MINISTRY OF ENVIRONMENT AND TOURISM

REDD+ MONGOLIA
Building resilience, livelihoods and economy

DOT-GRID ASSESSMENT FOR SAXAUL FOREST AREA ESTIMATES

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Participating organisation

[Forest Research and Development Centre]

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Background

The UN-REDD Programme is the United Nations Collaborative Initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme was launched in 2008 to assist developing countries prepare and implement national REDD+ strategies and builds on the convening power and expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

Since Mongolia became a partner country of the UN-REDD Programme in June 2011, the country has quickly taken steps to start implementing REDD+ readiness activities, including the preparation of its National REDD+ Readiness Roadmap, which was officially adopted by the Ministry of Environment and Green Development and Tourism (MEGDT) in June 2014, and based on which Mongolia's request for full-scale National Programme funding was approved by the UN-REDD Programme Policy Board in July 2014.

Within that purpose, Mongolia conducted National Forest inventory with cooperation with GIZ (German Corporation for International Cooperation GmbH) in boreal forest area between in 2014.

According to the National Forest Inventory Mongolian boreal area estimated 9.1±0.45 million-hectare forest. Yet, National Forest Inventory conducted only in intact forest area[1]. Wherefore, Mongolian UNREDD programme conducted additional forest inventory in degraded forest area to cover all boreal forest type, which estimated 1.58 million hectares in 2017[2].

However, Geographically Mongolian forests can be categorized into two broad zones: northern boreal forests and southern Saxaul (*Haloxylon ammondendron*) forests. The southern Saxaul (*Haloxylon ammondendron*) forests cover 1.9 million hectares and are estimated to be lost at the alarming rate of 6.5% per year in May 2015[3].

According to the Mongolian Forest Law[4] Saxaul (*Haloxylon ammondendron*) species covered area identified as forest, it also technically can fit international forest definition[5]. Moreover, Saxaul species cover area takes forest function in semi-arid desert land, which is highlighting further study in Saxaul forest.

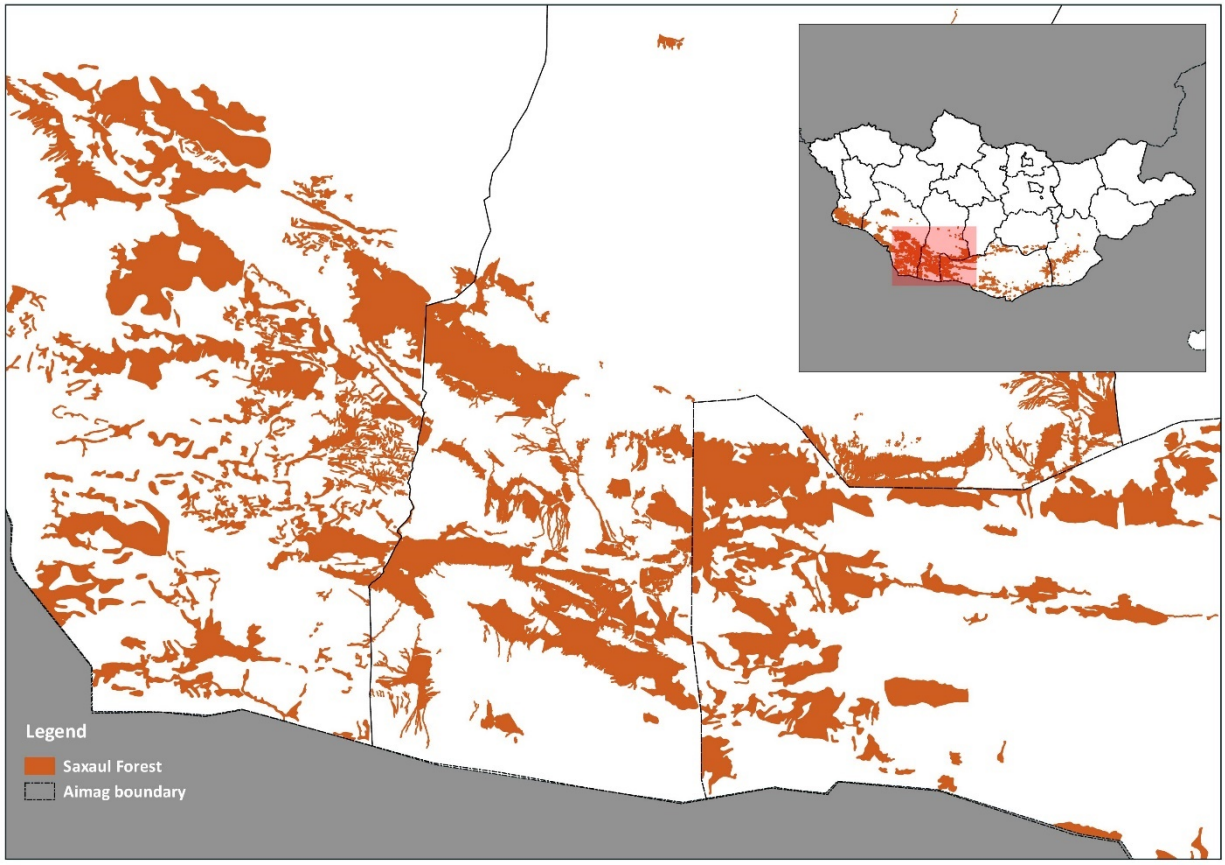
The current FRL submission didn't included saxaul (Haloxylon *ammondendron*) because lack of activity data. Therefore, it is essential to conduct Saxaul forest inventory to include further FRL submission. For that reason, Mongolian UNREDD programme conducted remote sensing analysis with cooperation of FRDC to deliver baseline data for potential Saxaul forest inventory.

[1] See details in here: http://www.forest-atlas.mn/Documentation.aspx NFI final report.
[2] See details in here: http://redd.unfccc.int/files/2018_frel_submission_mongolia.pdf
[3] See details in here: https://wedocs.unep.org/bitstream/handle/20.500.11822/9602/-UN-REDD_National_Programme_Submission_Form_Mongolia-2014EN_Mongolia_SubmissionForm_2014..pdf?sequence=4&isAllowed=y,%20Spanish||https://wedocs.unep.org/bitstream/handle/20.500.11822/9602/-UN-RE
[4] See details in here: http://www.legalinfo.mn/law/details/12171
[5] See details in here: http://www.fao.org/docrep/017/ap862e/ap862e00.pdf

Reference area estimation.

