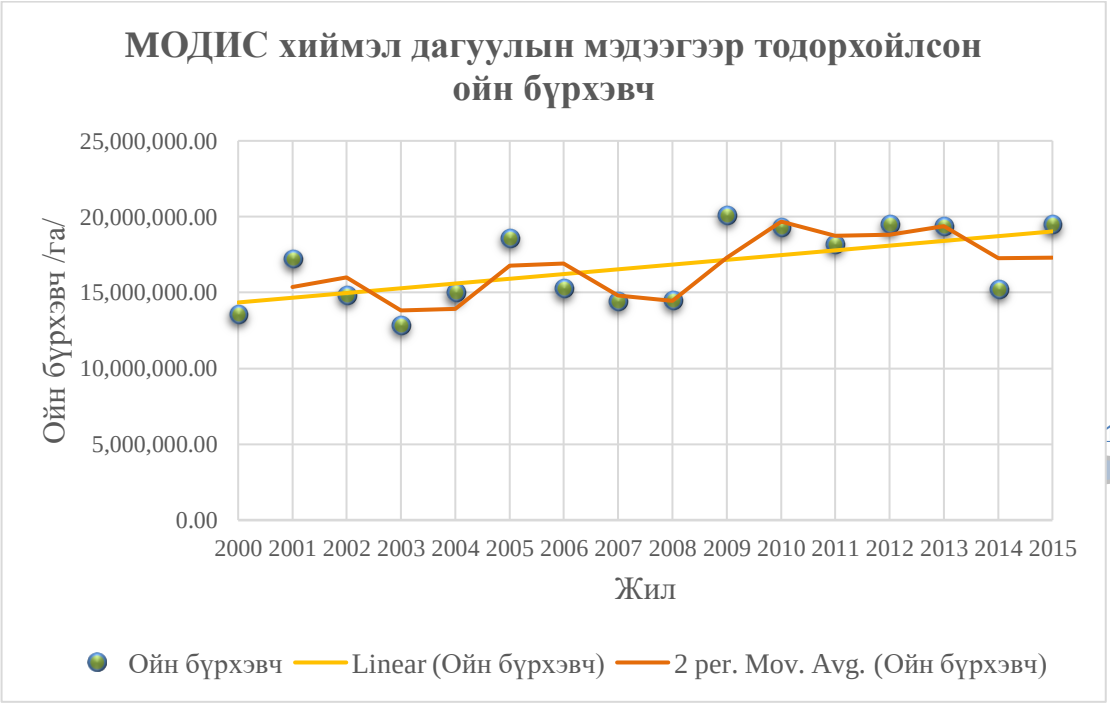


Table 29. Forest cover defined in MODIS satellite data (2000-2015)

	Forest cover area	Ойрхог чанар %	Taxation data
2000	13,554,184.05	8.66	10,386,900.00
2001	17,182,020.52	10.97	
2002	14,799,552.74	9.45	
2003	12,840,428.47	8.20	
2004	14,988,787.57	9.57	
2005	18,567,390.11	11.86	
2006	15,231,460.41	9.73	
2007	14,400,240.44	9.20	
2008	14,479,605.52	9.25	
2009	20,091,725.37	12.83	
2010	19,262,913.67	12.30	
2011	18,187,729.88	11.61	
2012	19,440,401.95	12.41	
2013	19,333,445.76	12.35	
2014	15,187,102.93	9.70	
2015	19,446,038.79	12.42	
Average	16,687,064.26	10.66	6.63
Country area	156,600,000.00		

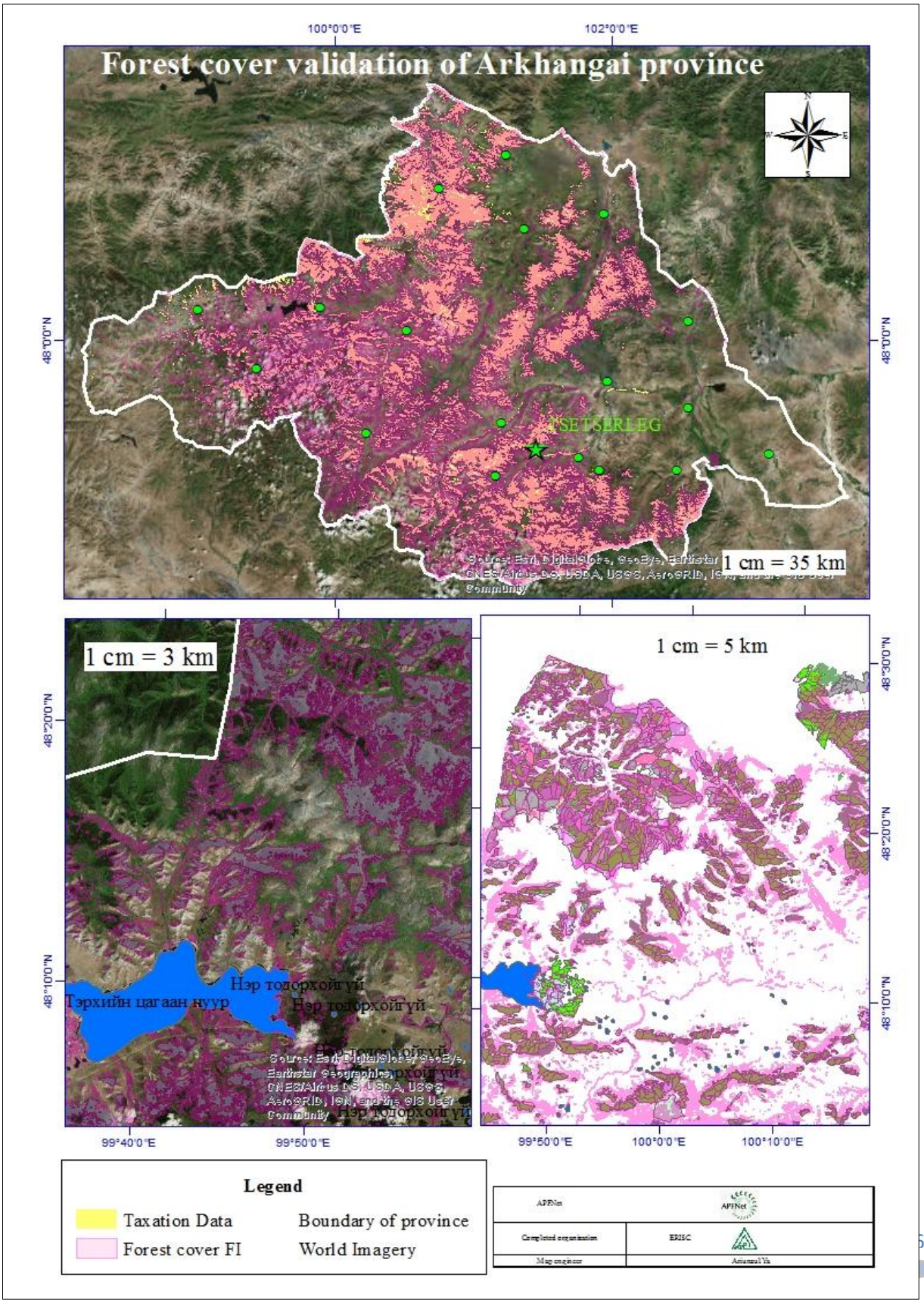
Mongolian forest cover which defined from MODIS satellite data has not classified shrub and saxual forest, the average of 15-year woody rate of Mongolia is 10.66. the official forestery woody rate from the FRDC is 6.63 included saxual forest and shrubs [7]. The increasement of forest cover that defined in MODIS satellite data influenced with waterbody and cropland and pasture area. But the advantage of MODIS forest data is one-day data which is 16th of August of 15 years can easily identify certain area change. For the Landsat data it is not possible to pick one-day data, then we chosen growth peak season data.

2.8. ACTIVITY LEVEL FIVE

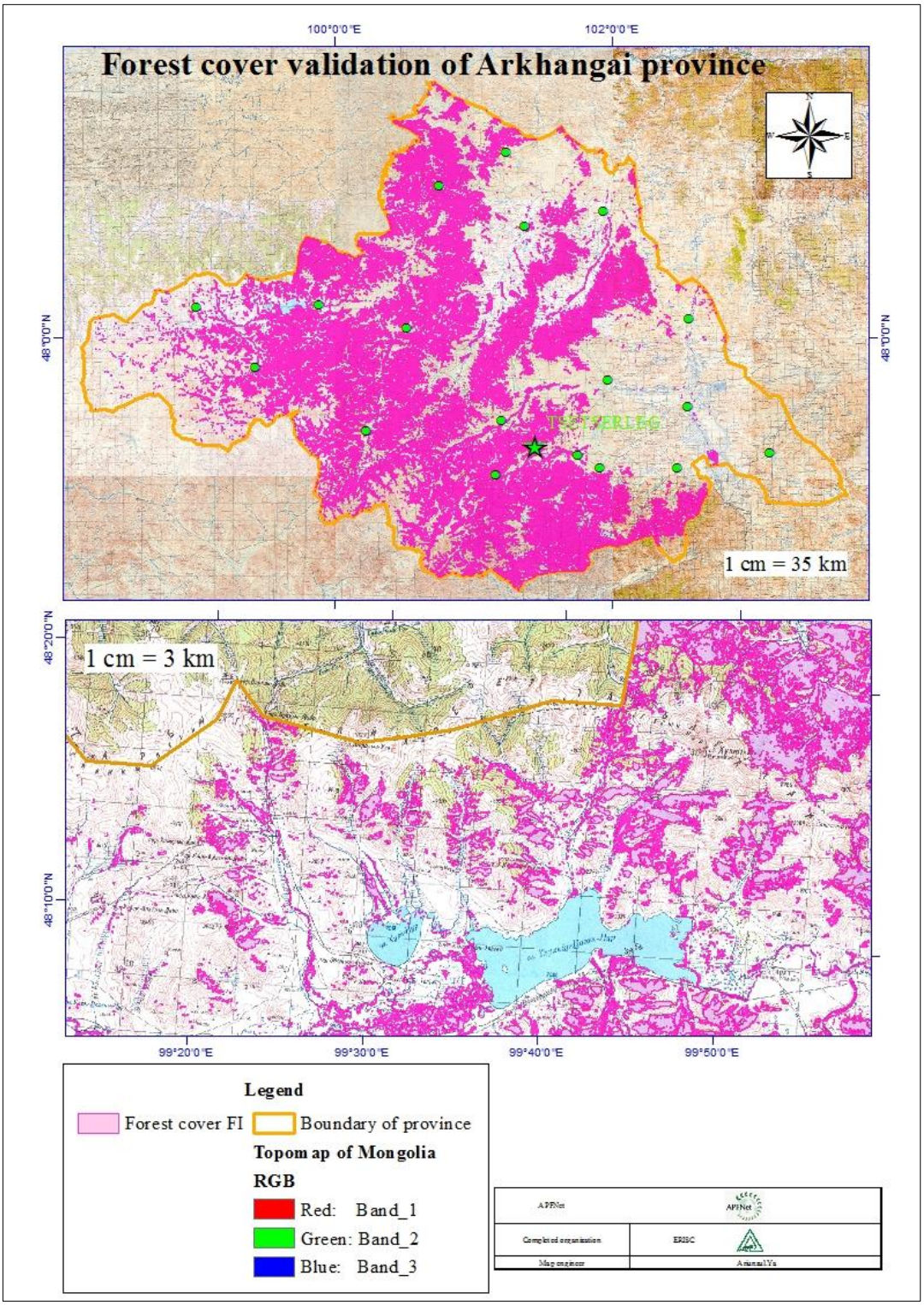
FOREST INVENTORY DATA COLLECTION, VALIDATION

2.8.1. Comparison between forest taxation data, topographic map and GoogleEarthPro

Forest cover map from the Landsat and MODIS compared and assessed by grid-sampling method with Forest taxation data, topographic map and Google EarthPro map in two community area of Bulgan province. Result analysed with ArcGIS software. The following map shows an Arkhangai province example. The first picture shows the comparison between forest cover map with taxation data and Google Earth Pro data. Second picture shows comparison by separately. Taxation data is 2016 data.



