Lecture 1

How Mongolia's Forests Contribute to Global Carbon Sequestration

Assessing Carbon Sequestration Potential through Mongolia's Billion Trees National Movement

Insights from Data Gap Analysis and Improvement Plan

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WORLD BANK GROUP

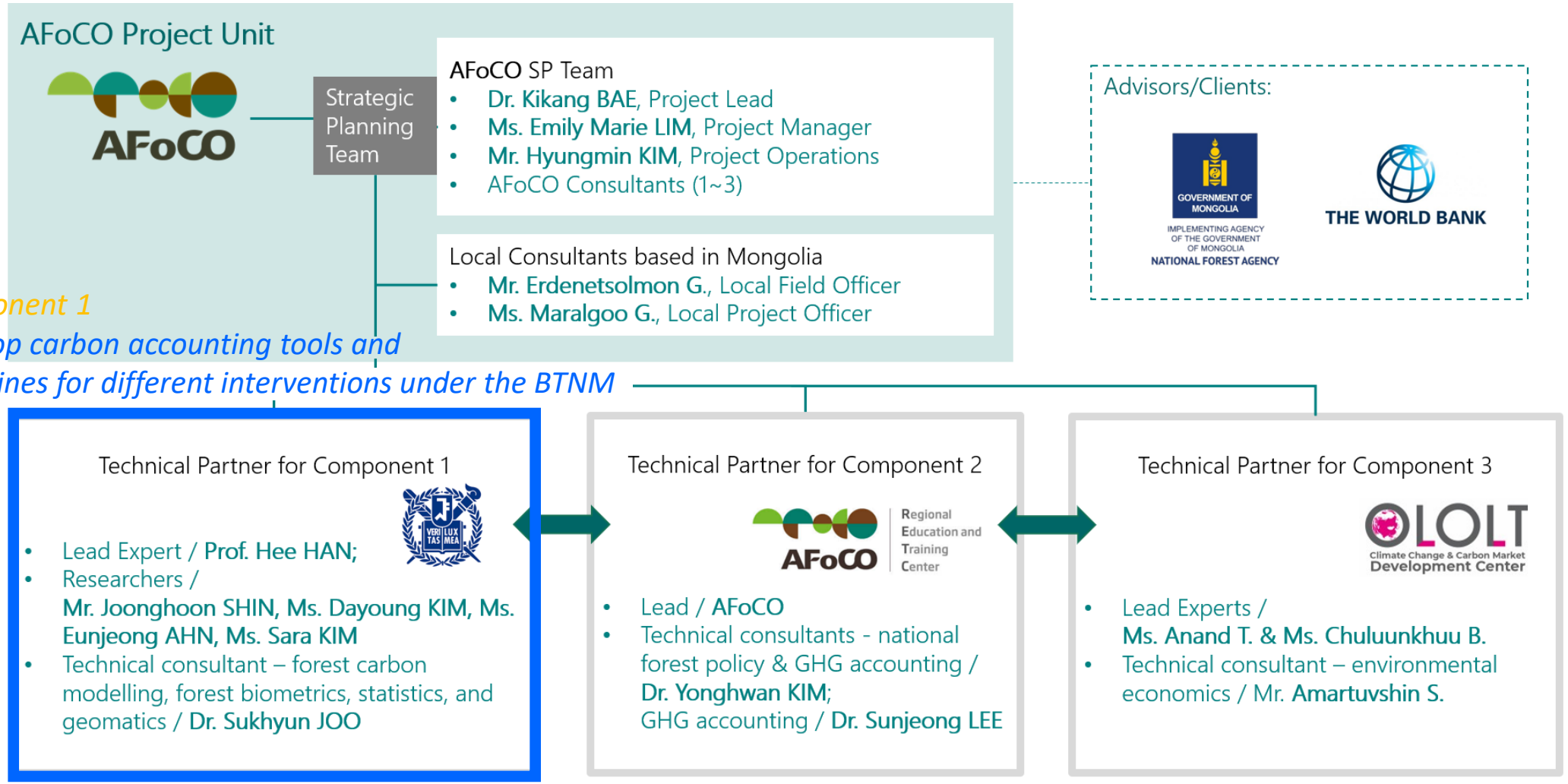
AFoCO

서 울 대 학 교
SEOUL NATIONAL UNIVERSITY

“Since August last year, we have been working to understand the carbon benefits of Mongolia’s BTNM and to explore how it can lead to meaningful, field-based carbon projects.

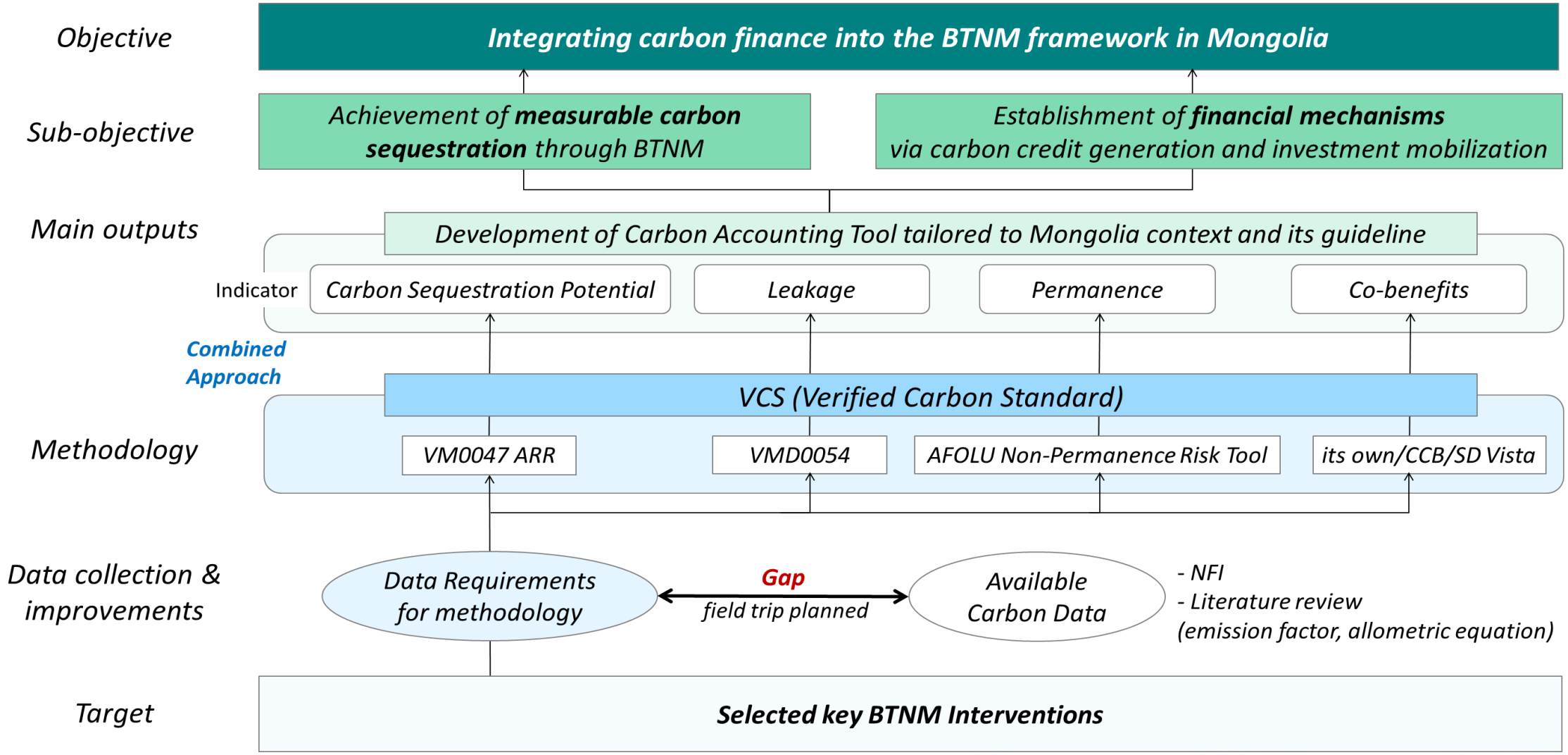
Today’s presentation highlights the key findings from our work to date and outlines the next steps needed to develop robust carbon initiatives aligned with BTNM efforts.”