According to the FRDC internal "Forest resource report 2016" Mongolia have approximately 4.7 million Saxaul forest, where is 1.9 million intact forest. However, these data unfitted into MRV function, as well as spatial data not perfectly matches each other. (See picture 1.)

Picture 1, Saxaul Forest Distribution Map (FRDC 2016)



For that reason, we made following calculation to avoid miss potential saxaul growing areas, where used previews Collect Earth assessment data[6]. Here is:

- Determine precipitation level in saxaul growing area
- Determine temperature level in saxaul growing area
- Determine elevation level in saxaul growing area

For reference Meteorological data

To determine meteorological factors, we used recorded weather data to construct mean annual precipitation map and average temperature map with the spatial accuracy of 1km in ANUSPLIN software[7] at Research Division of Climate Change and Resources, Information and Research Institute of Meteorology,

[6] See details in here: http://redd.unfccc.int/files/2018_frel_submission_mongolia.pdf
[7] See details in here: http://fennerschool.anu.edu.au/research/products/anusplin-vrsn-44

Hydrology and Environment. The meteorological data ranges between 1950 to 2012[8], where is recorded in 72 weather station and 3 glacier automatic station (See picture 2).

Map validation guided by recorded weather data. (See table 1, table 2)

Table 1, Annual mean precipitation maps average co-relation confidence

Spatial average co-relation confidence (ACC), Spatial root means square error (RMSE)	Annual sum of precipitation (mm)
ACC	0.98
RMSE (mm)	18.8

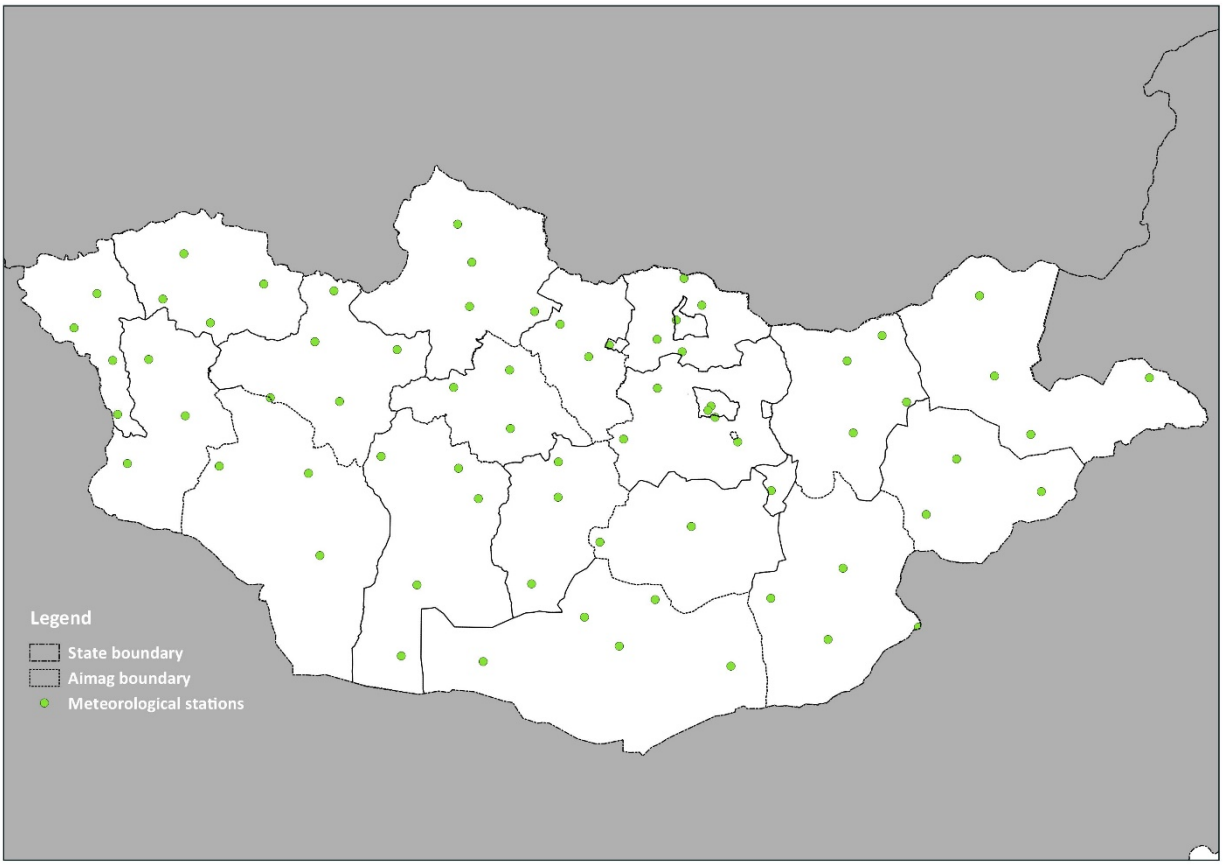
Table 2, Annual sum of temperature (Celsius degree)

Spatial average co-relation confidence (ACC), Spatial root means square error (RMSE)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual sum of temperature (Celsius degree)
ACC	0.97	0.98	0.99	0.97	0.96	0.96	0.98	0.97	0.97	0.97	0.97	0.95	0.97
RMSE (°C)	1.1	1.0	0.8	1.0	1.1	1.1	1.0	1.0	1.0	1.0	0.9	1.2	1.0

According to the Table-1 and Table-2, estimated annual mean precipitation and annual sum of temperature have more than 95 percent of average co-relation confidence with recorded anomaly weather data. Thus, clearly approving the predicted maps accuracy possible to use in the furthers weather related assessments.

[8] See details in here: http://www.jcm-mongolia.com/wp-content/uploads/2015/10/MARCC-Final-Bk-2014-book-lst.9.17-ilovepdf-compressed.pdf

Picture 2, Weather stations location



AFOLU sector CE assessment

In Frame of UNFCCC Non-Annex I Party, Mongolia has responsible to report internationally the land use and land use change information as fundamental activity data for the GHG emission and removal estimation of the AFOLU/LULUCF sector according to the IPCC guideline[9].

Within this purpose, the Collect Earth software, which developed by FAO under the Open Foris software[10], has been used to estimate land use, land use change in Mongolia. In the case of Mongolia, approximately 123 thousand systematically-stratified sample points covering the entire country using CE tools, were the allocated of the plots is based on the two grids combination: denser grid with 2.25 km x 2.25 km in the northern part of country with boreal forest and 9 km x 9 km in the southern half of country covers the most grassland types. The assessment was to determine the historical changes in forest and land use from 1986/1990-2016.