Picture 99. Comparison assessment for forest cover area with other data



Picture 100. Comparison assessment for forest cover area with other data

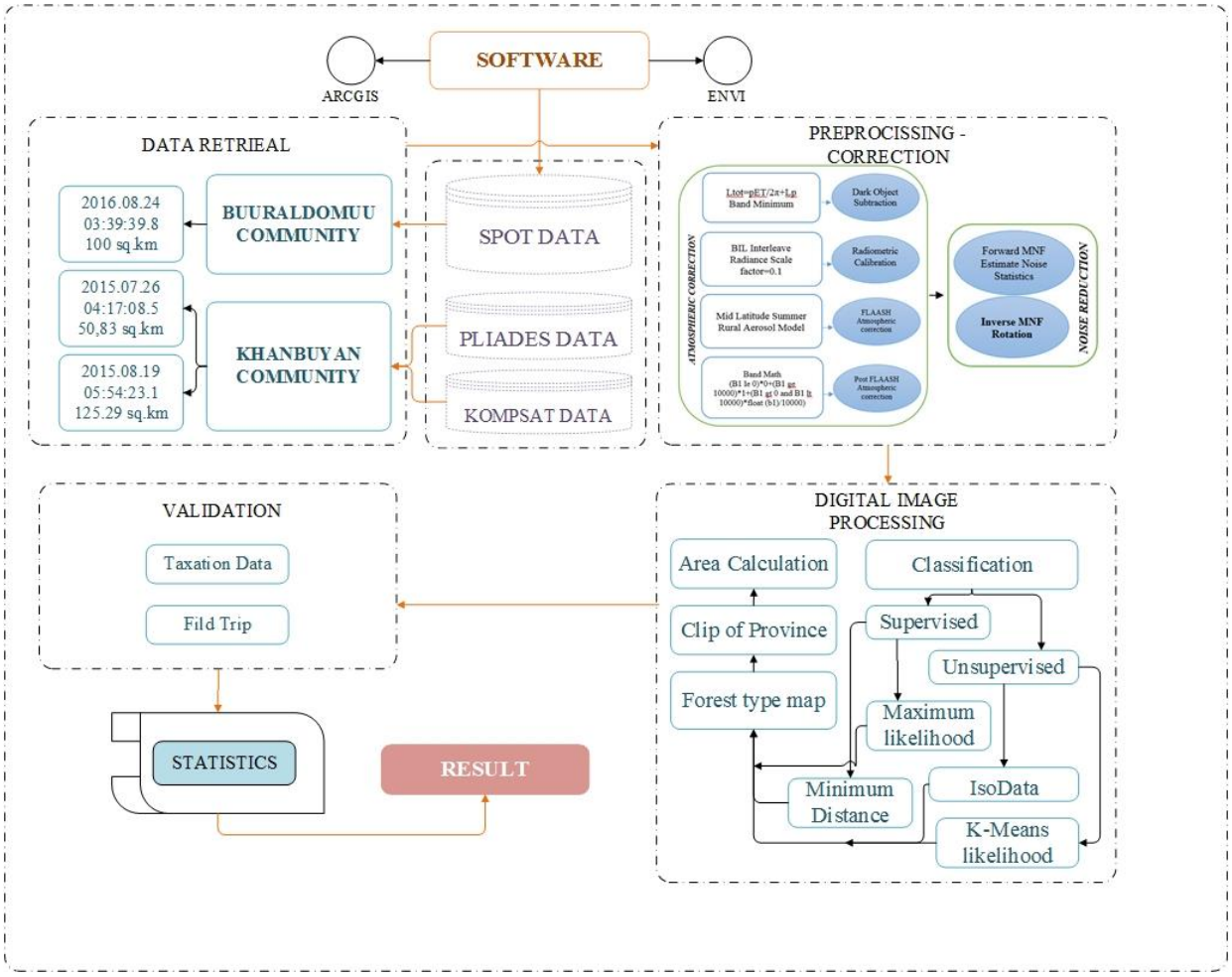
CHAPTER III

"MAPPING FOREST TYPE USING THE SATELLITE DATA"

3.1. METHODOLGY

Forest type has not been defined from the high-resolution satellite data in before Mongolia. This is related to less availability and expensive price of data. The project planned to define forest type maps from IKONOS high-resolution satellite data on 2015-2016. The IKONOS satellite resolution is 1 to 4 meters and it launched 24th of September 1999, first time they sold high-resolution data to public from 2000. Multispectral band resolution is 3.28 meter and panchromatic band has 0.82-meter resolution. The IKONOS satellite was active when we are writing the project but last three years the satellite has deactivated in Mongolia. That is why we have chosen same performance high resolution satellite such as SPOT, Pleiades and KOMPSAT. Schema 6 shows general sequence of methodology.

Schema 6. Schema of the methodology to define forest type



We used remote sensing approach for processing high resolution satellite data. The estimating result and changes used forest taxation data of FRDC with field trip by GIS software. To define forest type of selected two communities using the vegetation and forest index on SPOT, Pleiades, Kompsat high resolution satellite data. The result validated by field trip.

3.1.1. Activity plan:

Preparation activity:

- Activity level 1 - Data retrieval:
  - ✓ To prepare the relevant data of forest cover and forest fund at selected communities.
  - ✓ To collect and prepare about satellite and satellite data and nomenclature etc.
  - ✓ Create database for high resolution satellite data and bought SPOT, Pleiades, Kompsat high resolution satellite data.

Processing activity:

- Activity level 2 - Data correction:
  - ✓ To prepare for processing, we corrected satellite raw data.
- Activity level 3 - Field data collection:
  - ✓ Validate by field trip. Here: To go the sampling area and measure the coordinate, longitude, latitude, elevation, azimuth, character of land cover, character of forest, tree count in per pixel, value of forest index, forest age, forest components, forest average height, average diameter and crown diameter. etc.
- Activity level 4 - Validation:
  - ✓ Forest type validate on field trip data and taxation data

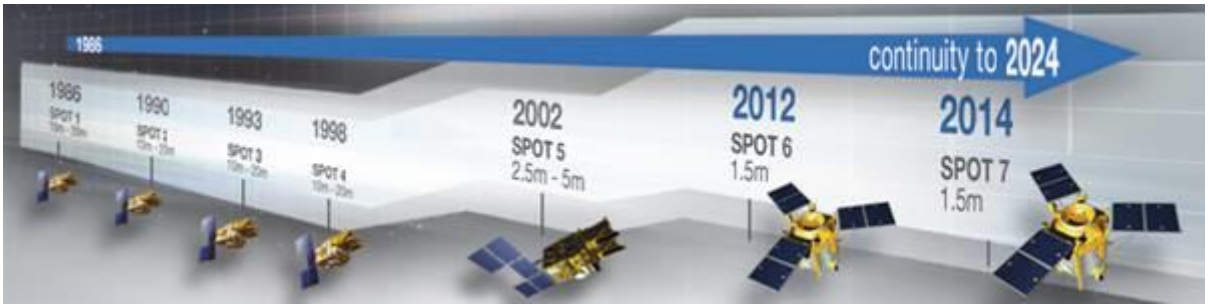
Processing activity:

- Report the result.
  - ✓ Communities forest's basic performance
  - ✓ Image processing. Forest distribution map for chosen community forest. Forest classification map from the NELDA land cover classification map. Forest type map from the high resolution satellite data. Locate scale, legend, grid on the all type of map.

3.2. ACTIVITY LEVEL 1 - DATA RETRIEVAL

3.2.1. ABOUT SPOT SATELLITE

The successful to beginning of series SPOT 1 has launched by French space agency (Satellite Pour de la Terre, Earth observation satellite) in 1986. The SPOT satellite has mapped the total 30 million scene since 1986. Furthermore, series went to SPOT 7 in thirty years, SPOT 7 has launched by the Indian Dkhavan Space Center on June 30, 2014.



Picture 101. Series of SPOT satellite

While retaining SPOT's trademark 60-km wide imaging swath, SPOT 6 and SPOT 7 offer users a number of key improvements:

- 1.5-metre-resolution natural-colour products, orthorectified as standard
- Multi-year coverage of entire national territories
- Daily revisits to any point on the globe
- Ability to accommodate last-minute tasking requests
- Billing per area of interest

Built with a 10-year lifetime warranty, SPOT 6 and SPOT 7 assure continuity of high-resolution data services through to 2024.

Table 30. Performance of SPOT 6 satellite

№	Spectra	Wavelength	Spatial solutions	Radiometric solutions
1	Panchromatic	0.450-0.745 µm	2 meters	12 bit
2	Blue	0.450-0.520µm	8 meters	12 bit
3	Green	0.530-0.590µm	8 meters	12 bit
4	Red	0.625-0.695 µm	8 meters	12 bit
5	Near-infrared	0.760-0.890 µm	8 meters	12 bit

SPOT 6 and SPOT 7 are designed to cover wide areas in record time, making it possible to regularly update national map series free from the constraints imposed by seasonal conditions.

The constellation covers up to 6 million sq.km. every day, an area larger than the entire European Union.

Four weather forecasts per day are integrated automatically into the tasking process to optimize efficiency. As a result, 60% of images have less than 10% cloud cover. Resource: http://www.satimagingcorp.com/, http://geo-eco.mn/?p=37. For the project activity, we used SPOT6 high-resolution satellite data with 1.5 meter resolution of 100 square killometer timeframe of 15:39, 27th August 2016

Table 31. Performance of SPOT 6 satellite data

Position	*Item*	*Description*
1	1	*PROD_SPOT6_001*
		VOL_SPOT6_001_A
		IMG_SPOT6_P_001_A : SPOT 6 2016-08-27:03:39:27.7 ORTHO P
		IMG_SPOT6_MS_001_A : SPOT 6 2016-08-27:03:39:27.7 ORTHO MS

Dataset Id/ product code	***ORT_SPOT6_20160827_03393770 0_000***
Unitary Production Date	***2017-02-23T06:42:36.00Z***
Image dimensions	***8968 rows x 7820 columns***
Acquisition date	***2016-08-27 03:39:27.7***
Platform name	***SPOT 6***
Spectral Mode	***PMS***
Spectral Processing	***P***
Processing level	***ORTHO***
Number of spectral bands	***1***
Spectral bands id	***P***
Solar irradiance value of raw radiometric Band	***1706.514896***
Orientation angle	***+159.39°***
Incidence angle	***+20.32°***
Sun Azimuth	***+146.50°***
Sun Elevation	***+47.22°***

Image Centre Location

Row	Column	Latitude	Longitude
4485	3911	**N048°56'41"**	**E103°14'03"**

Image Vertex Location

Row	Column	Latitude	Longitude
1	1	N049°00'14"	E103°09'07"
1	7820	N049°00'23"	E103°18'44"
8968	7820	N048°53'07"	E103°18'59"
8968	1	N048°52'59"	E103°09'23"

SPOT хиймэл дагуулын мэдээ

3.2.2. ABOUT PLEIADES SATELLITE

Pleiades satellite has launched by European Defense and Space Agency in 2011. It is capable of taking imagery of the high-resolution satellite 0.5 m. We used the area of 50.83 km^2 from Pleiades data of 2 m spatial resolution in 4:17 pm July 26, 2015. We bought SPOT, Pleiades satellite data from http://www.intelligence-airbusds.com/ through distributor "GeoMaster" LLC in Mongolian.

Table 32. Performance of Pleiades satellite

№	Spectra	Wavelength	Spatial solutions
1	Panchromatic	450-830 nm	0.50 meters
2	Blue	430-550 nm	2 meters
3	Green	500-620nm	2 meters
4	Red	590-710 μm	2 meters
5	Near-infrared	740-940 μm	2 meters

Picture 102. Image of Pleiades satellite

Table 33. Performance of Pleiades satellite

Name: DS_PHR1A_201507260416315_FR1_PX_E104N49_0209_01274

Form: POLYGON

Acquisition date: 2015-07-26 04:17:07.5

Platform PHR 1A

Acquisition mode: PX

Spectral processing: XS

Processing level: ORTHO

Coordinate system CRS type PROJECTED

CRS name 32648 CRS code EPSG: 32648

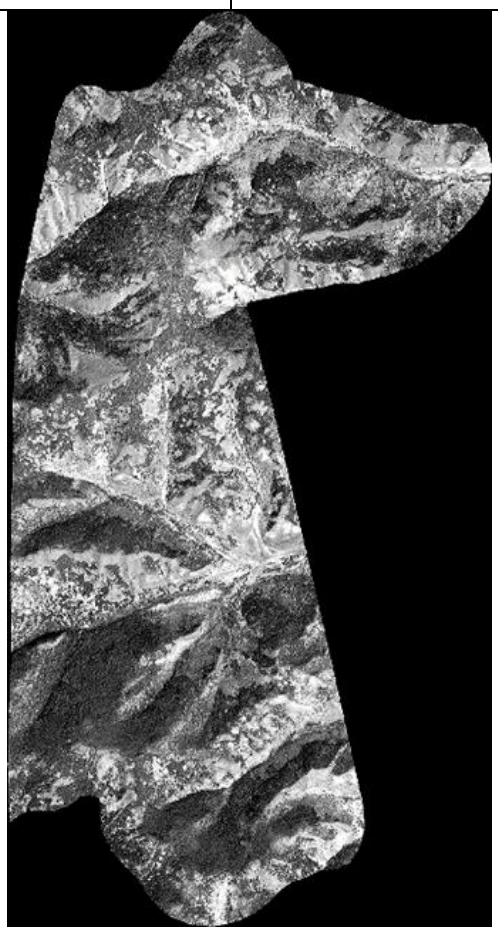
Product dimension: Number of lines 7299, Number of pixels per line 3849

Number of bands: 4

Band ID	B0	B1	B2	B3
Absolute calibration gains: (W/m2/sr/µm)	9.13	9.16	10.26	15.43

Incidences and orientation

	Start	Middle	End
Orentation	179.7978045033219	179.9426832901143	180.0346857463742
Global incidence	14.6707506579361	14.75005211456143	14.82997596046063
Across/along the track	-10.07086757749498 /10.88754750971913	-10.21088559830295 / 10.86952976374505	-10.3594865837199 / 10.84297051663013
Solar azimuth	155.5808773791566	155.5382260470337	155.4950532474308
Solar elevation	58.56260253531132	58.62047400706369	58.67826996209588