1. Project Consortium



Potential Collaboration with Researchers from: National Institute of Forest Science

2. Framework for Developing a Carbon Accounting Tool



First, how do we define the interventions?

3. The Identification of BTNM Interventions

- *What does 'interventions' mean in the context of this project?*
- *The definition can be reasonably based on the primary objectives outlined in the official framework*

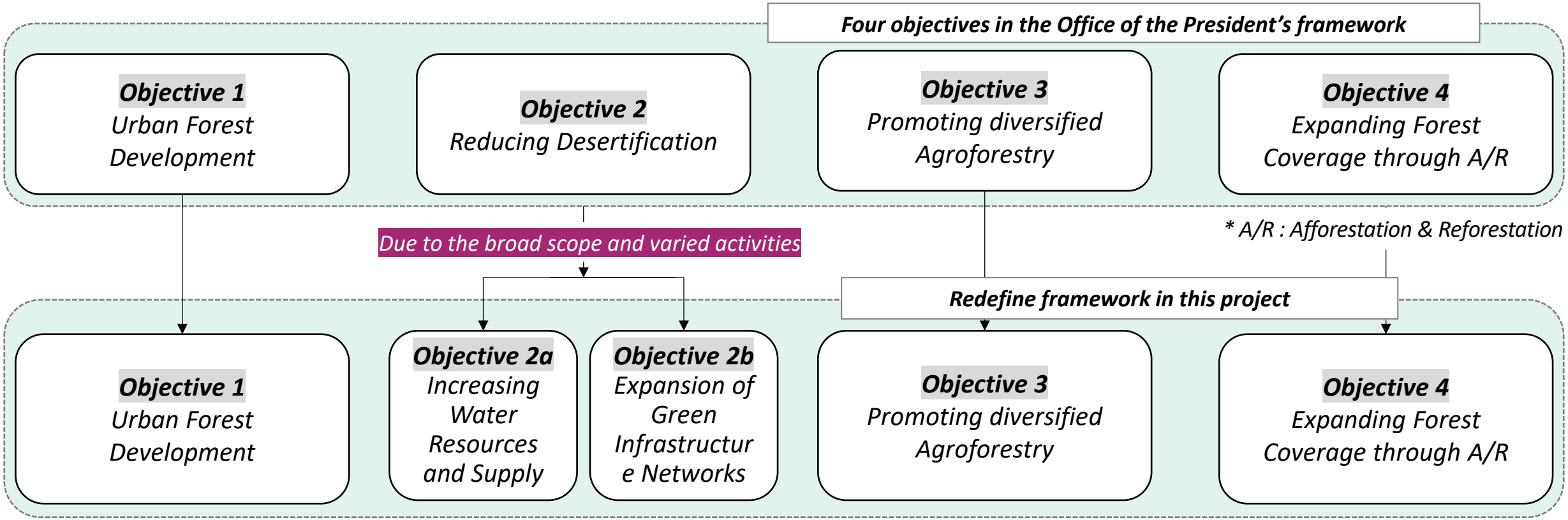
(Office of the President of Mongolia, 2023)

	Objectives	Activity
1	Maintaining and increasing the ecological balance of settlements, improving the living conditions of the people, developing "Urban Forest"	• Public utility • For Special needs • Limited use
2	Reducing desertification, sources of dust storms, and mitigating sand migration	• Protecting and restoring oasis • Construction of a forest strip to protect farmland • Rehabilitation of large rivers • Protection and restoration of river beds • Protection of springs and ponds • Construction of forest strips for road protection • Construction of forest strips for railway protection • Establishment of forest along infrastructure • (rail, train station, borders facilities, road)
3	Development of diversified agro-forestry in line with the goal of the national movement "Food supply and security"	• Establishment of fruit farms • Establishment of agroforestry • Establishment of saxaul and other medical plants • Cooperative framing
4	Reducing deforestation and degradation and increasing the area covered by forests	• Restoration of degraded forests • Restoration of sedge forests • Assist in natural regeneration

3. The Identification of BTNM Interventions

- *This framework prioritizes "tree planting actions" across urban, agricultural, and degraded forest areas etc.*
- *It offers a structured way to evaluate suitable areas and carbon sequestration potential for each intervention*

(Office of the President of Mongolia, 2023)



3. The Identification of BTNM Interventions

- *This framework prioritizes "tree planting actions" across urban, agricultural, and degraded forest areas etc.*
- *It offers a structured way to evaluate suitable areas and carbon sequestration potential for each intervention*

BTNM planning and objectives by tree planting activities

No	Objective/Sub-Objective		Activity		Number of trees to be planted
1	Maintaining and increasing the ecological balance of settlements, improving the living conditions of the people, developing "Urban Forest"		1-1	Public utility	86,993,197
			1-2	Special needs	14,536,000
			1-3	Limited use	85,390,487
			Sub total		186,919,684
2	Reducing desertification, sources of dust storms, and mitigating sand migration	2a. Increasing water resources and water supply	2-1	Protecting and restoring oasis	2,745,000
			2-2	Rehabilitation of large rivers	164,865,000
			2-3	Protection of springs and ponds	23,310,000
			2-4	Protection and restoration of river beds	41,625,000
			Sub total		232,545,000
		2b. Expansion of green infrastructure network	2-5	Construction of a forest strip to protect farmland	22,626,696
			2-6	Construction of forest strips for road protection	209,430,400
			2-7	Construction of forest strips for railway protection	46,953,885
			2-8	Establishment of forest along infrastructure	30,092,325
			Sub total		309,103,306
3	Development of diversified agro-forestry in line with the goal of the national movement "Food supply and security"		3-1	Establishment of fruit farms	37,674,804
			3-2	Establishment of agroforestry	117,590,446
			3-3	Establishment of saxaul and other medical plants cooperative farming	545,400
			Sub total		155,810,650
4	Reducing deforestation and increasing the area covered by forests by restoring natural forests		4-1	Restoration of degraded forests	379,065,910
			4-2	Restoration of sedge forests	223,380,000
			4-3	Assist in natural regeneration	22,775,450
			Sub total		625,221,360
Total trees					1,509,600,000