According to the Collect Earth assessment, Saxaul forest area estimated 2.04 million hectares. (See table 1.) Within 270 sample plots, where determined saxaul forest, used to further estimation of potential saxaul growth area based on climate factors precipitation and temperature. Table 3. Forest Land use subdivision[11]

[9] See details in here: https://www.unredd.net/documents/un-redd-partner-countries-181/asia-the-pacific-333/a-p-partner-countries/mongolia-1128/16455-land-assessment-for-afolu-lulucf-sector-of-the-mongolian-ghgi-using-collect-earth-tool.html

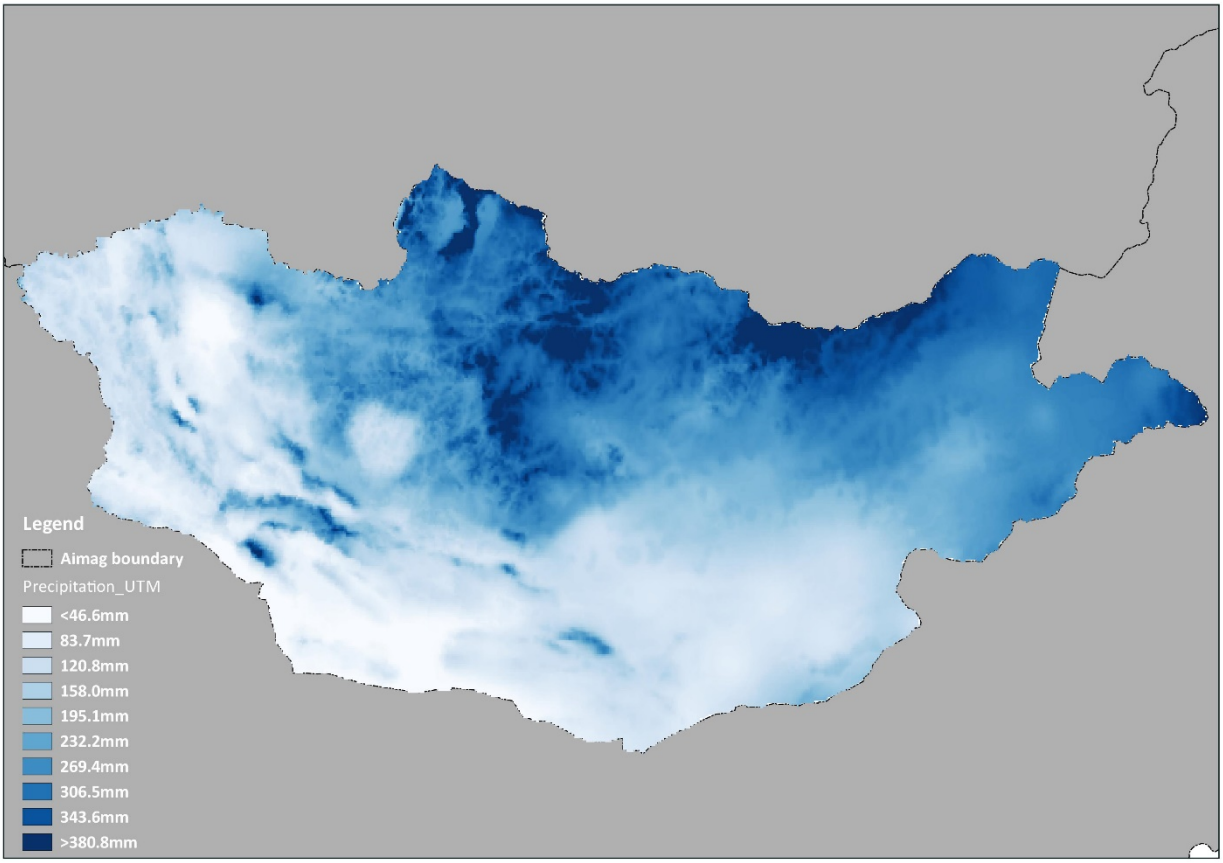
[10] See details in here: http://www.openforis.org/

[11] See details in here: Forest land use, land use change assessment report 2016-2017. Ministry of Environment and Tourism.

Forest land use subdivision	Total plot (#)	Total area (ha)	Percentage of total area
Boreal forest			
Broadleaved	2,414	1,298,643.55	8.00%
Coniferous	22,095	11,414,265.72	70.34%
Mixed	1,336	691,594.93	4.26%
Plantation-Boreal	14	7,087.93	0.04%
Boreal forest Total	**25,859**	**13,411,592.13**	**82.65%**
Saxaul	**270**	**2,048,002.93**	**12.62%**
Shrub	**1,244**	**766,739.69**	**4.73%**
Total forest	**27,373**	**16,226,334.75**	**100.00%**

Precipitation analysis

Picture 3, Mean annual precipitation map



Based on previews Collect Earth result, we made assessment on 549 sample plots to determine mean annual precipitation level threshold, which is established suitable condition for Saxaul tree (*Haloxylon ammodendron*) species growth[12]. In case of Mongolia, mean annual precipitation decreases from 600mm per year at the Northern Khuvsgul and Khentii regions to 25mm per year at the Southern part of Gobi region[13]. Within wide range of mean annual precipitation level determines variation of fauna. The precipitation effect estimation shows the median range of total precipitation in saxaul forest area. (See

[12] See more details in here: https://www.sciencedirect.com/science/article/pii/S1872032086001 41?via%3Dihub
[13] See more details in Multipurpose National Forest inventory Report 2014-2016. http://www.forest-atlas.mn/Documentation.aspx

table 2.) However, we used minimum (24.8 mm) and maximum (145.3 mm) data range to avoid underestimation of potential saxaul growing area. (See picture 3.)