Picture 103. Pleiades satellite data used in the project

3.2.3. ABOUT KOMPSAT SATELLITE

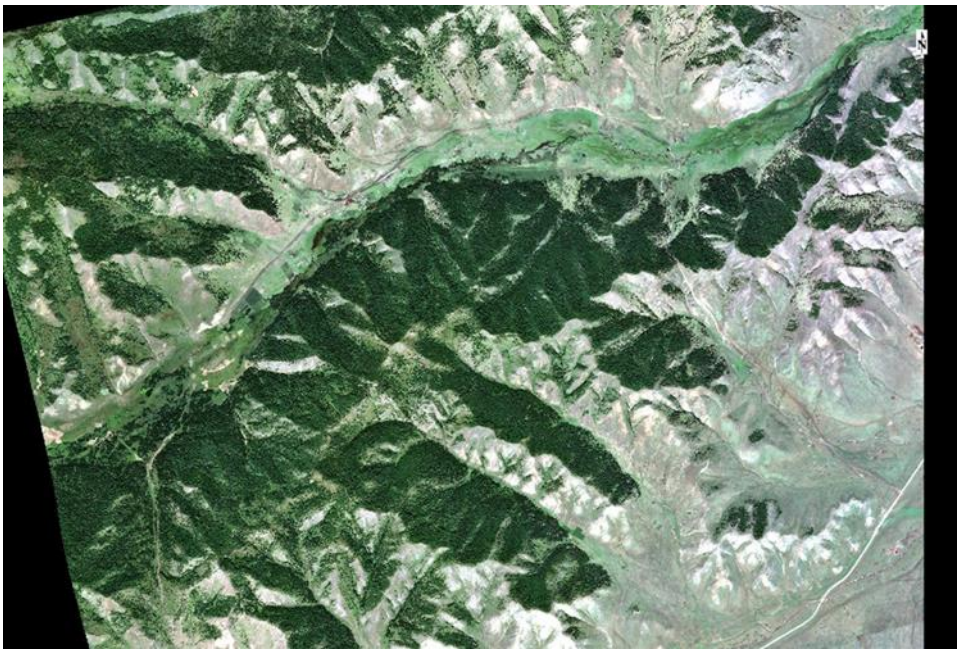
KOMPSAT, the Korea Multi-Purpose Satellite, was the first spacecraft development project for the South Korean Aerospace Research Institute (KARI) on 2016, that project launched to purpose use for agriculture, environmental, natural disasters. Activities have been observing earth Kompsat-2, Kompsat-3, Kompsat-5, DubaiSat-2 designed for high-precision infrared, visible support of scientific applications, geographic mapping. Kompsat-3 has launched in May of 2012. The spatial solutions 2.8-0.7 m. Source: http://www.satimagingcorp.com/satellite-sensors/kompsat-3/

We used area of 125.29 km2 data with spatial resolution 2.8 m in 5:54pm of 17th of August 2015. To selected quality qualifying of cloudless, wildfire smokeless in the project research. Therefore, we have chosen different time and satellite data. We bought KOMPSAT satellite data from http://www.si-imaging.com through distributor "ZOLOTON" LLC in Mongolian.

Table 34. Performance of Kompsat-3

№	Spectra	Wavelength	Spatial solutions	Radiometric solutions
1	Panchromatic	450-900 nm	0.7 meters	14 bit
2	Blue	450-520 nm	2.8 meters	14 bit
3	Green	520-600 nm	2.8 meters	14 bit
4	Red	630-690 nm	2.8 meters	14 bit
5	Near-infrared	760-900 nm	2.8 meters	14 bit

Picture 104. Kompsat-3 satellite



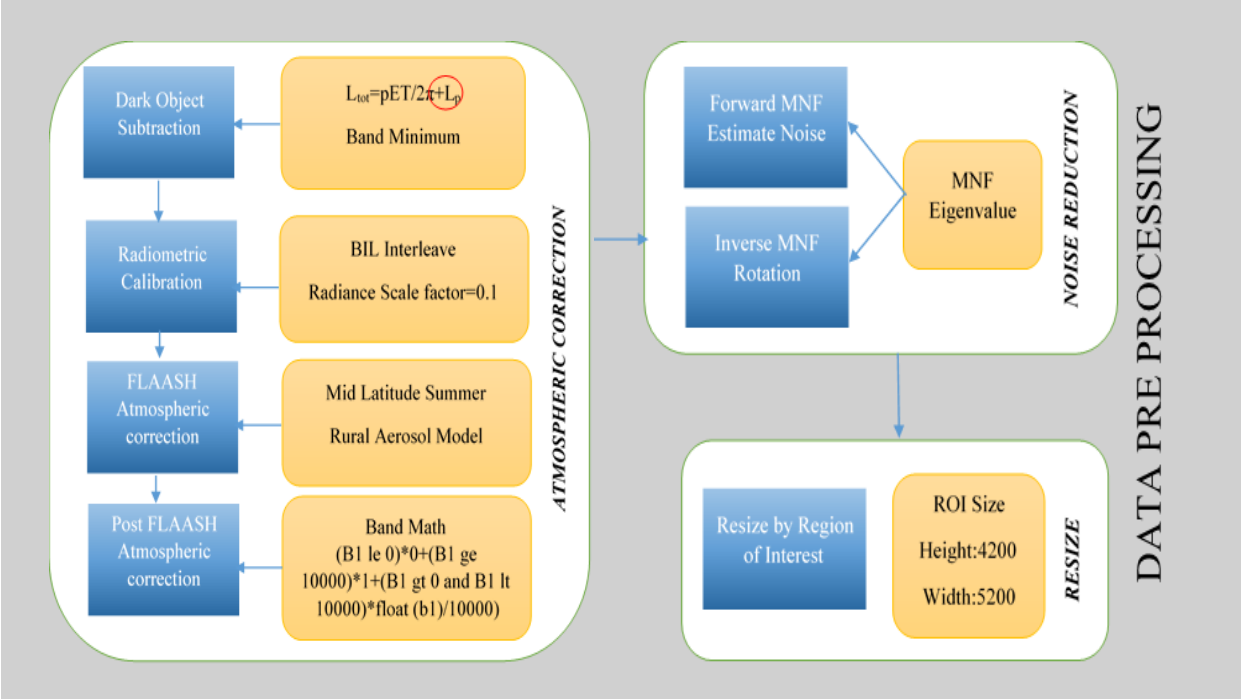
Picture 105. Purchased data of Kompsat-3 satellite

3.3. ACTIVITY LEVEL 2

PRE-PROCESSING, DATA CORRECTION

The purchased data is the raw data. Correction improves the quality of raw data and the results become more accurate. Our purchased data already done for Geometric correction. We completed radiometric and atmospheric correction as mentioned previous chapter. The detailed description of the methodology in the previous chapter, this stage included only scheme.

Schema 7. The schema of correction for high resolution satellite data



3.4. ACTIVITY LEVEL 3

FIELD DATA COLLECTION

Field trip completed in two times July and September at two community areas named as Khanbuyan of Khangal soum and Buuraldomuu of Bugat soum of Bulgan province. The field trip has a purpose with measure some point of validation and define landcover type, measure forest type in the field, meet the community members and define understanding of forest management plan.

Field trip completed by two ways. The first way has purposed to define land cover type by forest index and make sure accuracy assessment confusing points in July filed trip. The second way has purpose with check our results by a random sampling method in September field trip. Each sample points in field measured by 30x30 meter 900 square meter area. Khanbuyan community has 37 sample in July and 38 sample in September. Buuraldomuu community has 10 samples in July and 17 samples in September.

Following measurement completed:

1. Define location (coordinate)
2. Navigation
3. Azimuth
4. Land cover type /forest or nonforest/
5. Define forest origin
6. Forest components
7. Tree height
8. Diameter of tree
9. Canopy diameter
10. Distance between trees
11. Count the trees in 900-meter square area
12. Define field typology of forest /Logging, fired, nursing etc/
13. Define field typology of nonforest /pasture, meadow, water, road etc/
14. Count fallen trees in 900-meter square area
15. Count stub in 900-meter square area
16. Define shrub
17. Taken photograph
18. Measure depth of moss
19. Soil sample picked up from 5 field

Equipments of field trip

	Measuring prong
	GPS Ground position system
	Vertex
	Tree age drill
	Bussoli
	Tape measure

We attached all sample points measurement as Annex 4.

Picture 106. Field trip

Table 35. Members questionary of "Khanbuyan" forest community

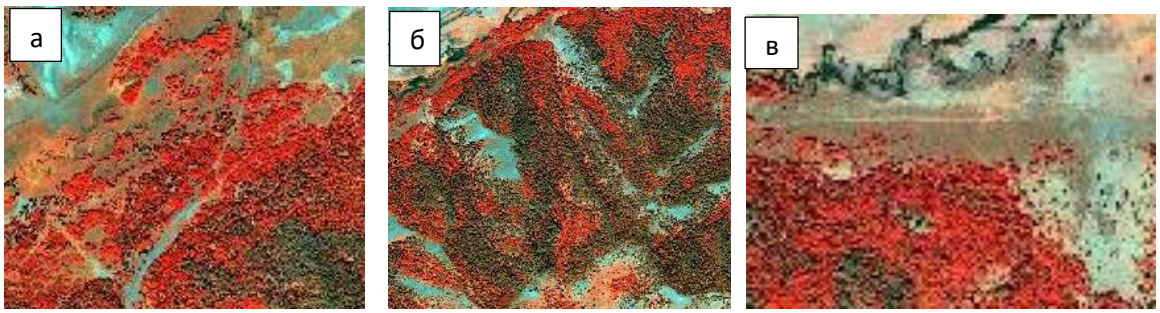
№	Name	Entry year	Reason to enter community	Do you have any income from community?	Do you know about forest managemet plan?	Operation
1	Ganbandi.B	2011	Protect forest	No	Use duly	Cultivator
2	Oyunbaigali.E	2015	Tree nursery	No	It has some benefit	Hiver
3	Nasantogtoh.D	2011	Tree nursery	No	I don't know	Miner
4	Tugsbayar.D	2012	Protect forest	No	I don't know	Herder
5	Badamgarav.D	2012	Tree nursery	No	I don't know	Hiver
8	Bat-Erdene.E	2012	Protect forest	No	I don't know	Farmer
9	Gundegmaa.B	2012	Protect forest	No	I don't know	Farmer
10	Gansum.B	2012	Protect forest	No	I don't know	Herder
11	Khishigdorj.O	2012	Protect forest	No	I don't know	Retired

12	Nyam.O	2012	Protect forest	No	I don't know	Retired

Table 36. Members questionary of "Buuraldomuu" forest community

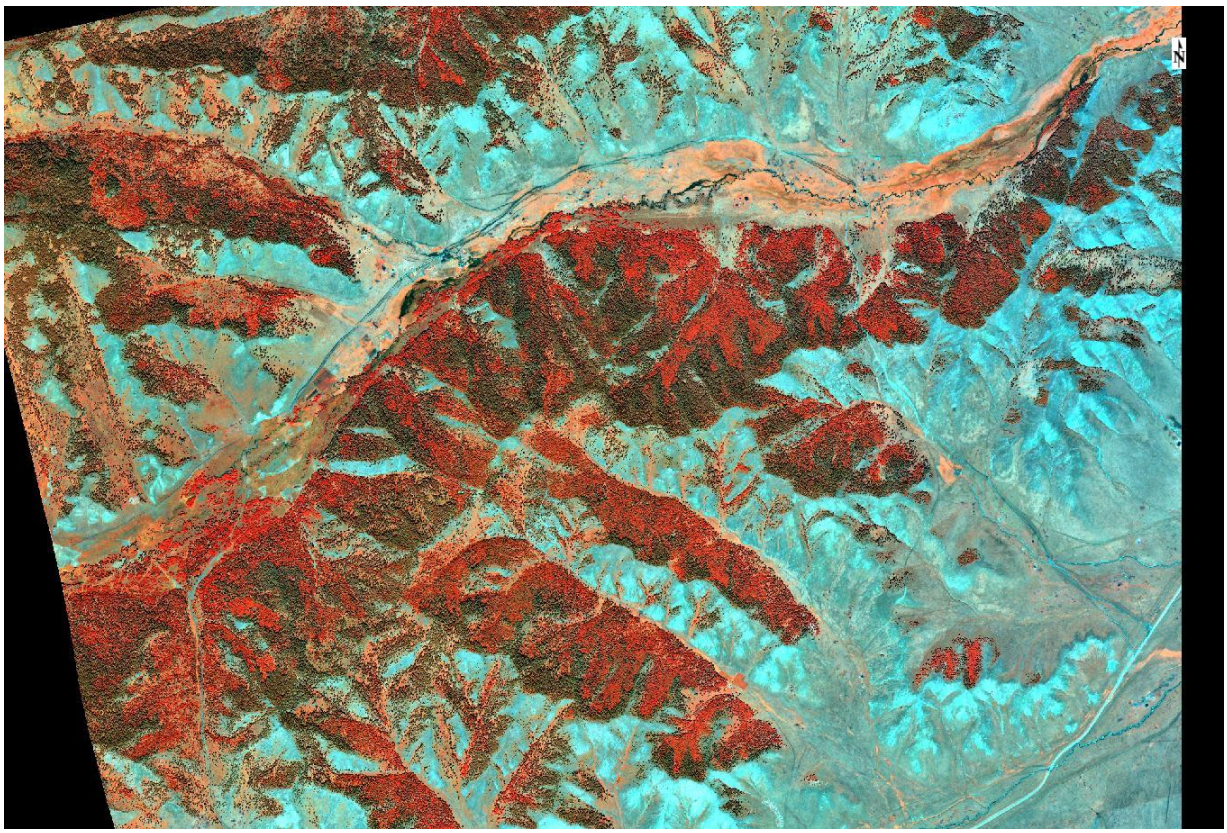
№	Name	Entry year	Reason to enter community	Do you have any income from community?	Do you know about forest managemet plan?	Operation
1	Erdenebileg.G	2011	Protect forest	Little bit	I don't know	Herder
2	Gantsetseg.Ts	2011	Tree nursery	No	I don't know	Herder
3	Galdan.G	2011	Tree nursery	No	I don't know	Retired
4	Badarch.D	2011	Protect forest	No	I don't know	Retired
5	Jiza.Ts	2011	Tree nursery	No	I don't know	Retired
6	Batsaikhan.B	2011	Protect forest	No	I don't know	Herder
7	Zolzaya.A	2011	Protect forest	No	I don't know	Herder
8	Azdelger.O	2011	Protect forest	No	I know	Unemployer
9	Chinzorig.G	2011	Protect forest	No	I know	Forest engineer

We have chosen band combination to define forest type from the high resolution data is RGB-421 means red-near, green-blue and blue-red. The forest community Khanbuyan has larex and betula forest. Following picture shows red as betula forest, б picture as larex forest and в picture as a shrub.