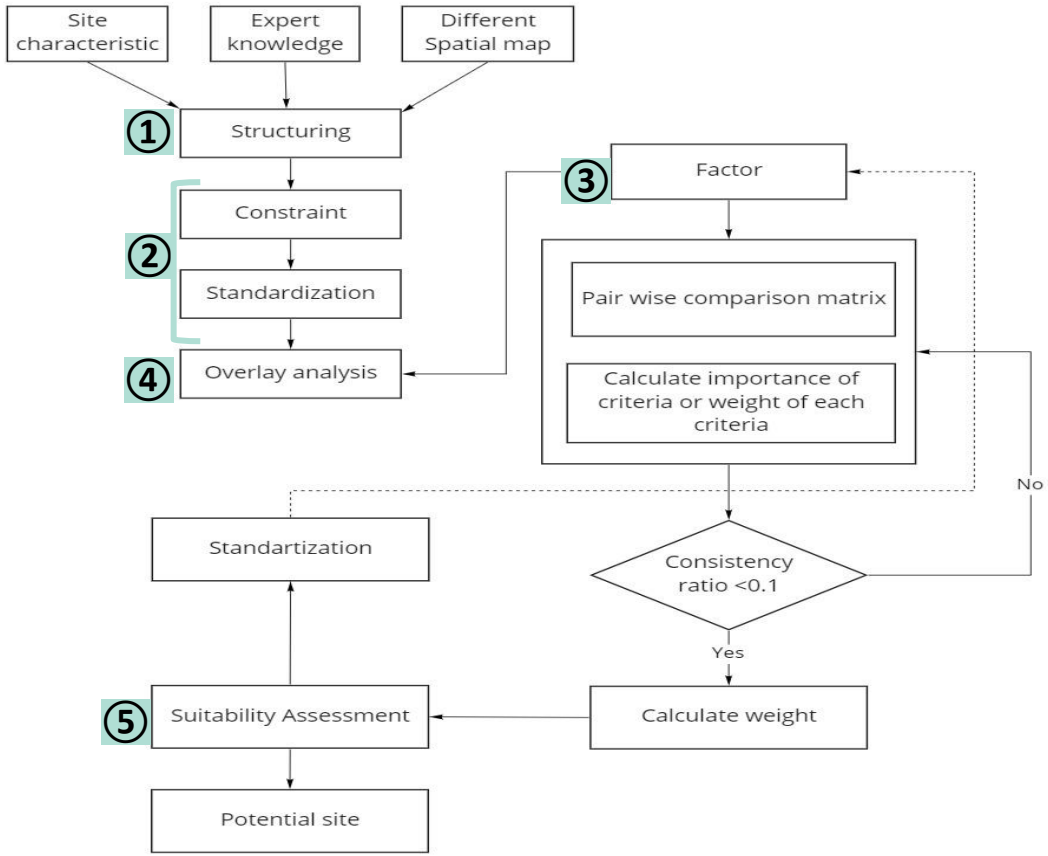
Broad set of activities and substantial target for tree planting can be divided into two interventions!!

Then, how do we identify the "key interventions"?

4. Multicriteria GIS Analysis for Assessing Tree Planting Suitability

- *Determine **suitable areas for each intervention across Mongolia** based on a multicriteria GIS analysis*

In terms of i) Maximizing carbon sequestration potential and ii) minimizing any adverse environmental impacts



<Multicriteria assessment process for designating potential areas>
proposed by MFRA (2021)

① Structuring and Data Collection

- *Ecosystem distribution, Slope, Aspect, Air temperature, Precipitation, Boreal Forest change map*

② Setting Constraints and Standardizing Data

- *Constraints to exclude non-contiguous areas*

③ Factor Weighting via Pairwise Comparison

- *AHP(Analytical Hierarchy Process) will be employed*

④ Overlay Analysis

⑤ Suitability Assessment and Identification of Potential Sites

4. Multicriteria GIS Analysis for Assessing Tree Planting Suitability

- *Multicriteria GIS Analysis to identify areas suitable for tree planting activities in BTNM*
- *Two types of input data are considered:*

  1) Vector data: NFI, Ecosystem distribution, Natural complex conditions, Road network, Urban area, Surface waters...