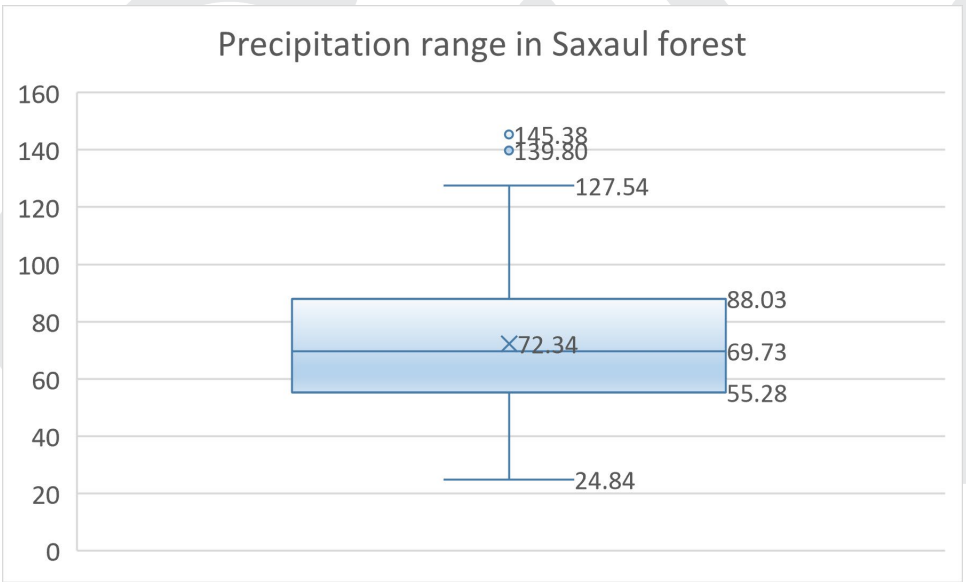
Table 4, Precipitation range in Saxaul forest

Mean	St. Err	lower	Upper	CI
72.34	0.97	70.44	74.25	5%

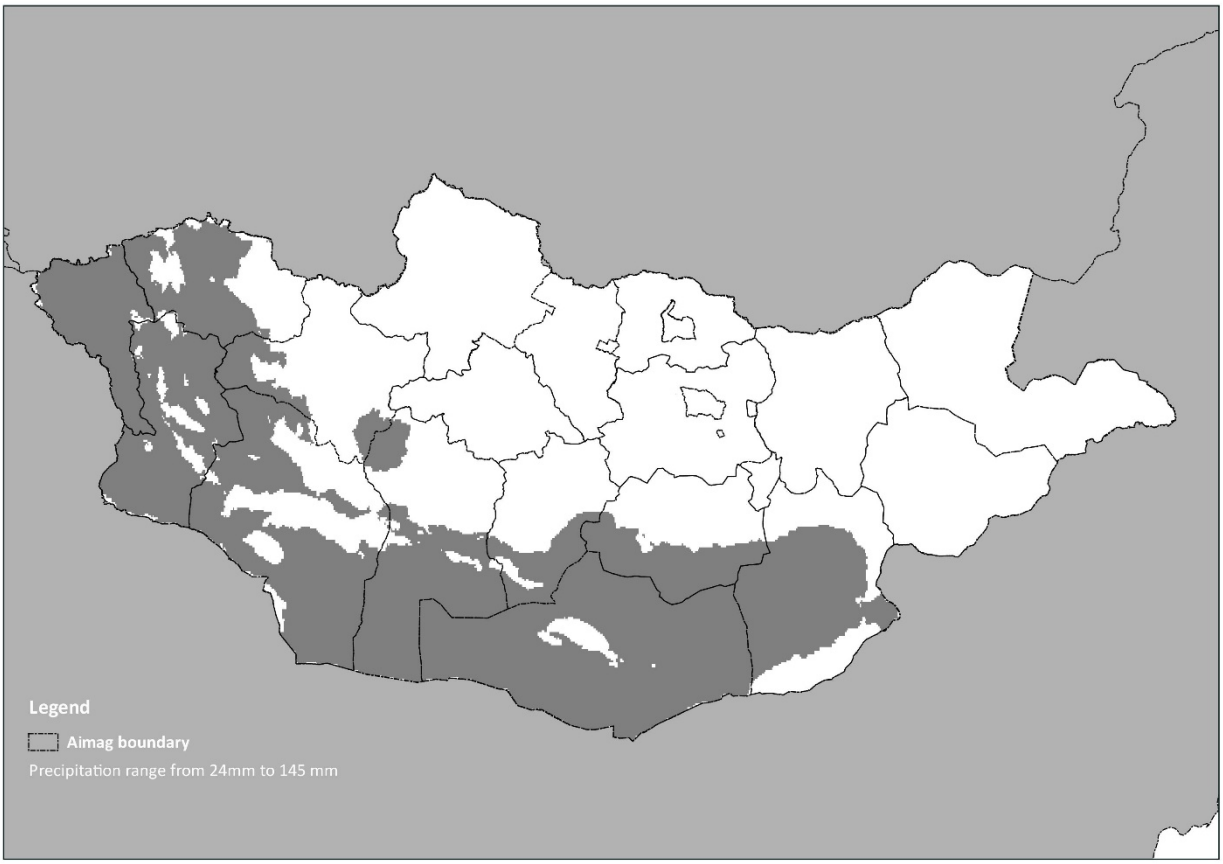
Table 5, Descriptive statistic of Saxaul forest precipitation range

Precipitation range estimation	
Mean	72.34
Standard Error	0.97
Median	69.73
Standard Deviation	22.70
Sample Variance	515.24
Kurtosis	-0.55
Skewness	0.30
Range	120.53
Minimum	24.84
Maximum	145.38
Count	549.00
Confidence Level (95.0%)	1.90

Chart 1, Median precipitation range in Saxaul forest



Picture 4, Potential saxaul forest area in precipitation range from 25mm to 145mm



Temperature analysis

Geographically Mongolia locating between Russian Siberia and China in deep continental position, it spans between in latitudes 41° N to 52° N (around 1200km) and in longitude 88° E and 120° E (around 2400km). Therefore, makes the climate cold and dry. The Temperature increases from the north to the south. In the July mean temperature up to 15C° in the Northern part of Mongolia and 30C° in the Southern Gobi region.

However, in the winter monthly average temperatures - 15C° in January. Therefore, temperature plays vital role for plant species growth and development[14].

According to the Collect Earth assessment, made estimation on 546 sample plots to determine potential suitable temperature range in saxaul forest. (See table 5.) However, we used minimum (0.015C) and maximum (7.64C°) temperature range to avoid underestimation. Based on this study created potential saxaul tree (*Haloxylon ammodendron*) growth map in case of temperature effect. (See picture 4.)