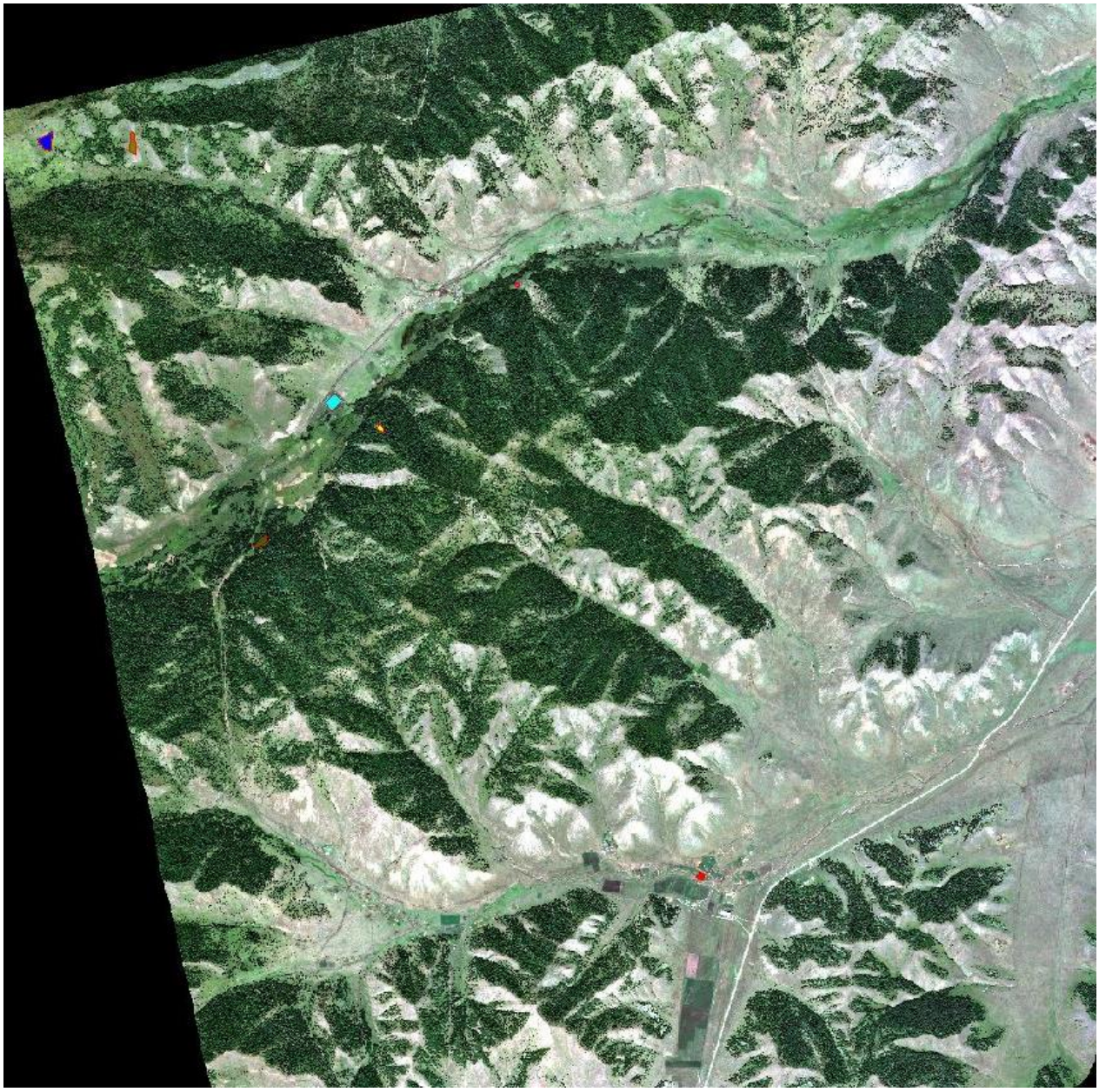
Picture 107. а) Betula, б) Larex, в) Shrub

Larex forest, Betula forest and shrub types area chosen based on field trip data.



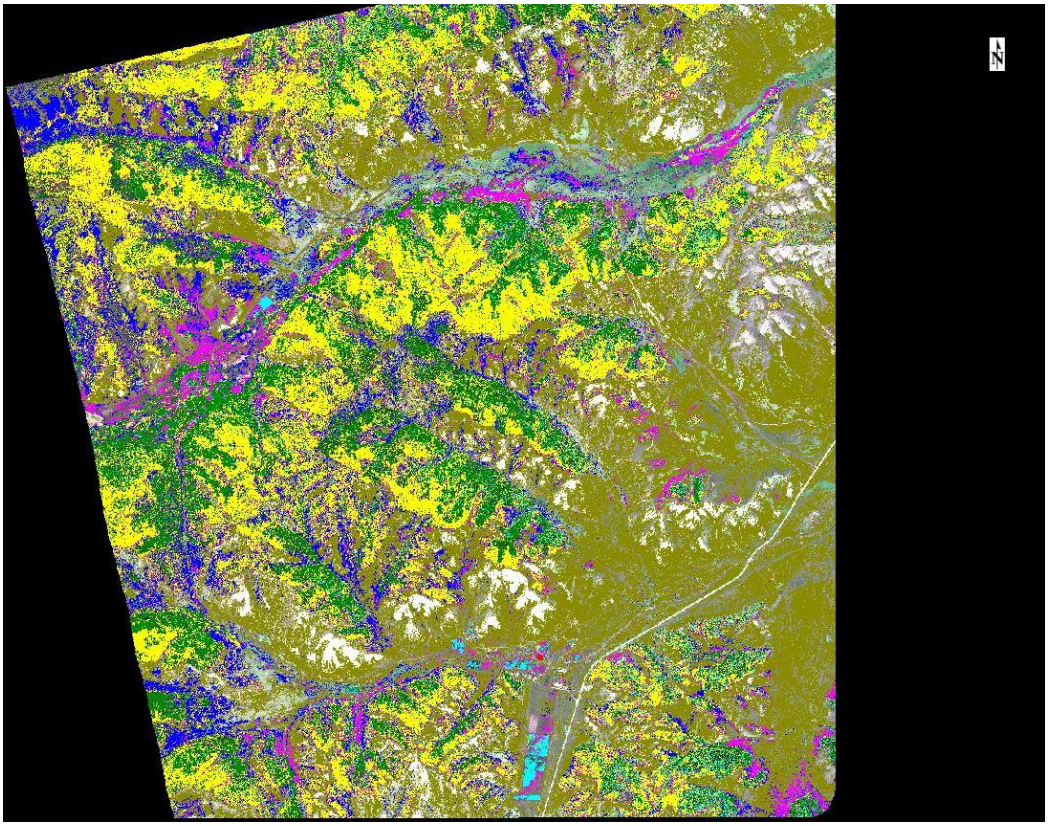
Picture 108. Forest type from the Kompsat satellite data

We had classified other classes by NELDA project as meadow, pasture, cropland and public place for classify full scene. Then we icked up 7 land cover type by ROI.