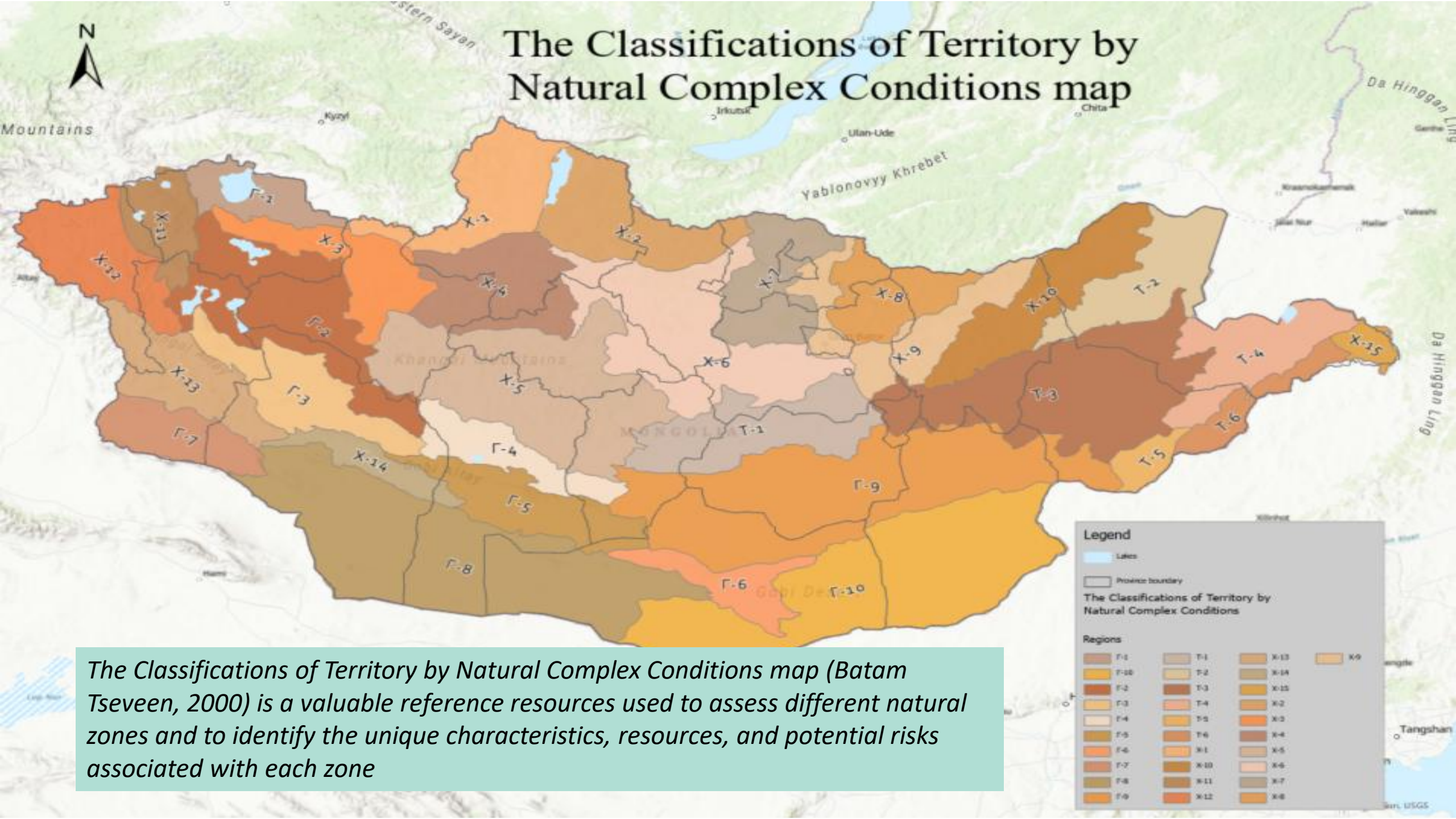
  2) Raster data: Topography, Soil quality, Climate condition, Forest cover changes...

Data type	Source	Optimal range/Condition
Ecosystem distribution	The national scale ecosystem distribution map, EIC	The Natianol Level
Forest Inventory Data (NFI)	Forest Agency	The Natianol Level
CropLand	ALAMGC	The National Level
The Classifications of Territory by Natural Complex Conditions map	Badam Tseveen, Gazar Servis LLC	Weighted score: X=1, T=0.6 and G=0
Road Newtwork	Open street map and ALAMGC	The National Level

This map helps in understanding the ecological balance, biodiversity, and suitability of land for various uses such as agriculture, forestry, urban development, or conservation (See the next slide)

Data type	Source	Optimal range/Condition
Slope	SRTM90m DEM data	USGS, NASA
Aspect	SRTM90m DEM data	USGS, NASA
Air temperature	The mean temperature, 1950-2012, IRIMHE	Broadleaves: -1.18°C and -2.41°C Larch: 7.47°C and -3.09°C Pinus: -0.69°C and -2.19°C
Precipitation	The annual precipitation, 1950-2012, IRIMHE	Broadleaves: 346 mm-320.3 mm Larch: 286.65mm-327.92mm Pinus: 312mm-346mm
Boreal Forest change map	GLC_FC30	Forest change map between 1990-2022
Urban Area	Sentinel-2 Global Land Cover Data	2023
Current Forest Cover Data	Sentinel-2 Global Land Cover Data	2023

The Classifications of Territory by Natural Complex Conditions map



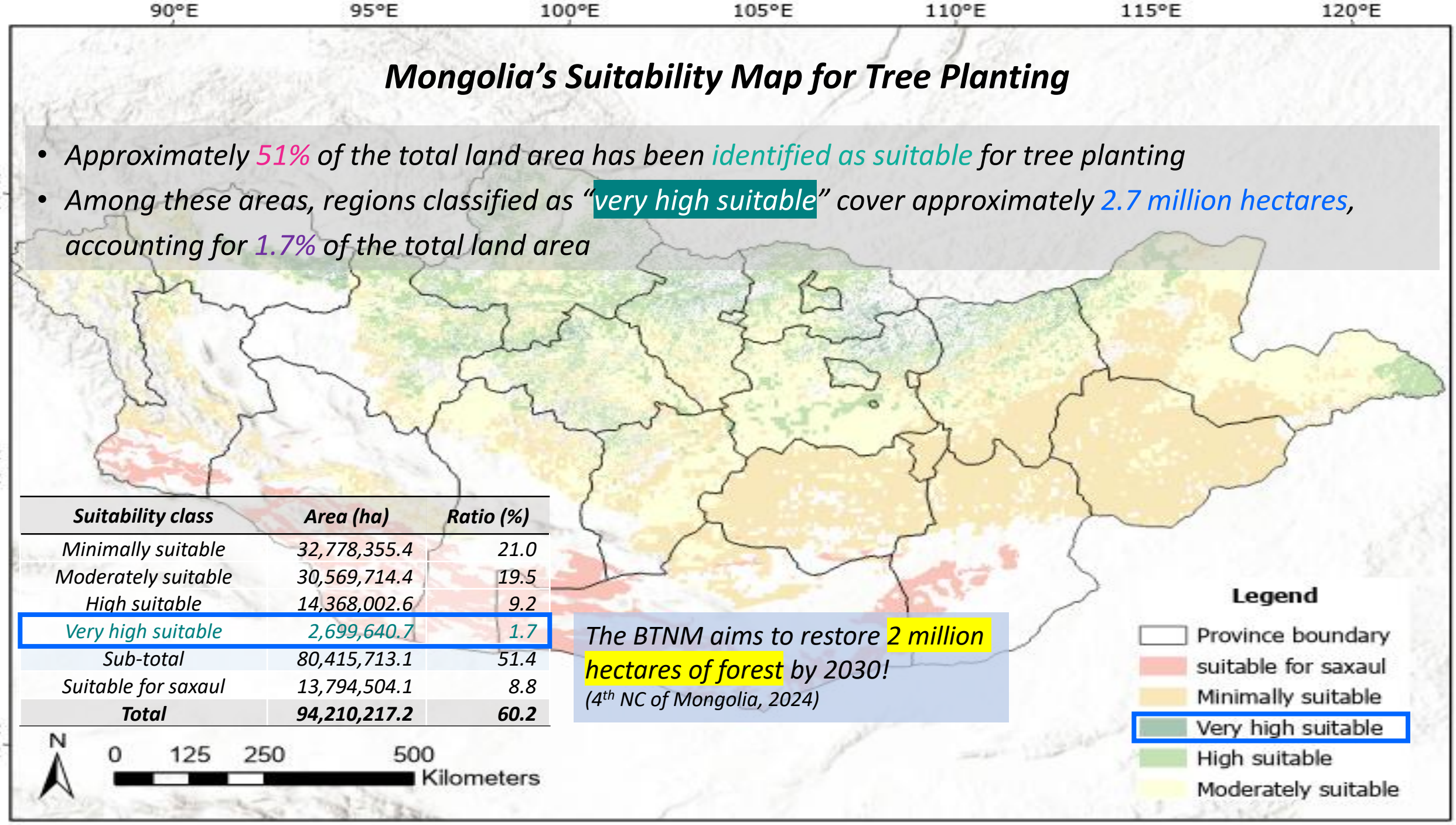
The Classifications of Territory by Natural Complex Conditions map (Batam Tseveen, 2000) is a valuable reference resources used to assess different natural zones and to identify the unique characteristics, resources, and potential risks associated with each zone