[14] See more details in here: https://reader.elsevier.com/reader/sd/AC7CA07B7F6DEFB98FA729D4AC715F45682A637F817E6303D21EF17A42EF343673E4346000B4D71306FF8147686F93FA

Picture 5, Average Temperature map

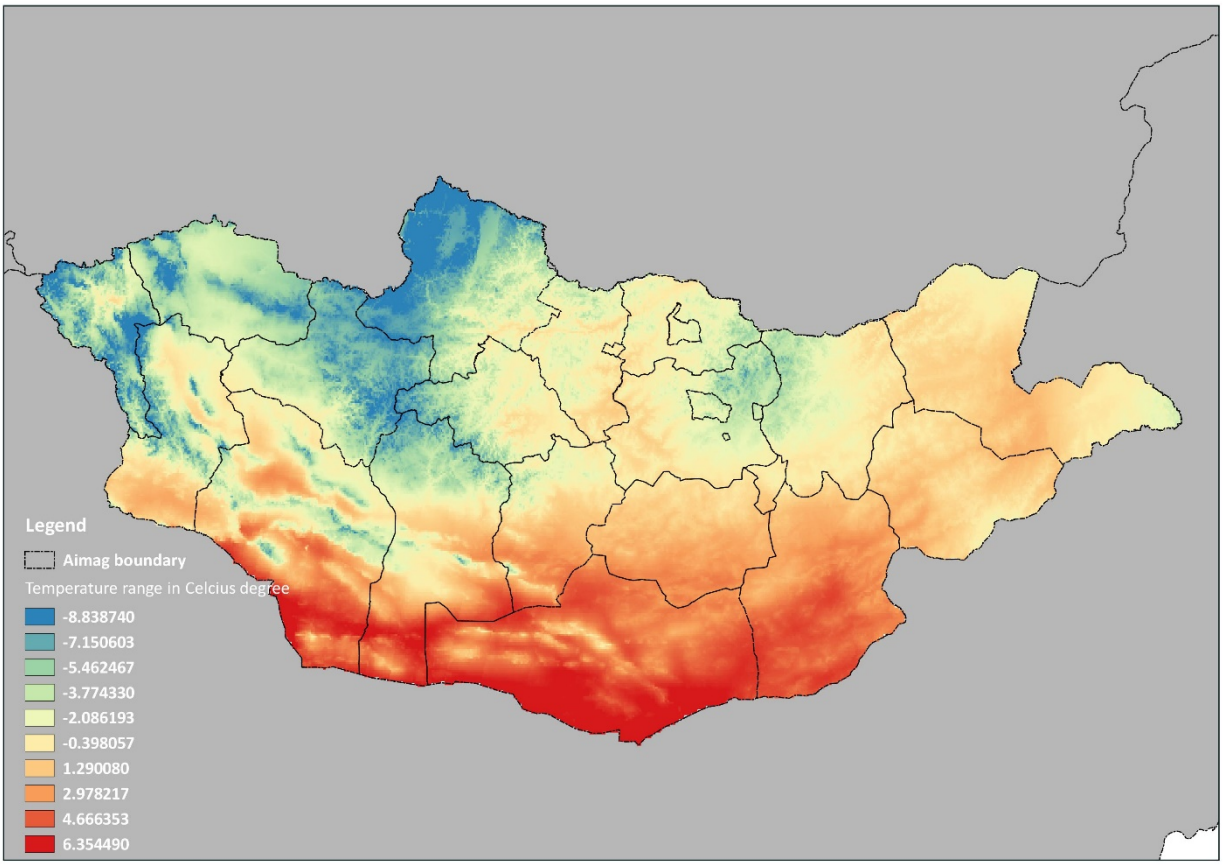


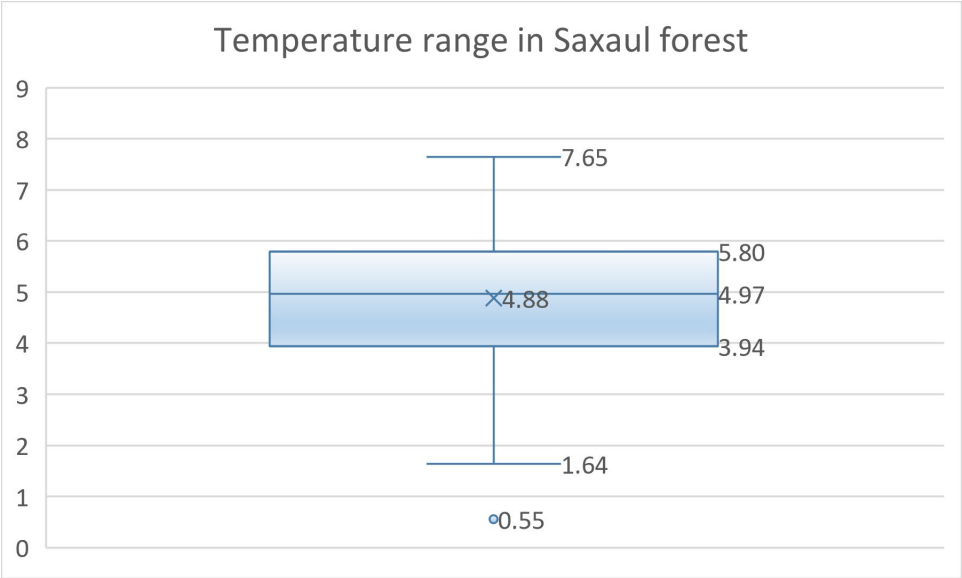
Table 6, Average Temperature range in saxaul forest