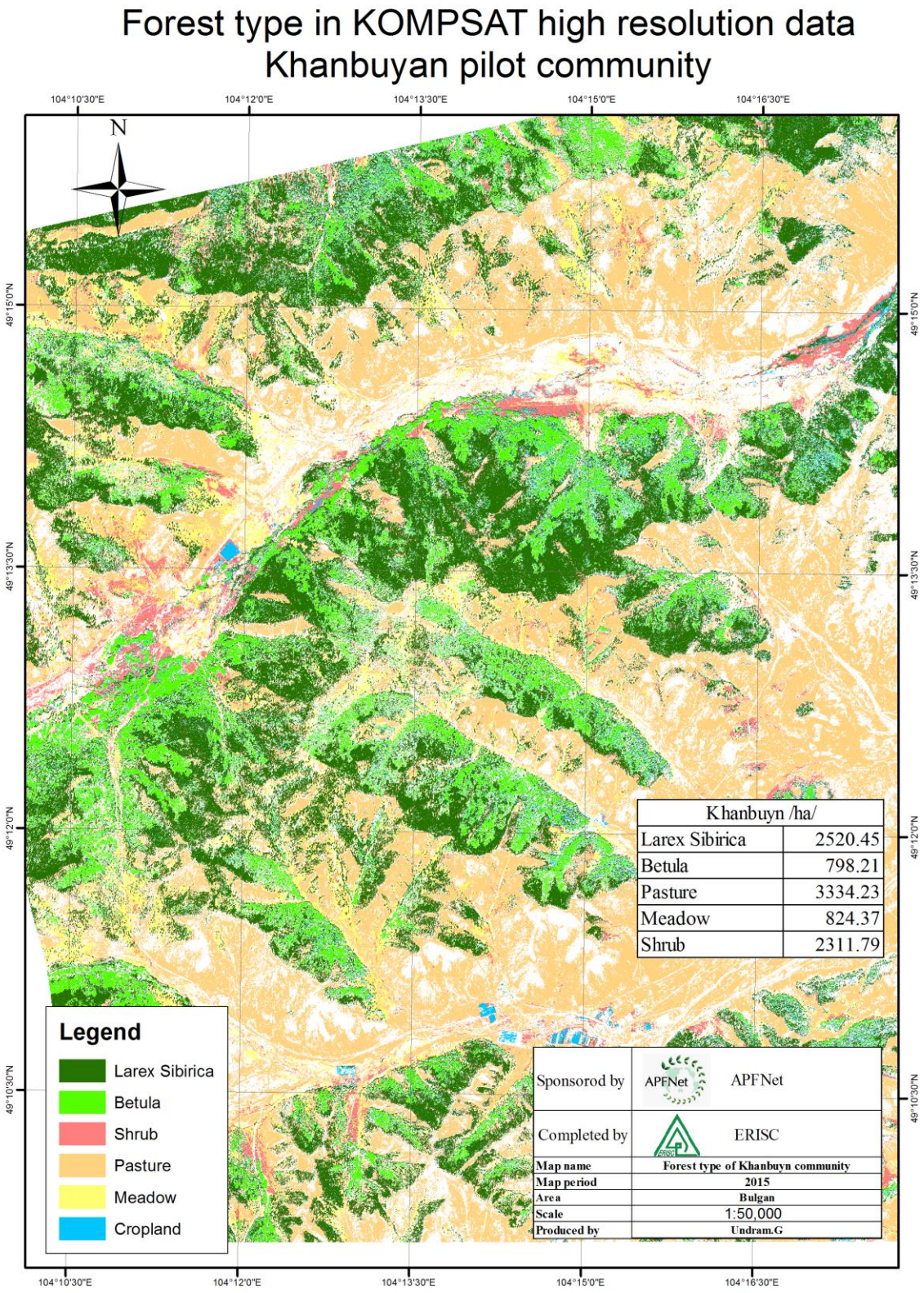


Picture 109. The ROI selection

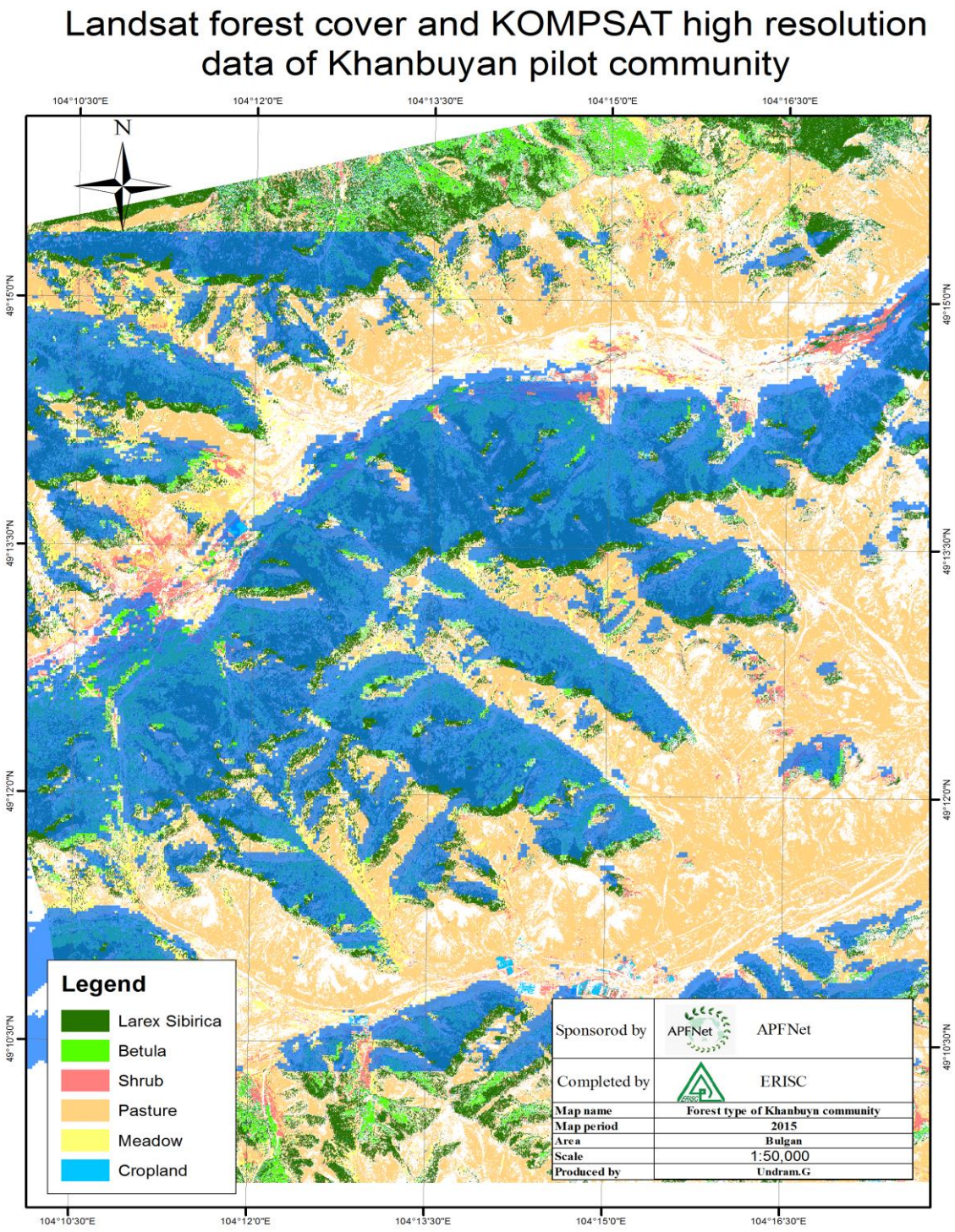
Then classified with seven type by Maximum likelihood classification.



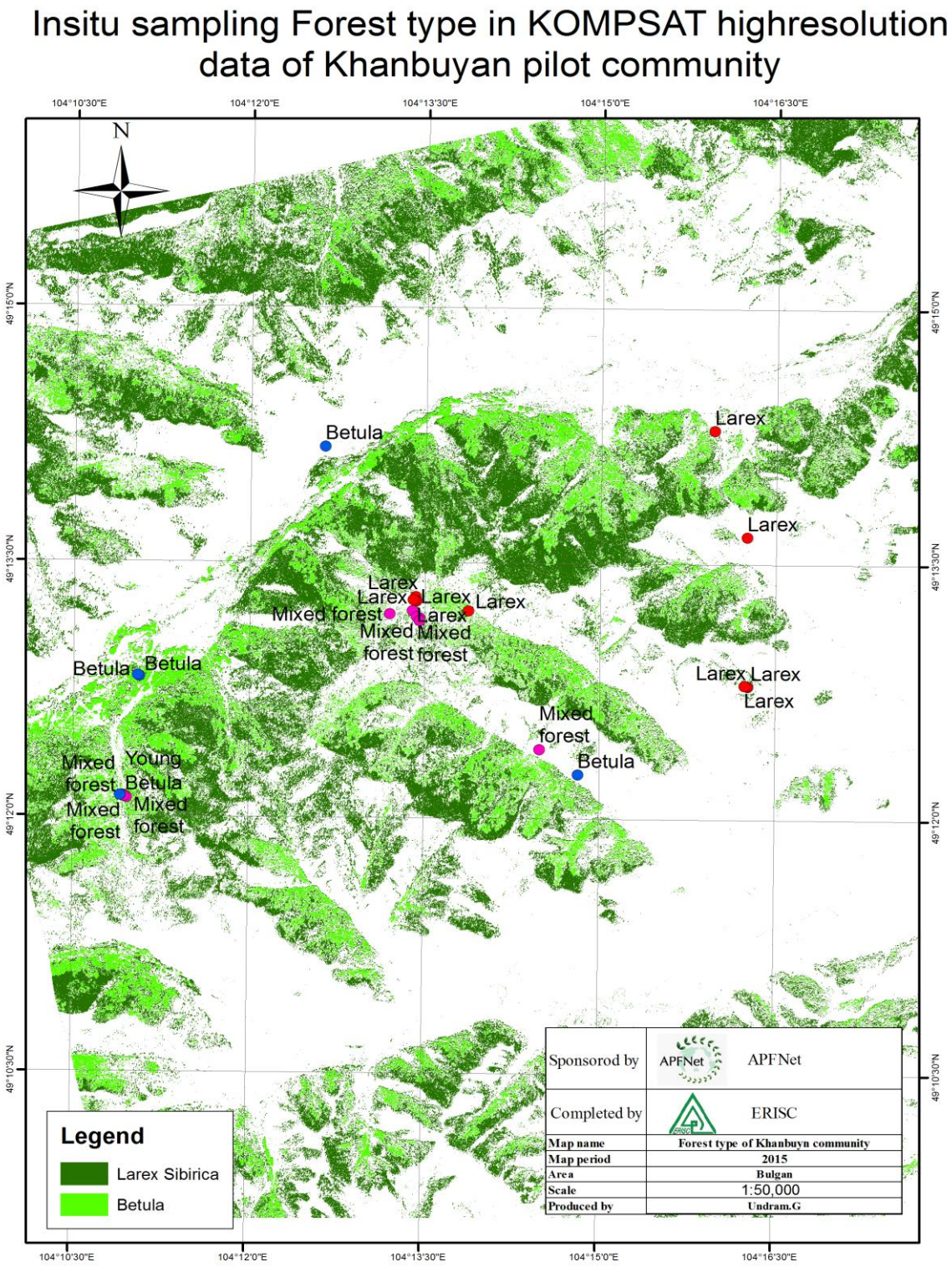
Picture 110. Maximum likelihood classification



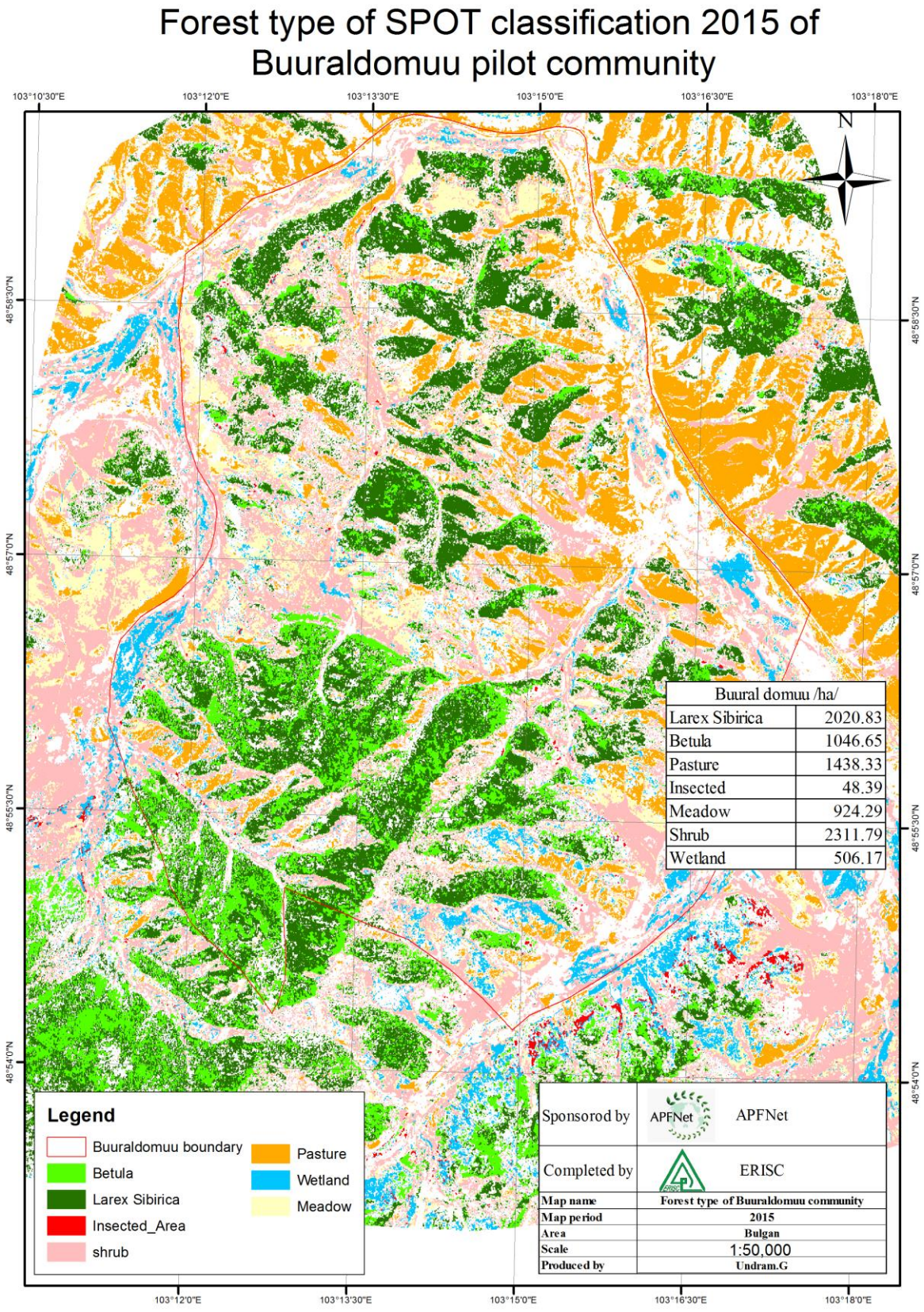
Picture 111. Landcover classification of Khanbuyan community from Kompsat satellite data



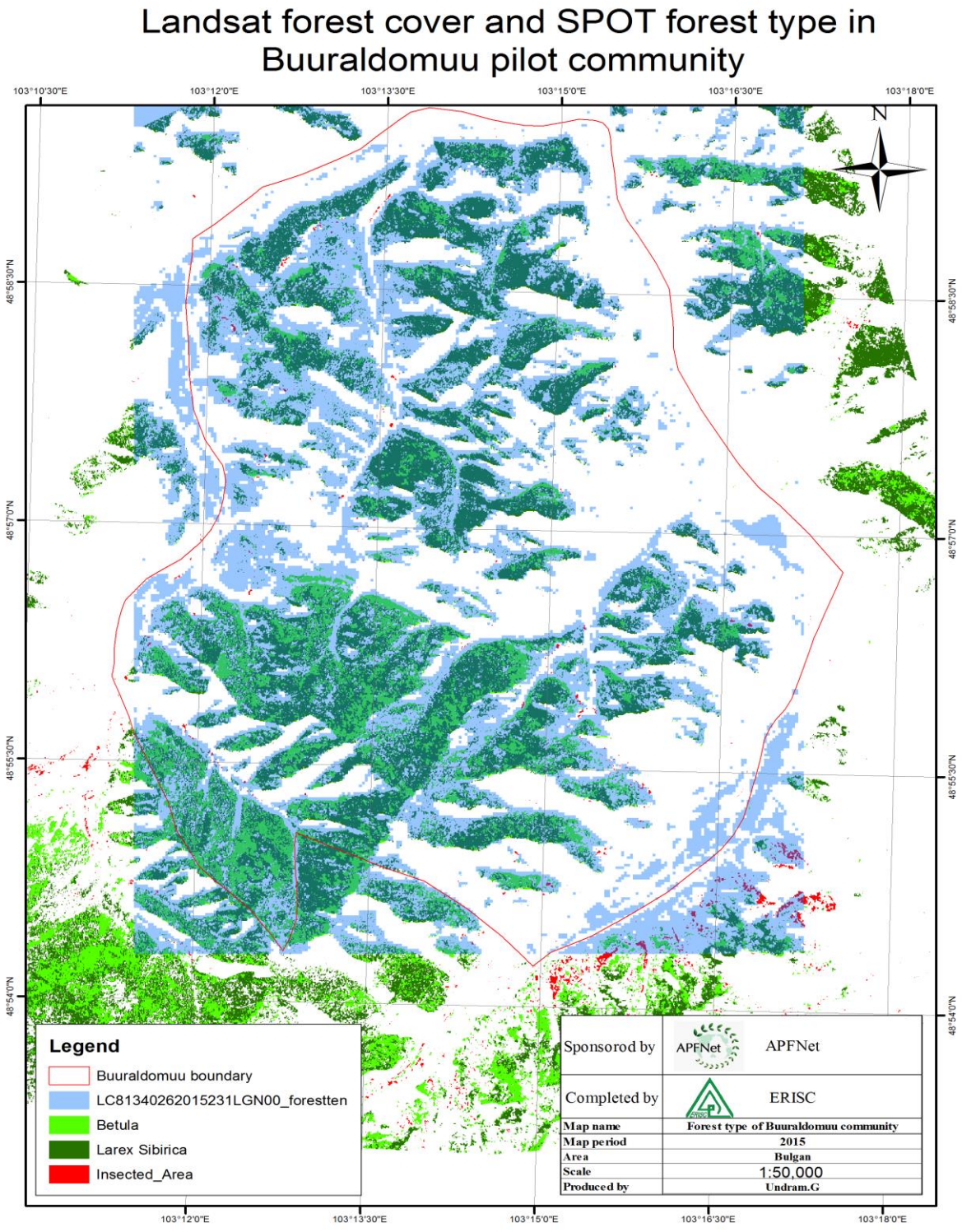
Picture 112. Forest map comparison between Landsat forest index and Kompsat satellite classification of Khanbuyan forest community area