Mongolia's Suitability Map for Tree Planting

- *Approximately 51% of the total land area has been identified as suitable for tree planting*
- *Among these areas, regions classified as "very high suitable" cover approximately 2.7 million hectares, accounting for 1.7% of the total land area*

Suitability class	Area (ha)	Ratio (%)
Minimally suitable	32,778,355.4	21.0
Moderately suitable	30,569,714.4	19.5
High suitable	14,368,002.6	9.2
Very high suitable	2,699,640.7	1.7
Sub-total	80,415,713.1	51.4
Suitable for saxaul	13,794,504.1	8.8
Total	**94,210,217.2**	**60.2**

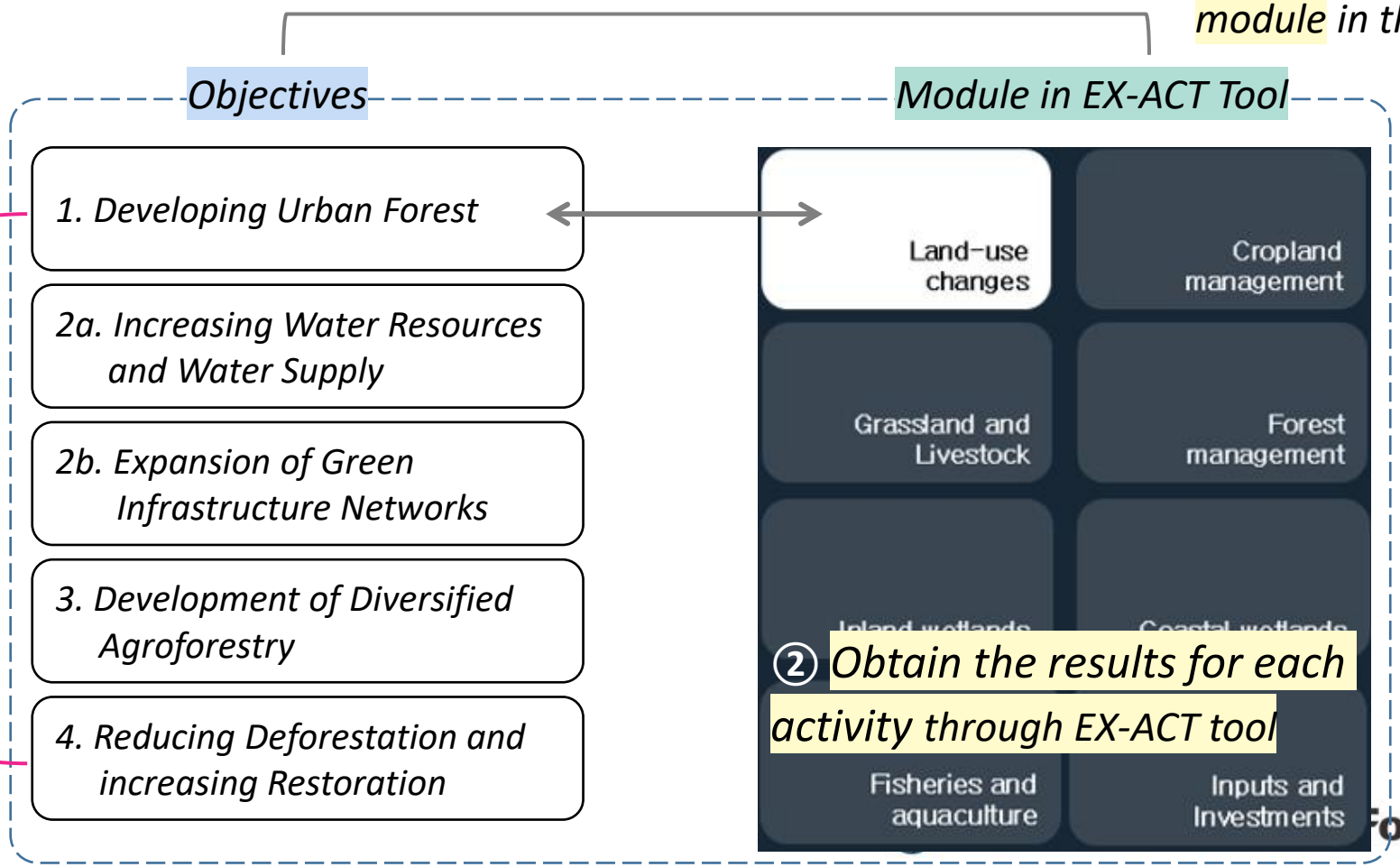
The BTNM aims to restore 2 million hectares of forest by 2030!
(4th NC of Mongolia, 2024)



5. Estimation of Carbon Sequestration Potential for BTNM Interventions

- *Use EX-ACT tool to compare the estimated potential carbon sequestration for each intervention*
- *Serve as the primary basis for selecting three major interventions*

① *Link the Activity w/ the corresponding module in the EX-ACT tool*



③ *Compare the EX-ACT results by intervention*

② *Obtain the results for each activity through EX-ACT tool*

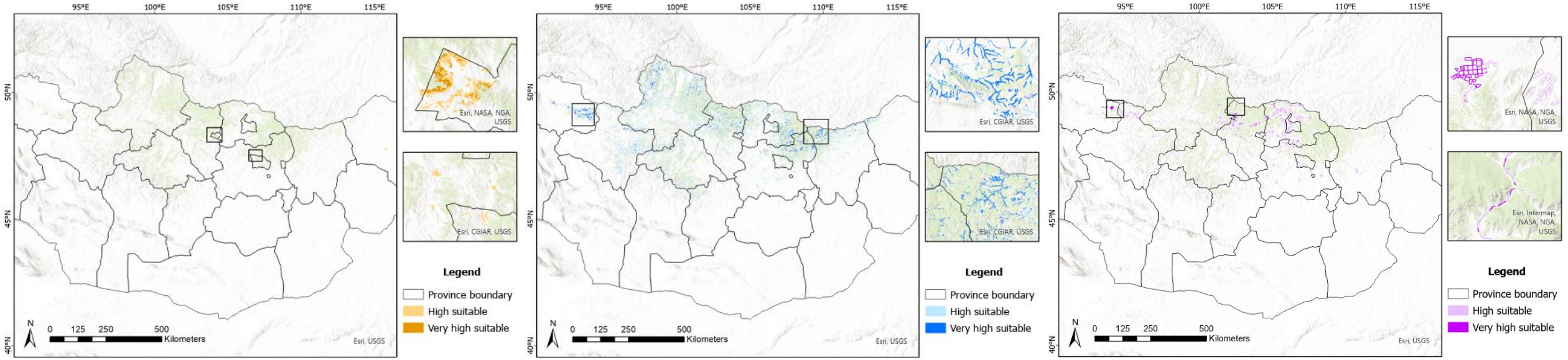
5. Estimation of Carbon Sequestration Potential for BTNM Interventions