Mean	St. Err	lower	Upper	CI
4.08	0.07	3.94	4.23	7%

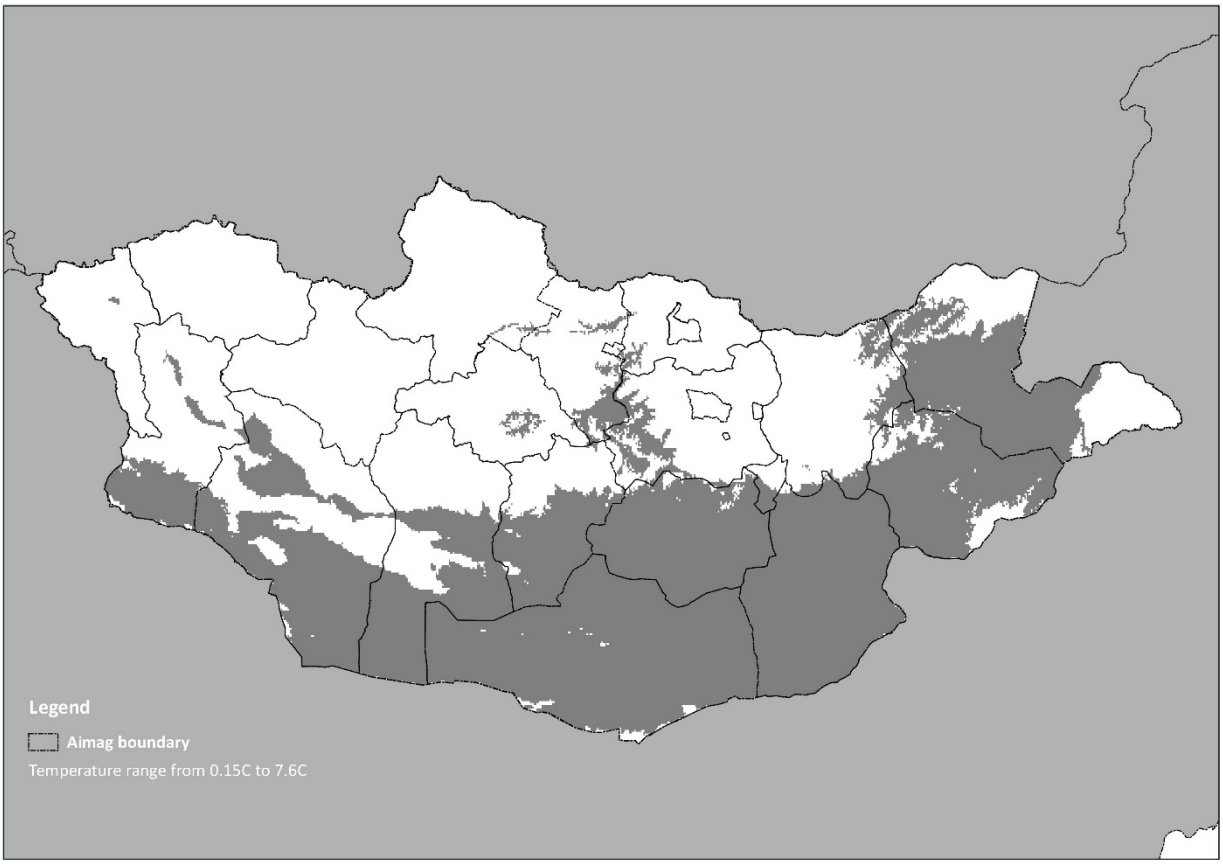
Table 5, Descriptive statistic of Saxaul forest temperature range

Annual temperature range estimation	
Mean	4.084
Standard Error	0.073
Median	4.205
Standard Deviation	1.700
Sample Variance	2.889
Kurtosis	-0.830
Skewness	-0.071
Range	7.632
Minimum	**0.015**
Maximum	**7.647**
Sum	2229.716
Count	546.000
Confidence Level (95.0%)	0.143

Chart 2, Median temperature range in Saxaul forest

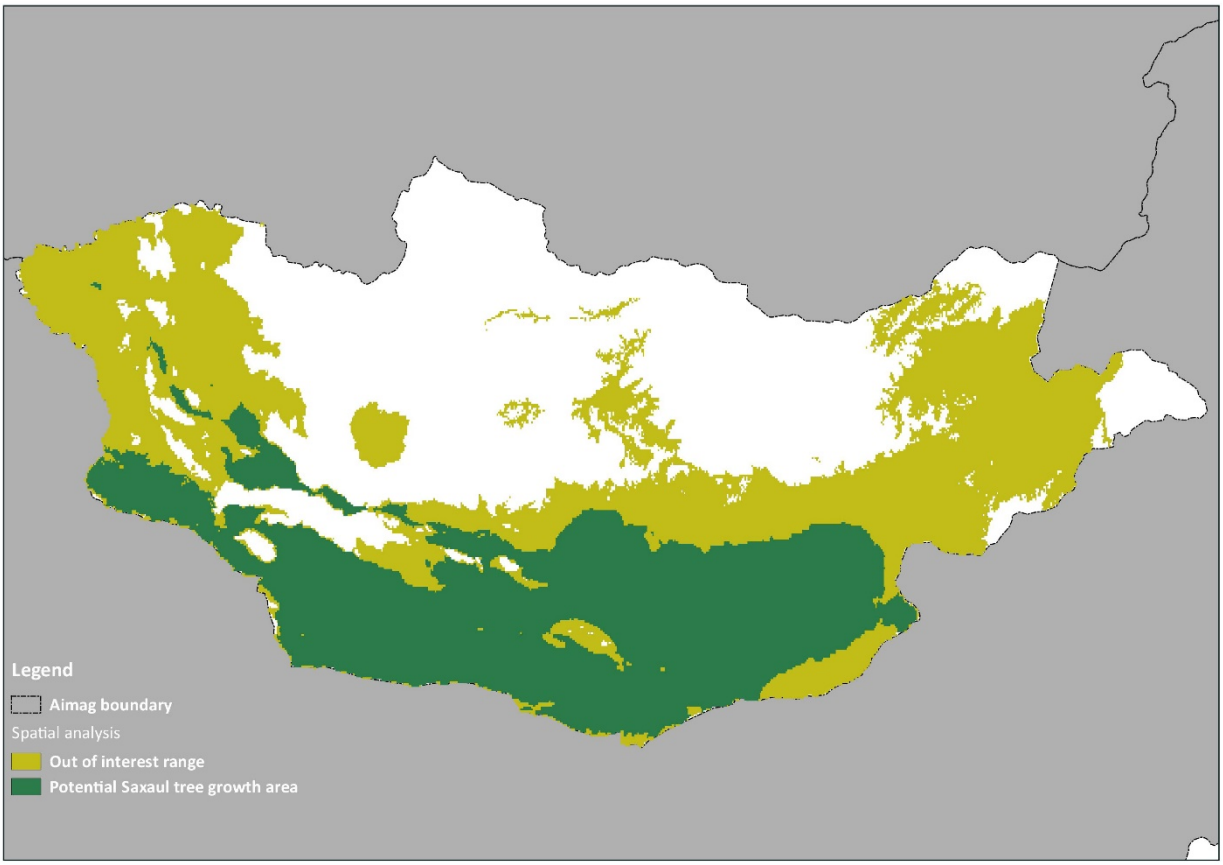


Picture 6, Potential saxaul forest area in temperature range from 0.015C to 7.64C



Within above mentioned studies used to define maximum potential area, where Saxaul tree suitable to grow. (See picture 6.)