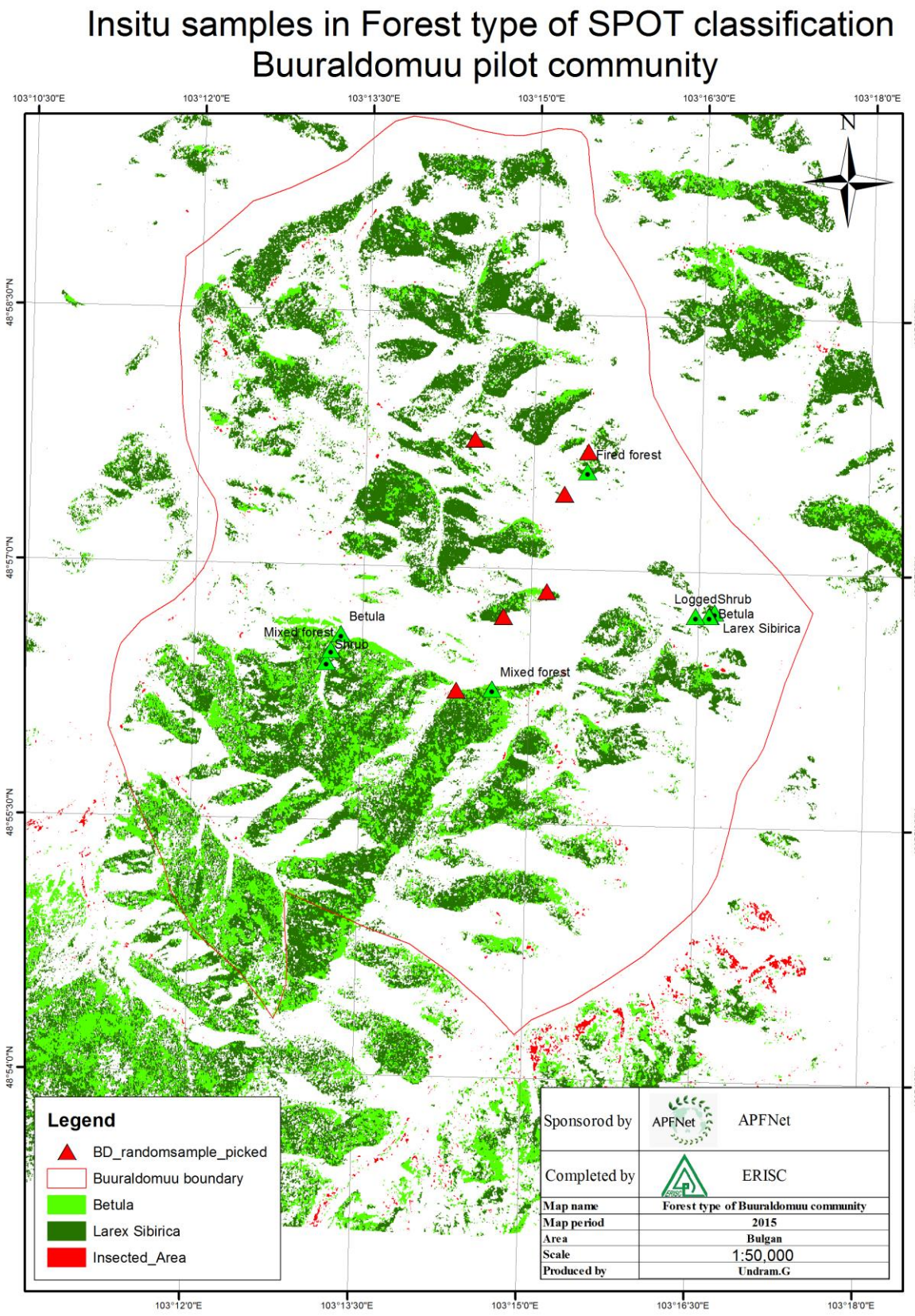
Picture 113. Forest type map validated by field trip байдал



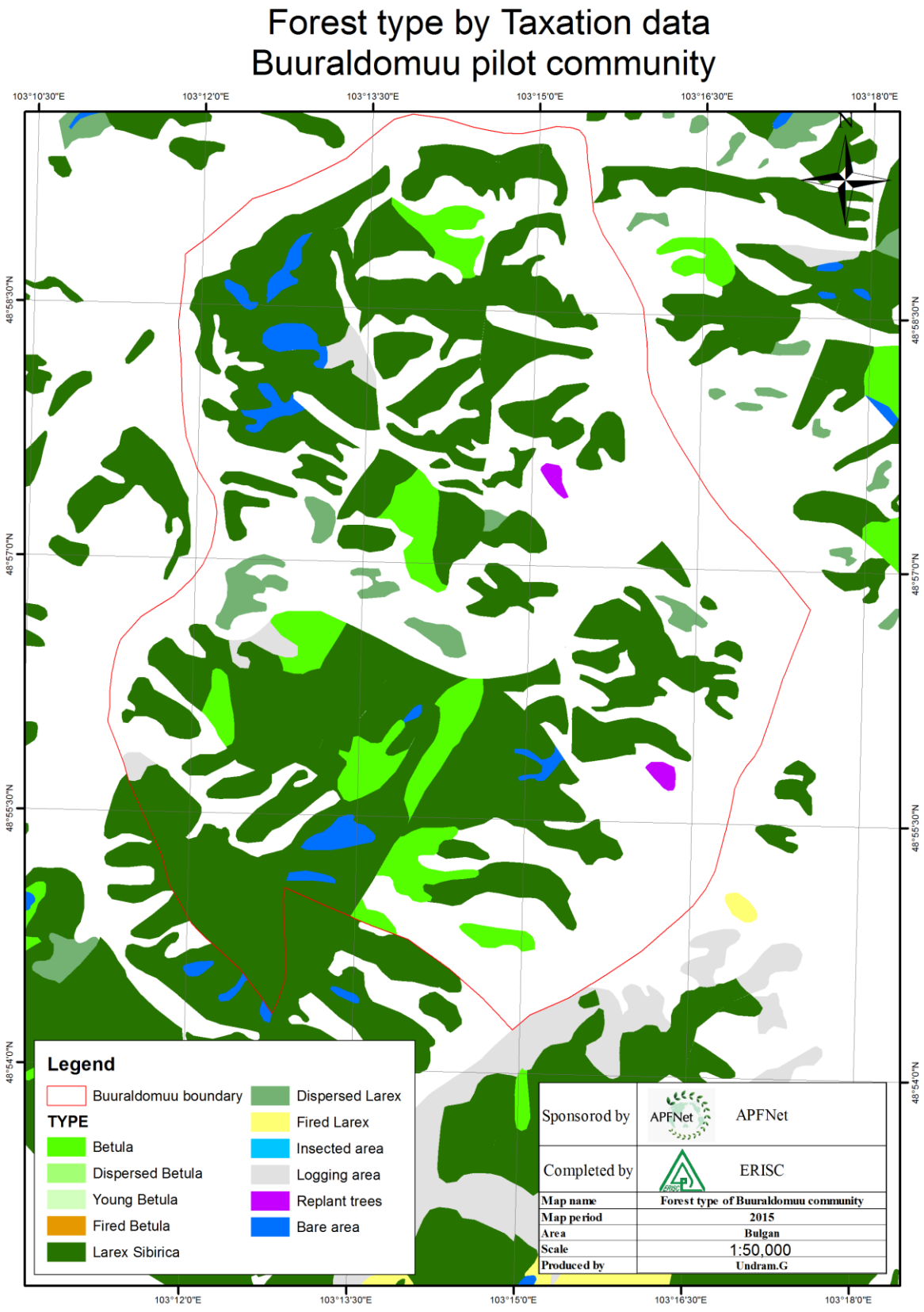
Picture 114. Forest type map of Buuraldomuu community from SPOT satellite data



Picture 115. Forest map comparison between Landsat forest index and SPOT satellite classification of Buuraldomuu forest community area



Picture 116. Forest type map validated by field trip in Buuraldomuu forest community



Picture 117. Forest type map of taxation data in Buuraldomuu community

Picture 118. Conversation with head of Khanbuyan forest community

Picture 119. Conversation with head of Buuraldomuu forest community

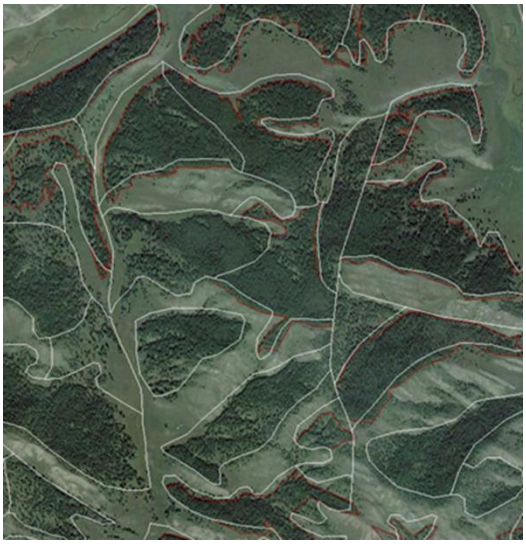
3.5. ACTIVITY LEVEL 4

VALIDATION

We completed three level validation during the project for validate forest cover map from the forest index. The first level was a Base error matrix method that creates 5000 grid sample by 100 meters and assess forest/nonforest manually. After that, we went to community area by field trip in July measured differenced sample points of accuracy assessment. Last level of validation is random sampling method validated by field trip of September.

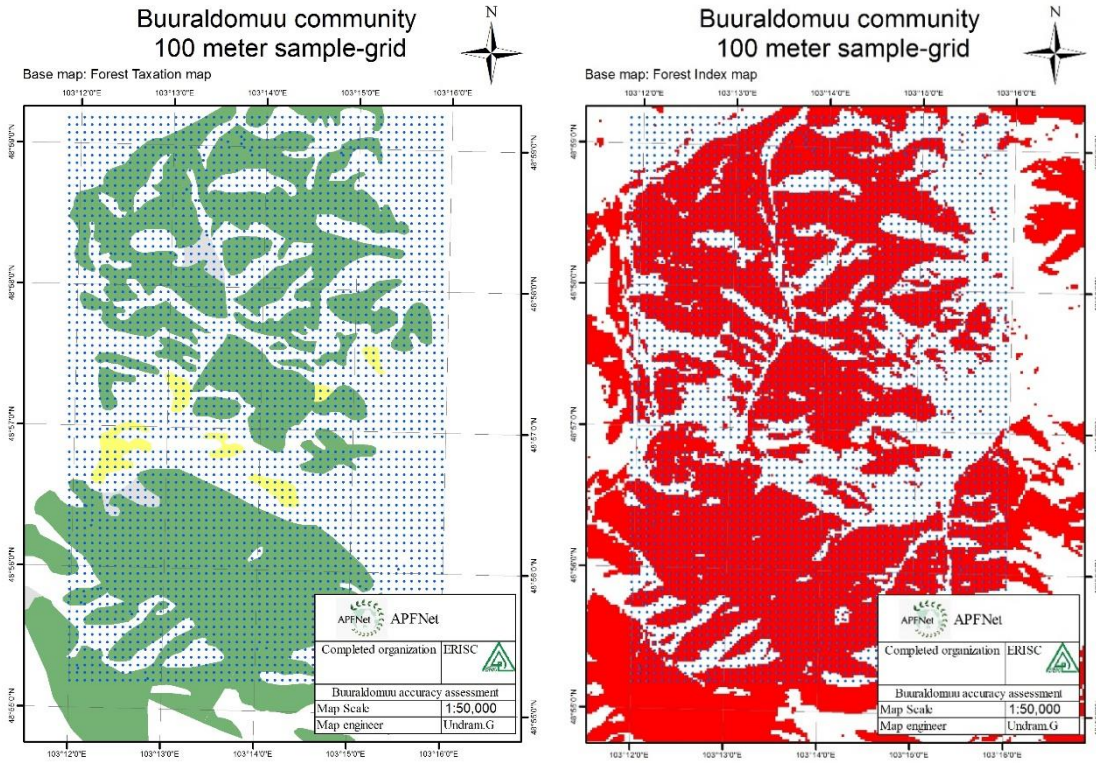
1. Base Error Matrix

The first level was Base error matrix method 5000 grid sample by 100 meter created in each forest community area and the actual land cover (i.e. forest/non-forest) of these points was identified through visual interpretation with the aid of high spatial resolution images in the Google Earth. These points used as reference data to generate the confusion matrices of the two maps and calculate their overall, users and producer's accuracies. The taxation data's forest boundary includes fire, logged insected forest and 100 meters from the forest edge. That is why we could not assess with directly taxation data and we renewed the forest edge by Google Earth Pro. In other word we renewed forest edge with replacing by high-resolution satellite map as Google Earth Pro for assess grid-sampling method.