- *Relevant spatial data were used to extract potential area for each intervention from the suitability map*

No	Intervention	Activity	Spatial parameters	
			GIS data	Buffer(m)
1	Developing Urban Forest	Public utility Special needs Limited use	Urban area map	-
2a	Increasing water resources and water supply	Protecting and restoring oasis	Oasis map	50
		Rehabilitation of large rivers	Rivers map	200
		Protection of springs and ponds	Spring map	50
		Protection and restoration of river beds	Seasonal rivers map	50
2b	Expansion of green infrastructure	Construction of a forest strip to protect farmland	Cropland area map	30
		Construction of forest strips for road protection	Roads map	30
		Construction of forest strips for railway protection	Railways map	30
		Establishment of forest along infrastructure	Excluded due to lack of spatial data	
3	Development of Diversified Agroforestry	Establishment of fruit farms Establishment of agroforestry Establishment of saxaul and other medical plants cooperative farming	Potential agroforestry map	-
4	Reducing deforestation and increasing Restoration	Restoration of degraded forests	Degraded Forest map	-
		Restoration of saxaul forests	Potential Saxaul forest map	-
		Assist in natural regeneration	Existing Forest map	100

5. Estimation of Carbon Sequestration Potential for BTNM Interventions

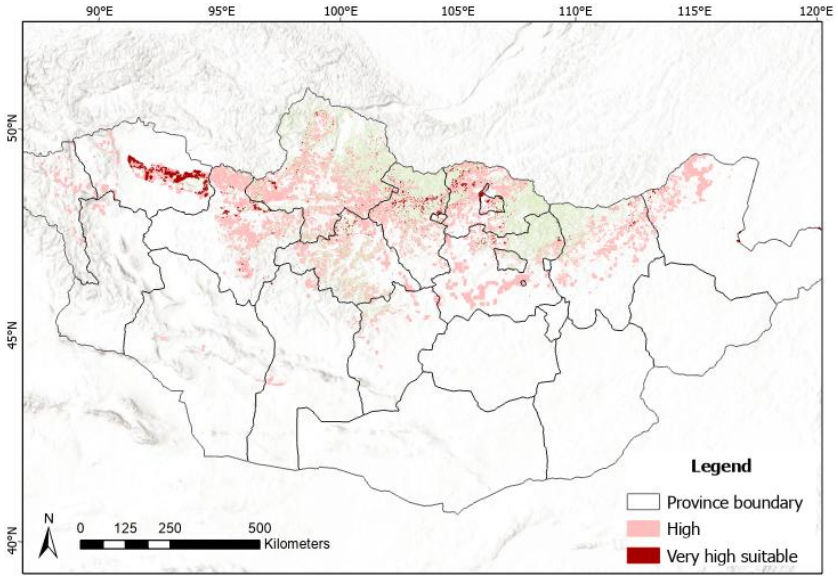
- *Analysis of high and very high suitability areas by intervention –Agroforestry (Int 3) is the largest!*

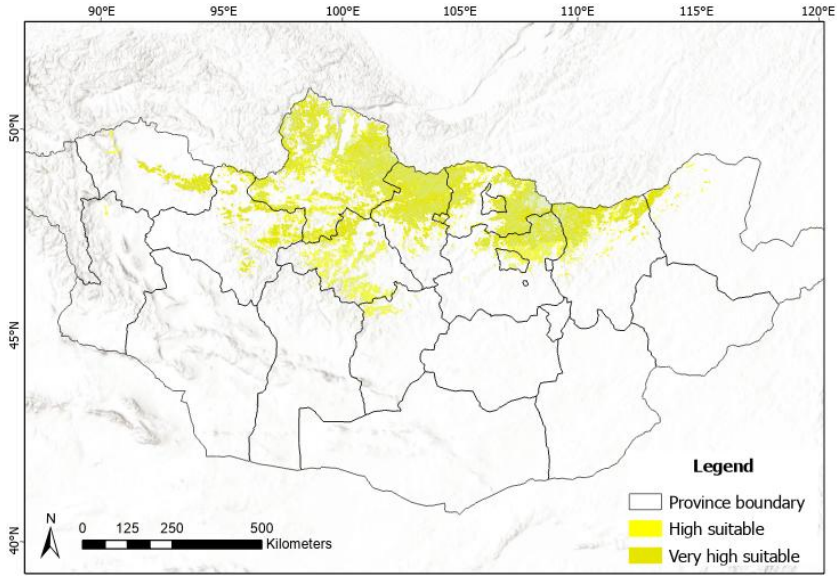


Suitability Class	Intervention 1	Intervention 2a	Intervention 2b	Intervention 3	Intervention 4	Sum
High	*76,800*	*1,043,528*	*32,621*	*8,528,305*	*4,281,058*	*13,962,312*
Very high	*8,895*	*304,649*	*2,109*	*705,241*	*1,562,105*	*2,582,999*
Sum	***85,695***	***1,348,177***	***34,730***	***9,233,546***	***5,843,163***	***29,684,338***

5. Estimation of Carbon Sequestration Potential for BTNM Interventions

- *Rank by area: Agroforestry (Int 3) > A/R (Int 4) > Water res. (Int 2a) > Green Infra. (Int 2b) > Urban for. (Int 1)*