Picture 7, Poteantial suitable areal of Saxaul tree (Haloxylon ammodendron)



The study shows in total approximately 41.8-million-hectare area suitable for growth Saxaul tree (*Haloxylon ammodendron*) in the South of Mongolia. (See picture 6.) Where is selected for dot grid assessment.

Collect Earth assessment

The collect earth survey conducted to determine saxaul forest area. However, to determine saxaul forest from other shrubland was technically impossible due of spatial resolution range (from 500m to 10m)[15]. Wherefore, further dot-grid assessment considered all type of shrubland in interested area.

Sample number

It's essential to correctly define requiring sample number for further analysis. For that reason, we made following estimation based on Normal distribution[16]. Within confidence level 99% and margin error 1% we required in total 16581 samples in 41866072.27-hectare area.

In terms of the above-mentioned numbers, the sample size *n* and margin error E area given by following equation.

i) $$x = Z\left(\frac{c}{100}\right)^2 r(100 - r)$$

[15] See more details in here: https://www.researchgate.net/publication/308786077_Collect_Earth_Land_Use_and_Land_Cover_Assessment_through_Augmented_Visual_Interpretation

[16] See more details in here: http://www.raosoft.com/samplesize.html

ii) $n = \frac{Nx}{(N-1)E^2+x}$

iii) $E = \sqrt{\frac{(N-n)x}{n(N-1)}}$

Where N is population size, *r* is the fraction of responses and Z*(c/100)* is the critical value for the confidence level *c.* Setting the response distribution to 50% is the suitable to determine forest or non-forest land in our case.

Since sampling clusters must be allocated systematically at grid, it is required to determine spacing between 16581 sample plots in potential Saxaul growth area. The distances interval calculated by following formula.

$$a = \sqrt{\frac{F}{n}}$$

Where

F = Potential Saxaul growth area

n = number of sampling clusters

a = distance between systematically disturbed samples. (Spacing between grid)

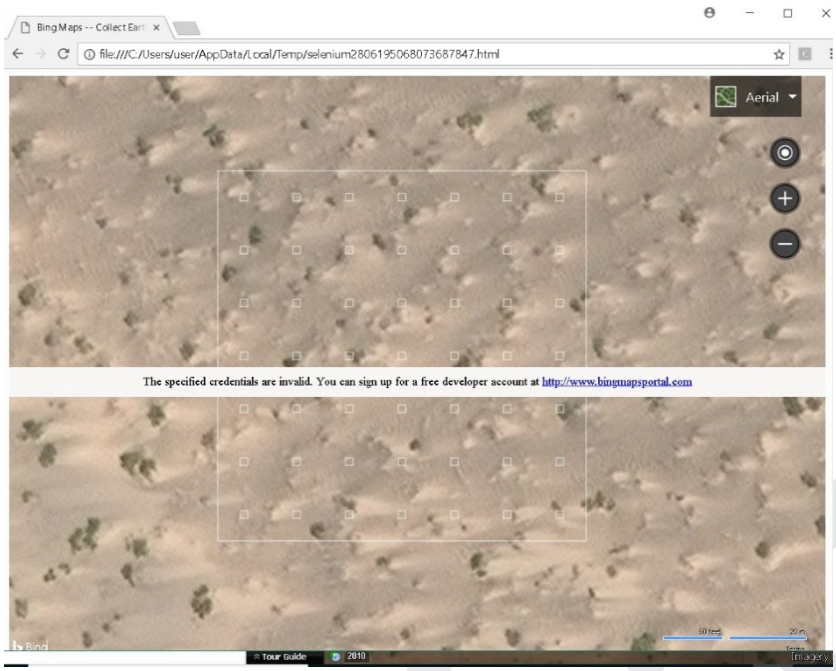
According to the picture-6 potential saxaul growth area is 41.8 million hectares and it is required to allocate 16581 sample plots systematically in the interest area, then distance between samples are 5025 meters.

$$a = \sqrt{\frac{418660.7km^2}{16581}} = 5.0248\,km$$

Survey design

The survey form was design using Collect tools to gather information in a manner consistent with the further National Forest Inventory, where including Saxaul forest, thus aims to fulfill second FRL submission. The Graphic 1 shows flow chart of dot-grid assessment. The Collect earth assessment contains 49 sub sampling plots. The Sampling plots used to quantify and characterize saxaul and shrubland's crown cover. (See picture 7.), which represents 2 percent canopy cover in one sub sampling plots.

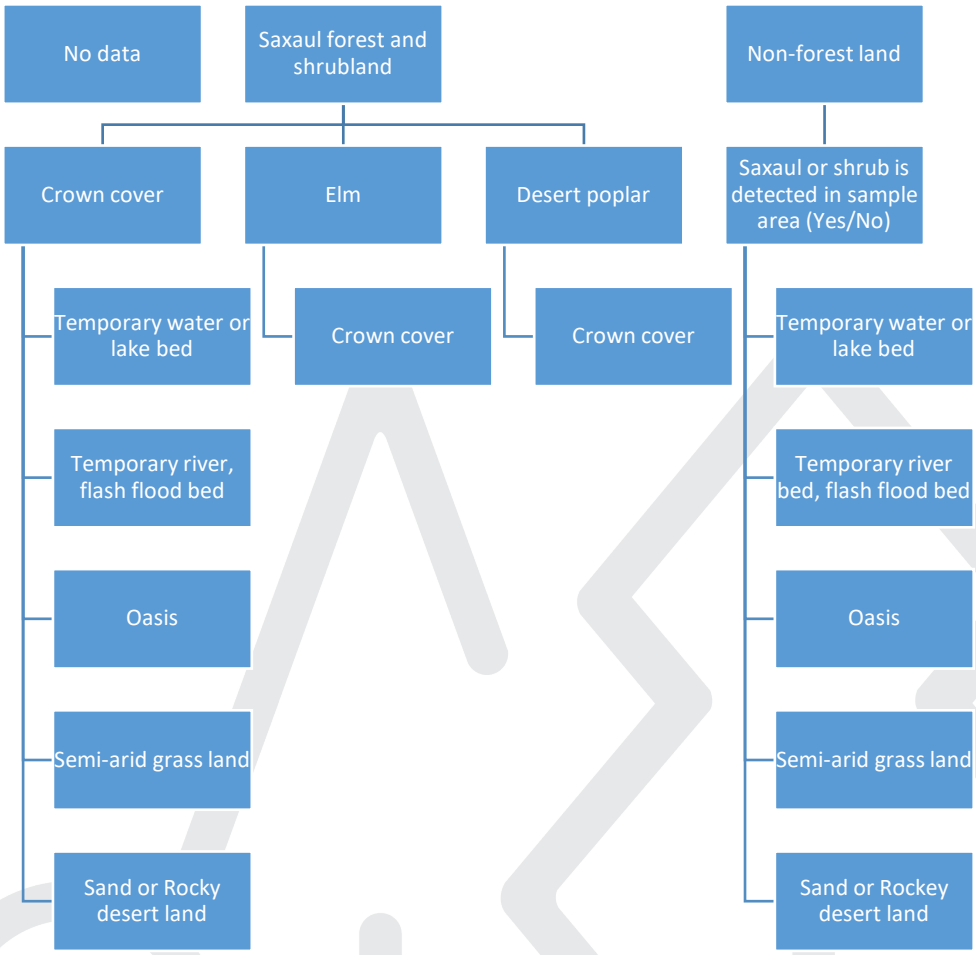
Picture 8, Collect Earth survey plot in Saxaul Forest