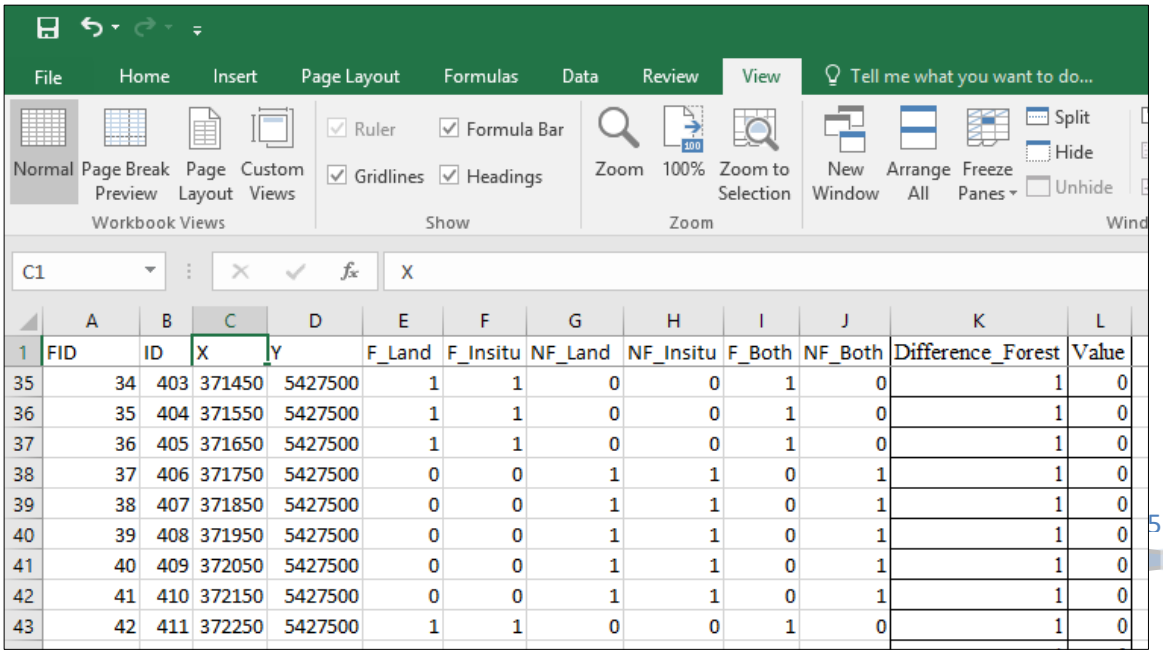


Picture 120. Taxation forest edge as (a) white line and renewed taxation boundary as (b) red line on Google Earth Pro map.

In Buuraldomuu forest community area 4615 grid samples by 100 meters in 2395.2 hectare area. 1664-forested area validated, 2373 nonforest area validated and 261 forest area not validated, 317 nonforest area not validated from total 4615 sample points. We manually assessed every sample points as forest or nonforest in taxation data or Forest index value.



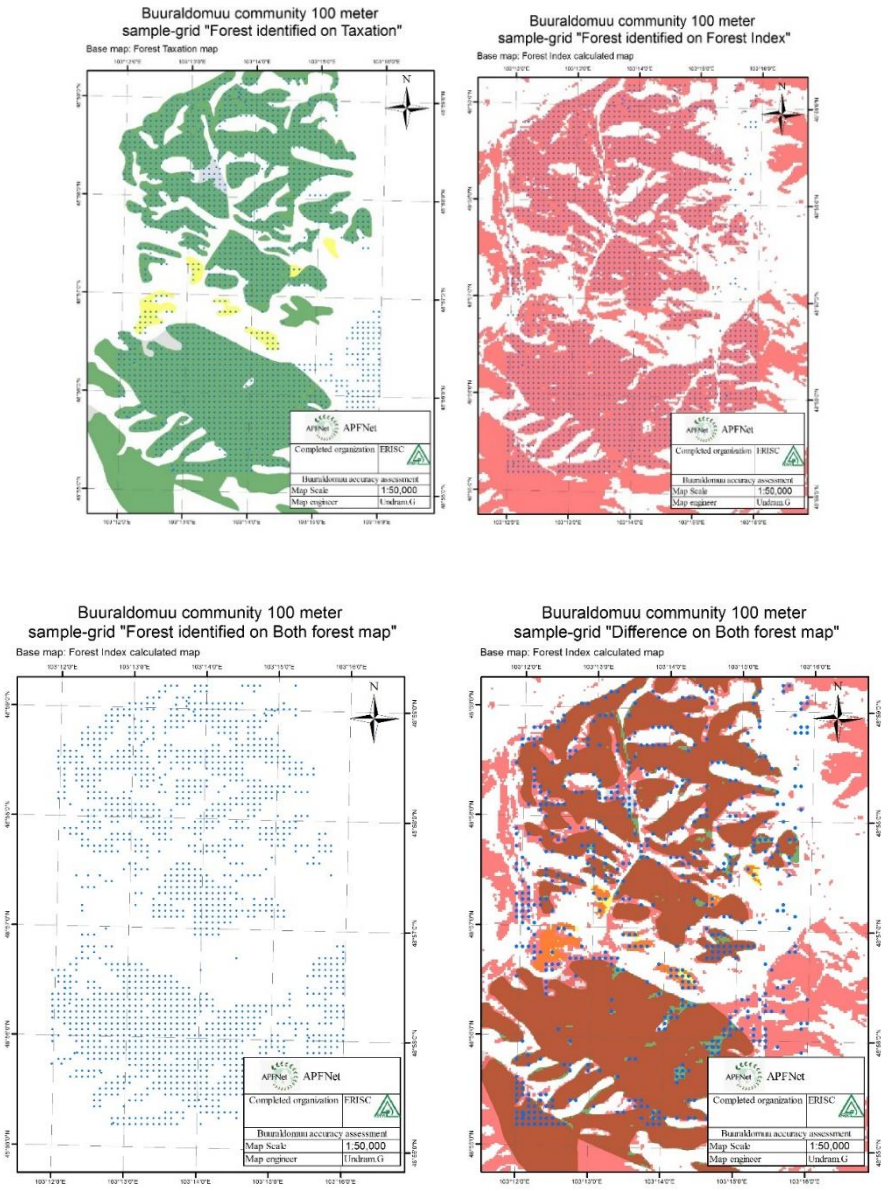
Picture 121. 100 meter sample grid in Buuraldomuu community area



	A	B	C	D	E	F	G	H	I	J	K	L
1	FID	ID	X	Y	F_Land	F_Insitu	NF_Land	NF_Insitu	F_Both	NF_Both	Difference_Forest	Value
35	34	403	371450	5427500	1	1	0	0	1	0	1	0
36	35	404	371550	5427500	1	1	0	0	1	0	1	0
37	36	405	371650	5427500	1	1	0	0	1	0	1	0
38	37	406	371750	5427500	0	0	1	1	0	1	1	0
39	38	407	371850	5427500	0	0	1	1	0	1	1	0
40	39	408	371950	5427500	0	0	1	1	0	1	1	0
41	40	409	372050	5427500	0	0	1	1	0	1	1	0
42	41	410	372150	5427500	0	0	1	1	0	1	1	0
43	42	411	372250	5427500	1	1	0	0	1	0	1	0

Picture 122. Database of assessing on Excel software

We went to field trip to check not validated points of forest in July. Usually those points located in the forest edge. Overall result of accuracy assessment in Buuraldomuu community of path 26/row 133 of forest index is 87.5%.



Picture 123. The accuracy assessment of Buuraldomuu community area by forest

Table 37. The accuracy assessment of Buuraldomuu community area by forest index

VALIDATION OF BUURALDOMUU	In situ FOREST	In situ NONFOREST	Total	Validation
Landsat FOREST	1664	317	1981	84
Landsat NONFOREST	261	2373	2634	90
Total	1925	2690	4615	
Validation				87.5

Table 38. Ханбуян нөхөрлөлийн баталгааажилт

VALIDATION OF KHANBUYAN	In situ FOREST	In situ NONFOREST	Total	Validation
Landsat FOREST	1824	157	1981	92
Landsat NONFOREST	14	2236	2250	99
Total	1838	2393	4231	
Validation				96

Validation points picked up and checked by June and September field trip in two forest community areas. Those points show us the threshold of 3.5 is suitable for Mongolian forest and Forest index true meaning of in situ data.

Table 39. Sample points characteristic

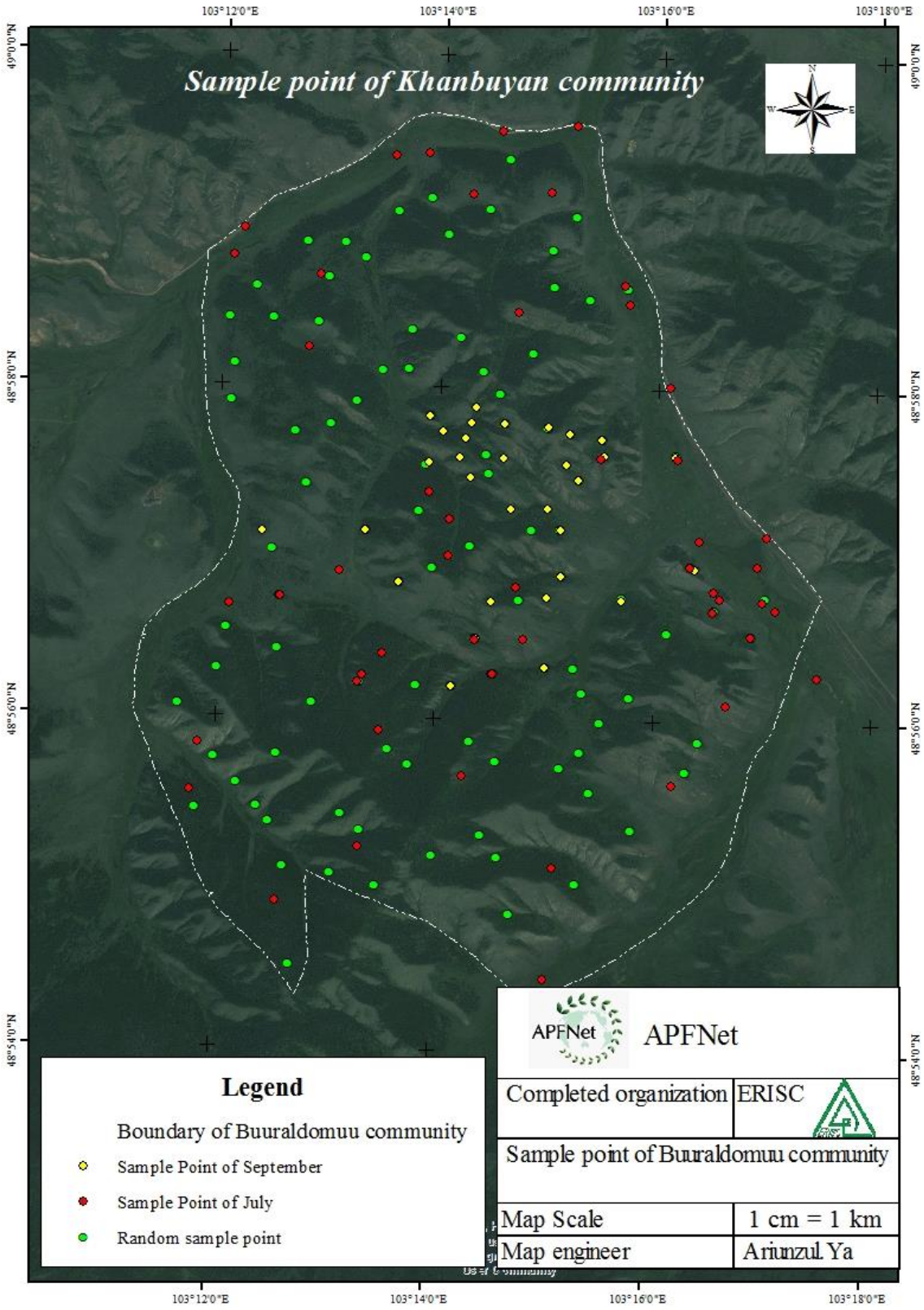
	NELDA			Description	Planned			Sample of BD		Sample of KhB		Sum point
	Legend	Class			Pixels	Prop S	Sample	Point	Pixel	Point	Pixel	
1.	Forest	Tree needleleaf decidious closed	TNDC	Needleleaved evergreen closed stands (Tree cover > 65%);	5%	15	30	0	0	0	0	0
2.		Tree needleleaf open	TNO	Needleleaved evergreen open stands (Tree cover < 65%);	21%	11	15	150	2250	120	1800	270
3.		Tree decidious open	TDO	Decidious open stands (Tree cover < 65%);	10%	10	15	22	330	27	405	49
4.		Tree mixed closed	TMC	Mixed closed stands (Tree cover > 65%)	26%	28	78	0	0	0	0	0
5.		Tree mixed open	TMO	Mixed open stands (Tree cover < 65%)	17%	51	51	9	135	16	240	25
6.	Shrub	Shrub broadleaf open	SBO	Deciduous regeneration (height 2..5 m); Mixed shrubs	5%	15	12	7	105	9	135	16
7.	Vegetation Dominated	Herbaceous open-Pasture	HO	Mixed grasses	4%	10	12	14	210	43	615	57
8.		Herbaceous closed wetland-Nuga	HCW	Wetlands	4%	10	12	17	255	17	255	34
9.	Bare Land sparce vegetation	re sparse-Tsagaan enger		Sparse vegetation	4%	10	12	19	285	18	270	37
10.	Water body	Water		Water bodies	4%	9	13	6	90	0	0	6
11.		Road		Road	1%	1	1	4	60	2	30	6
12.		Sum				170	250	251	3765	250	3750	500