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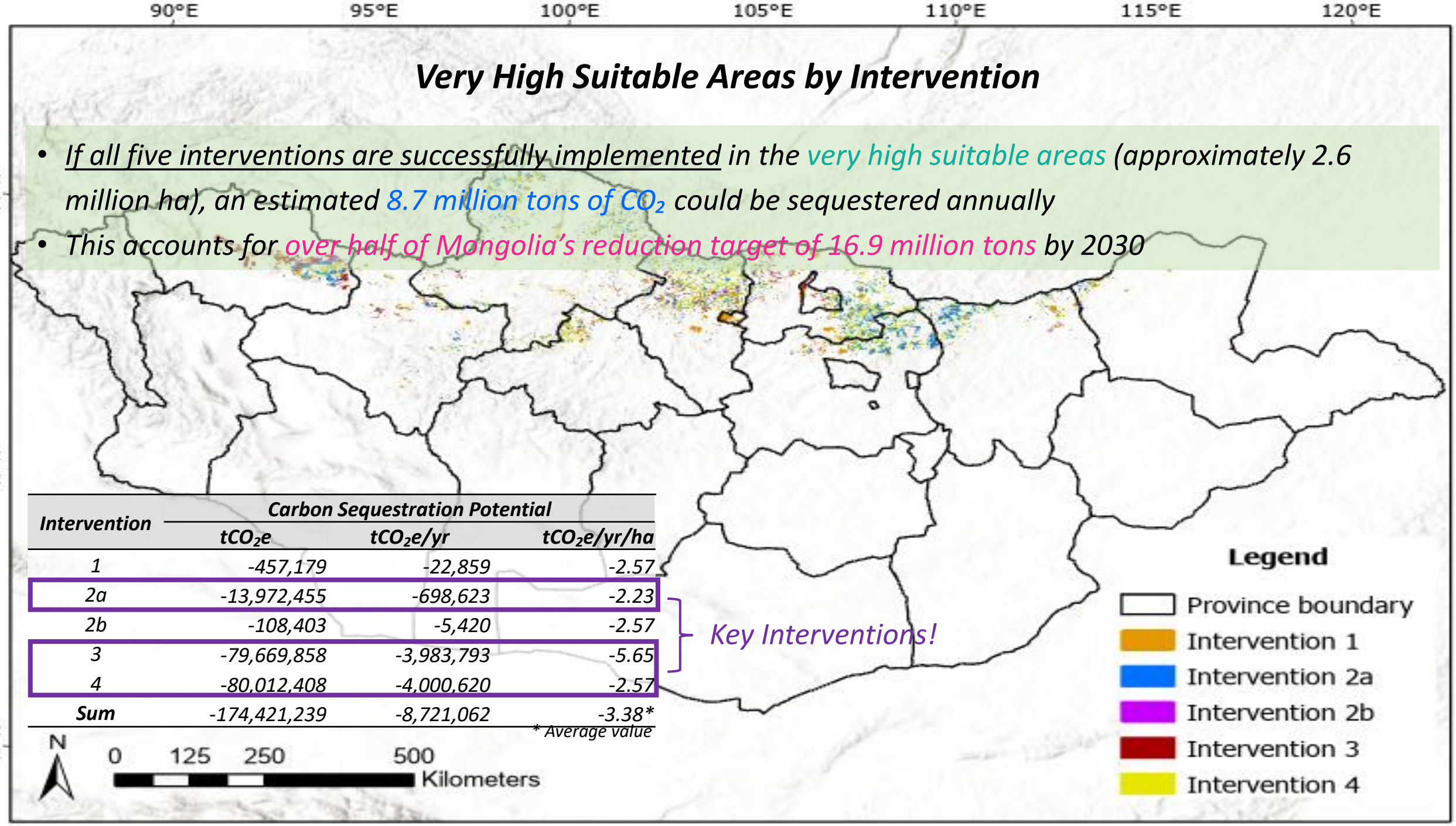
Very High Suitable Areas by Intervention

- *If all five interventions are successfully implemented in the very high suitable areas (approximately 2.6 million ha), an estimated 8.7 million tons of CO_2 could be sequestered annually*
- *This accounts for over half of Mongolia's reduction target of 16.9 million tons by 2030*

Intervention	Carbon Sequestration Potential		
	tCO_2e	tCO_2e/yr	$tCO_2e/yr/ha$
1	-457,179	-22,859	-2.57
2a	-13,972,455	-698,623	-2.23
2b	-108,403	-5,420	-2.57
3	-79,669,858	-3,983,793	-5.65
4	-80,012,408	-4,000,620	-2.57
Sum	-174,421,239	-8,721,062	-3.38*

* Average value

Key Interventions!

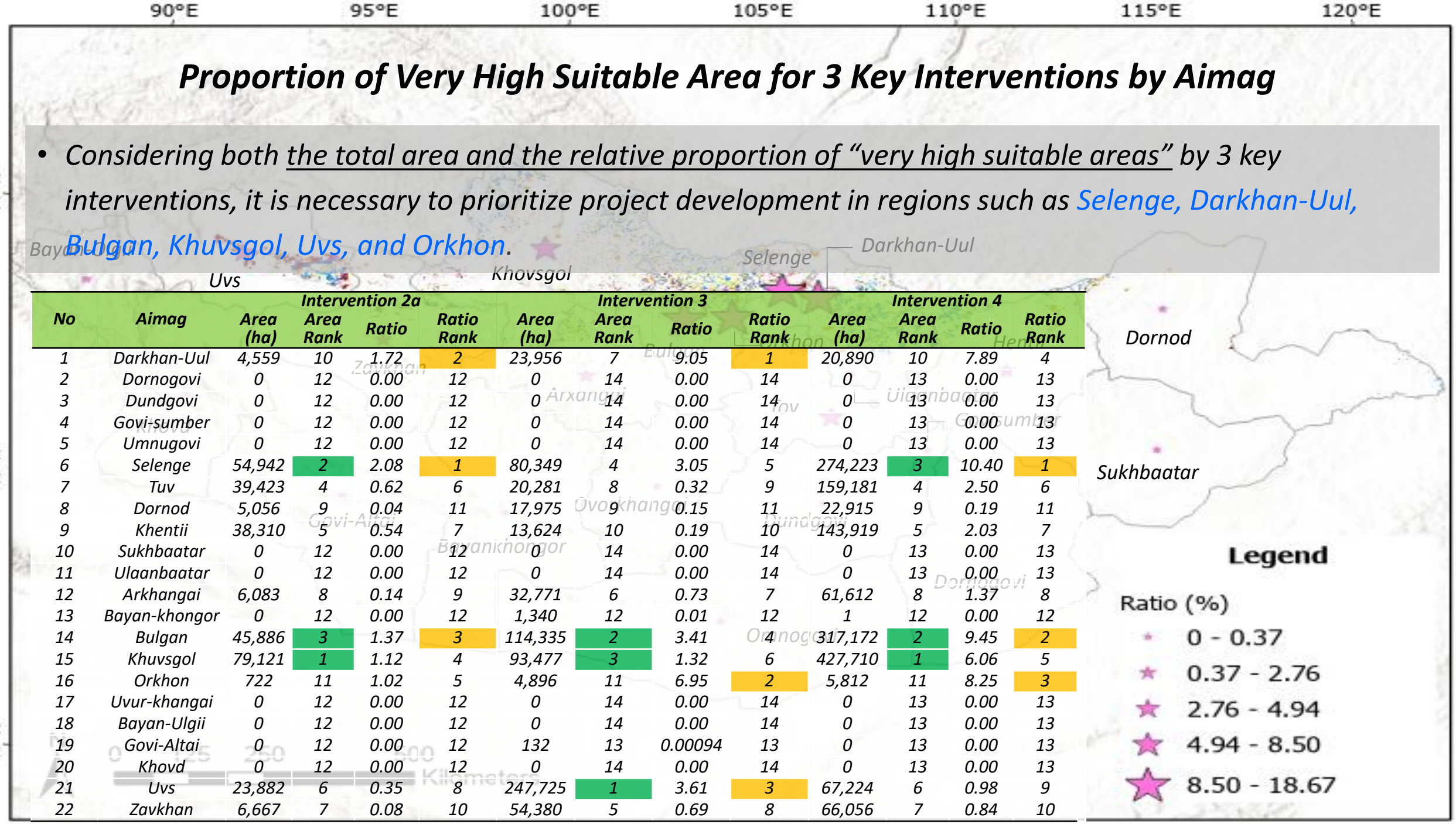


Where are the priority regions and What are the suitable GHG methodologies for developing a forest carbon project?