However, it is technically impossible to define saxaul tree (*Haloxylon ammodendron*) from other type of shrubs in semi-arid desert land. For that reason, our survey design principally covers only “forest” or “non-forest land”. (See Graphic 1.)

Also, the survey aimed to determine other tree species distribution Elm (*Ulmus pumila*) and Desert poplar (*Populus diversifolia*).

Graphic 1, Collect earth dot-grid assessment design



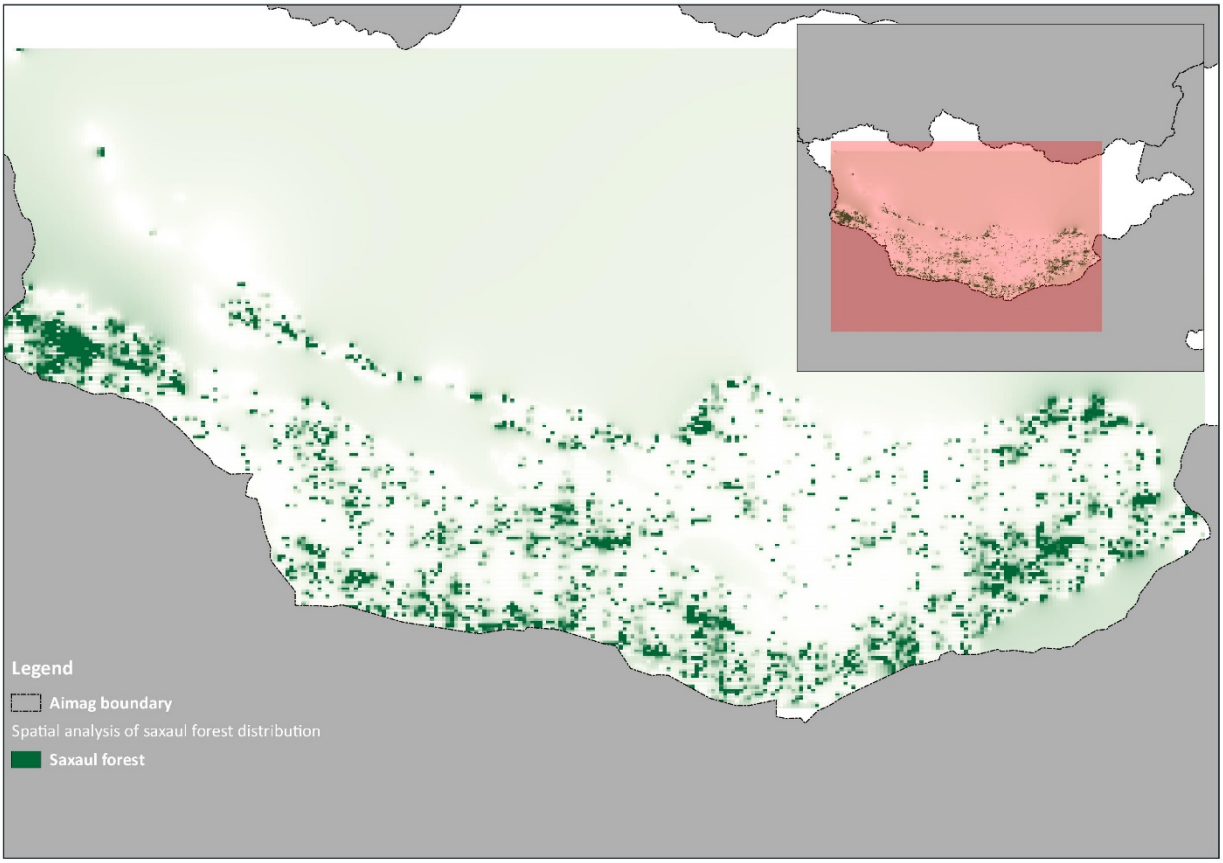
Result

Table 7, Result of Saxaul forest Collect Earth assessment

		Crown cover percentage	
Shrub crown cover	0 crown cover but saxaul or shrub was detected in 1-hectare sample plot	2%<4%	4%<
0 crown cover but saxaul or shrub was detected in 1-hectare sample plot	4960		
2%<4%		1247	
4%<			1052

The refernce area of the Collect earth assessment, one sample plot represents 2525 hectare area. Therefore, Saxaul and shrubland distributed in 18’256’385±182’563.9 hectare area, were is 3’136’205±31’362.05 hectare area have 2 percent canopy cover and 2’645’780±26’457.8 hectare area have more than 4 percent canopy cover at the confidence level 99%.

Creation spatial data



Conclusion

The Landsat (30m) or Sentinel (10m) NDVI based supervised classification methodology inefficient to classicification in Saxaul (*Haloxylon ammodendron*) forest land. For that reason, the combined remote sensing methodology efficient to determine forest cover area, general habitat distribution and main concentration of population. It's also cost-efficient methodology instead using high resolution satellite image (less than 5m).

To produce accurate base map of Saxaul forest. It is essential to combine with other real time data source such as high resolution areal ortho photo or SAR data[17].

However, it is difficult to distinguish Saxaul (*Haloxylon ammodendron*) from other shrubland. For that reason, it is suitable to include both class in other wood land category. In the Mongolian case, saxaul and other shrubland fulfills forest role[18] in semi-arid desert land.

[17] See more details in here: https://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/III-7/227/2016/isprs-annals-III-7-227-2016.pdf
[18] See more details in here: http://www.fao.org/docrep/011/i0670e/i0670e13.htm

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