Landsat satellite data information in picked sample points for study to define forest index

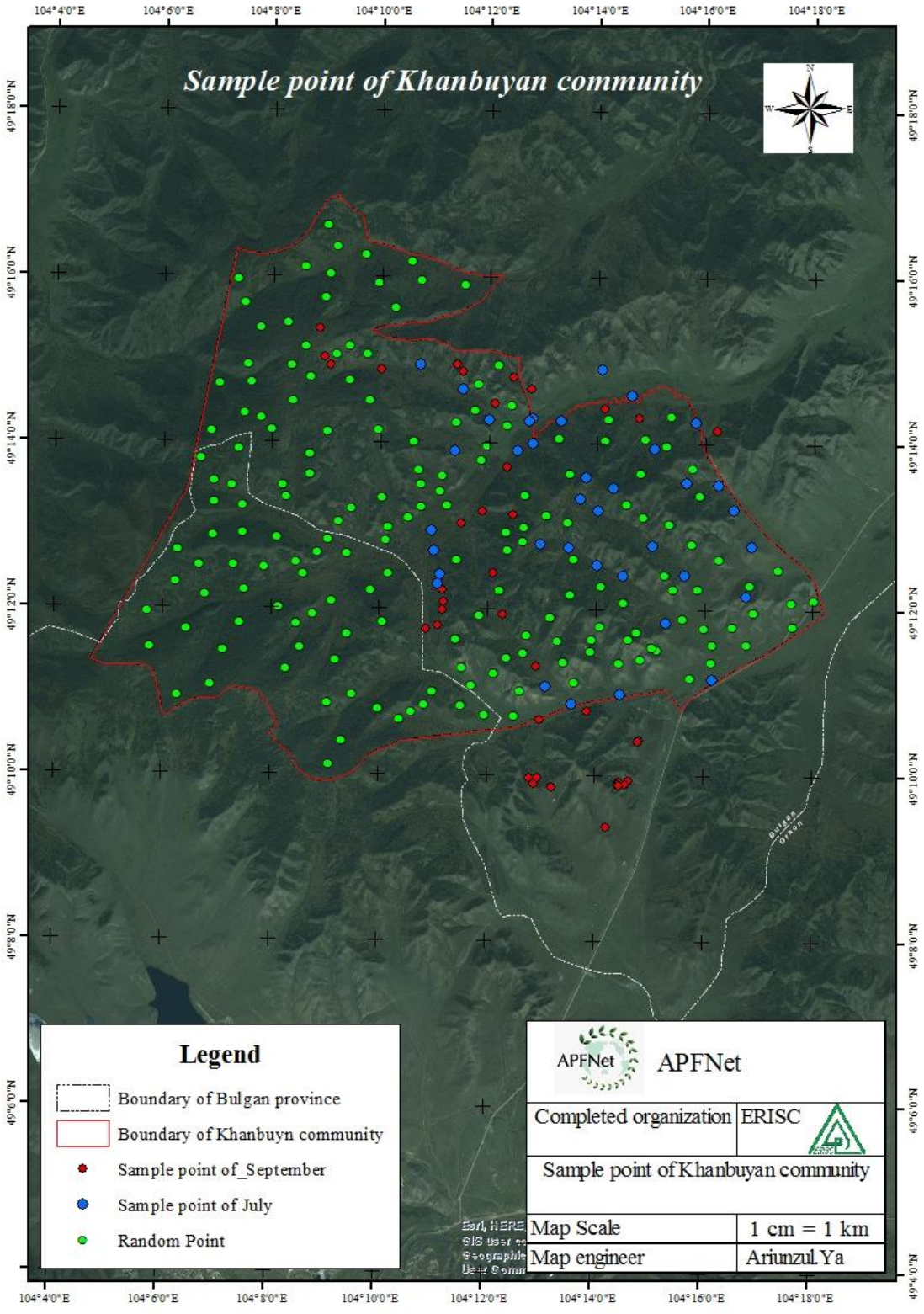
Table 40. Data information in Buuraldomuu and Khanbuyan community

№	WRS		Image type	Image format	Date_acquired	Image source	Scene ID
	Path	Row					
1	133	26	LANDSAT-5 TM	GeoTiff	2000-08-18	U.S. Geological Survey	LT51330262000231BJC00
2					2001-09-06		LT51330262001249BJC00
3					2002-09-09		LT51330262002252BJC01
4					2003-07-10		LT51330262003191BJC00
5					2004-08-13		LT51330262004226BJC00
6					2005-08-16		LT51330262005228BJC00
7					2006-09-04		LT51330262006247IKR00
8					2007-06-19		LT51330262007170IKR00
9					2008-08-08		LT51330262008221BJC00
10	134				2009-05-31		LT51340262009150BJC00
11	133				2010-08-30		LT51330262010242IKR00
12					2011-08-17		LT51330262011229IKR02
13			LANDSAT OLI-8 OLI_TIRS		2013-09-07		LC81330262013250LGN00
14					2014-07-24		LC81330262014205LGN00
15					2015-09-09		LC81330262015256LGN00

We picked up three kinds of points as a sample in the forest community area. The first kind of samples is located on Landsat data, Google Earth map, Taxation data and topographic map randomly. We have chosen affected forest as a sample like fired, logged and insected in situ by field trip. Although we picked up sample in insected forest, it was already re-grown, so forest cover change has not high. Whereas, Khanbuyan community area has logged and fired area, because of it locates near the Erdenet city and has good road. We tried to pick up more samples from like that effected forest.



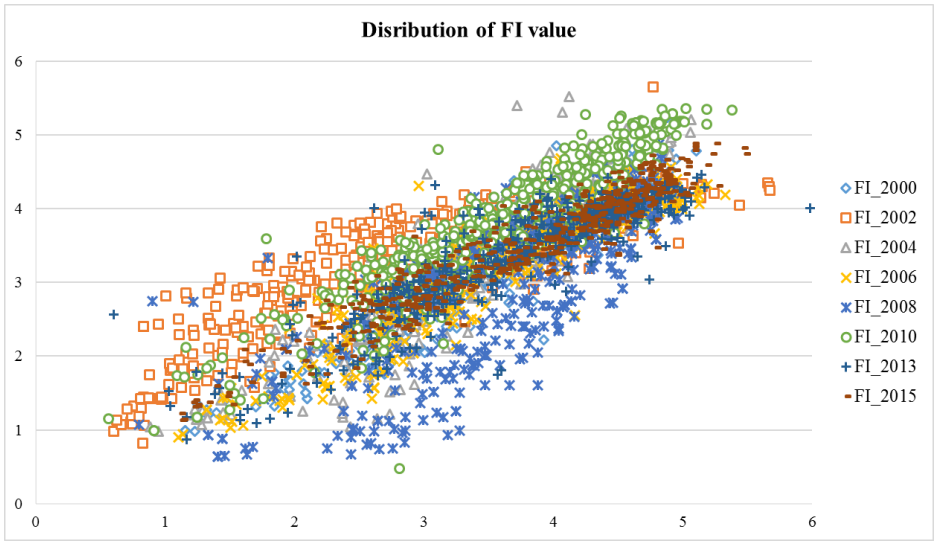
Picture 124. Study sample points from Buuraldomuu community area



Picture 125. Study sample points from Khanbuyan community area

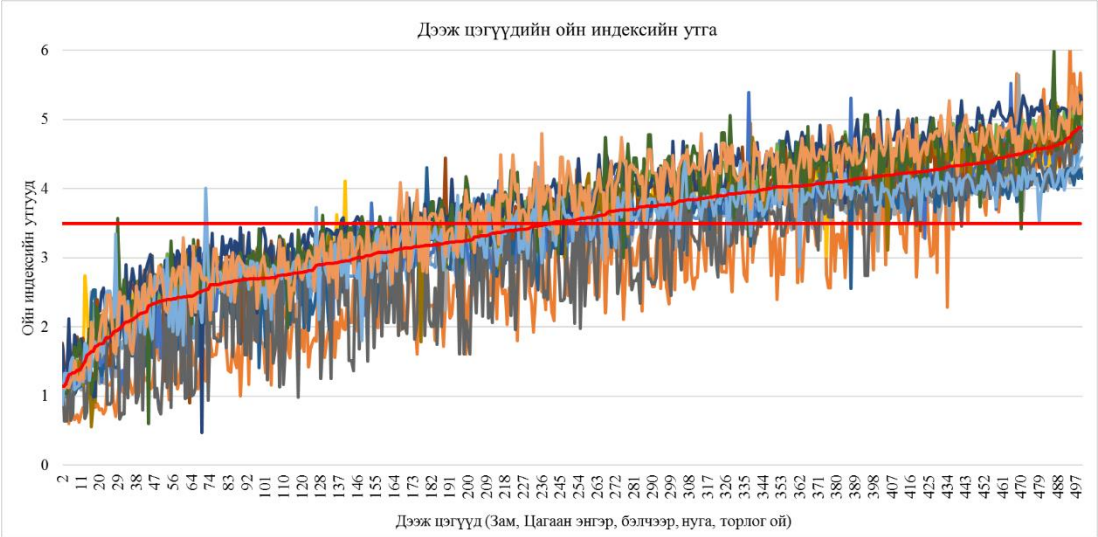
The overall samples 72.2 percent shows greater value than 3.5 of forest index. Following graph shows a distribution graph of forest index value. The graph shows 6 percent of value under the threshold 3.5 affected by 31st May 2009 data value. If there was valuable data that included growth period of forest, then 78.2 percent of points shows the value of greater than 3.5. However, 47 percent of scattered forest gives under the value of 3.5. Finally, we have chosen threshold value of forest cover as a 3.5.

Graph 37. Distribution of forest index value



The 52 percent of 500 samples of two pilot community area taken greater value than 3.5. 91.3 percent of forested 344 points taken the value of greater than 3.5. From all those results, we decided to pick up 3.5 as a forest threshold of forest index in Mongolia. However, if there is no data in forest growth period then early spring and late autumn data should have taken threshold as a 3.

Graph 38. Distribution of forest index value



4. CONCLUSION

The biggest result of this one-year project funded by APFNet implemented in Mongolia is defined forest cover mapping methodology from the satellite data. The importance of the project is the creation of the methodology that can define forest cover change by every year. The project itself is now one-step onward for science of the Remote Sensing in the Mongolian forestry sector. We are hoping the project result creates a lot of new chronology of the forest cover data. The result shown increasement and decreasement of the forest trend in Mongolia.

Law of the Forest declared forest taxation job has to complete by every ten years. Forest inventory has to complete by every five years. There is full opportunity to define forest experts of the each province will start to produce forest map by methodology that we declared. Project result and digital mapping and methodology should have use following way:

1. A Mongolian forest cover area of the forest steppe zone is 9 480 923.23 hectares by the average of fifteen years data. That is 6.06 percentage of Mongolian landscape.
2. A Mongolian forest cover area of the forest steppe zone decreased in the last fifteen years.
3. Eight province's forest cover area has decreased and other provinces forest cover area has increased.
4. Northern part of Mongolian forest with frost increasing is may influenced by climate change. We should have concern if natural forest increasing area should not have nursing but helping natural reforestation.
5. Steppe forest zone of Dornod and Khentii province's forest cover area has great decreasement. May be those province should have more tree nursing.
6. Every province's forest cover area is decreasing in public place and with near the road area. We should have more investigation on such forest area.
7. Most of time increasement shows in edge of the forest and decreasement shows in depth of the forest.
8. Forest boundary have possible to mapping on Landsat or other high-resolution satellite data.
9. Forest unit has possible to define forest plan uses project result by 5 to 10 years.
10. Forest result possible to use to choose tree-nursing area.
11. We should have unite about forest definition.
12. Project team collected knowledge of remote sensing technique for the forest