Proportion of Very High Suitable Area for 3 Key Interventions by Aimag

- *Considering both the total area and the relative proportion of "very high suitable areas" by 3 key interventions, it is necessary to prioritize project development in regions such as Selenge, Darkhan-Uul, Bulgan, Khuvsgol, Uvs, and Orkhon.*

No	Aimag	Intervention 2a				Intervention 3				Intervention 4			
		Area (ha)	Area Rank	Ratio	Ratio Rank	Area (ha)	Area Rank	Ratio	Ratio Rank	Area (ha)	Area Rank	Ratio	Ratio Rank
1	Darkhan-Uul	4,559	10	1.72	2	23,956	7	9.05	1	20,890	10	7.89	4
2	Dornogovi	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
3	Dundgovi	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
4	Govi-sumber	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
5	Umnugovi	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
6	Selenge	54,942	2	2.08	1	80,349	4	3.05	5	274,223	3	10.40	1
7	Tuv	39,423	4	0.62	6	20,281	8	0.32	9	159,181	4	2.50	6
8	Dornod	5,056	9	0.04	11	17,975	9	0.15	11	22,915	9	0.19	11
9	Khentii	38,310	5	0.54	7	13,624	10	0.19	10	143,919	5	2.03	7
10	Sukhbaatar	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
11	Ulaanbaatar	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
12	Arkhangai	6,083	8	0.14	9	32,771	6	0.73	7	61,612	8	1.37	8
13	Bayan-khongor	0	12	0.00	12	1,340	12	0.01	12	1	12	0.00	12
14	Bulgan	45,886	3	1.37	3	114,335	2	3.41	4	317,172	2	9.45	2
15	Khuvsgol	79,121	1	1.12	4	93,477	3	1.32	6	427,710	1	6.06	5
16	Orkhon	722	11	1.02	5	4,896	11	6.95	2	5,812	11	8.25	3
17	Uvur-khangai	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
18	Bayan-Ulgii	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
19	Govi-Altai	0	12	0.00	12	132	13	0.00094	13	0	13	0.00	13
20	Khovd	0	12	0.00	12	0	14	0.00	14	0	13	0.00	13
21	Uvs	23,882	6	0.35	8	247,725	1	3.61	3	67,224	6	0.98	9
22	Zavkhan	6,667	7	0.08	10	54,380	5	0.69	8	66,056	7	0.84	10



6. Policy Considerations for Priority Regions

- *The selection of priority regions also reflects the Government of Mongolia's policy direction*
- *『The 2024–2028 Government Program of Action』emphasizes large-scale water infrastructure projects such as the Kherlen-Toono and Orkhon-Ongi water complexes*

https://dialogue.earth/en/water/analysis-blue-horse-mongolia-water-infrastructure/

These policy initiatives align directly with Intervention 2a (Increasing Water Resources and Supply), highlighting the critical importance of riparian restoration in upstream provinces such as Arkhangai and Khentii aimag, where key surface water sources are located

7. GHG Methodology for Each BTNM Intervention

- For each BTNM intervention, the most appropriate GHG accounting methodologies under Verra and the Gold Standard were identified
  - VCS Afforestation, Reforestation, and Revegetation vs. GS A/R GHG Emissions Reductions & Sequestration

Int.	Objective/Sub-Objective		VCS	GS
1	Maintaining and increasing the ecological balance of settlements, improving the living conditions of the people, developing "Urban Forest"		VM0047 Afforestation, Reforestation, and Revegetation (VCS-ARR)	A/R GHG Emissions Reductions & Sequestration (GS-A/R)
2	Reducing desertification, sources of dust storms, and mitigating sand migration	2a. Increasing water resources and water supply 2b. Expansion of green infrastructure network		
3	Development of diversified agroforestry in line with the goal of the national movement "Food supply and security"			
4	Reducing deforestation and increasing the area covered by forests by restoring natural forests			

7. GHG Methodology for Each BTNM Intervention – Data Requirement

- *Above- and belowground woody biomass is mandatory inclusion in both VCS-ARR and GS-A/R*
  - *In VCS-ARR, some carbon pools are optional; however, they must be included if the project activity significantly reduces the carbon pool*

Carbon Pool	VCS-ARR	GS-A/R
Aboveground woody biomass	Y	Y
Aboveground non-woody biomass	Y/O	Y
Belowground woody biomass	Y	Y
Belowground non-woody biomass	Y/O	Y
Dead wood	O	N
Litter	Y/O	N
Soil organic carbon (SOC)	Y/O	O
Wood products	N	N

** Y: Yes (included), N: No(excluded), O: Optional*

*These pools can be included depending on **specific activities** in different interventions!*

7. GHG Methodology for Each BTNM Intervention – Data Requirement

- For the implementation of carbon methodologies under BTNM, each standard imposes specific data requirements aligned with its accounting principles
  - Key data needs of VCS-ARR and GS-A/R, with a focus on their applicability to BTNM interventions as follows:

	VCS-ARR	GS-A/R
Carbon pools	Aboveground and belowground biomass mandatory; optional inclusion of litter, SOC, and dead wood if significant	Aboveground and belowground biomass mandatory; SOC optional
Quantification	Area-based (stock difference) or census-based (planting unit)	Modeling Unit (MU)-based with growth curve calibration
Inventory requirement	Periodic tree measurements; stand-level or plot-level sampling	MU-specific forest inventories to validate models
Conversion factors	Species-specific BEF, wood density, R/S ratio	MU-level default or country-specific parameters
Leakage and emissions	Requires estimation of leakage and project emissions (VM0054 module)	Leakage required; fertilizer emissions optional

So, what is the current status of forest data in Mongolia for developing carbon projects?

And where do the key data gaps remain?

8. Data Gap Analysis for Data Collection and Data Improvement Plan

- *Collect information below from existing literature*
  - *Species, sample size, biomass component, range of DBH & tree height, coordinates of sample plots*

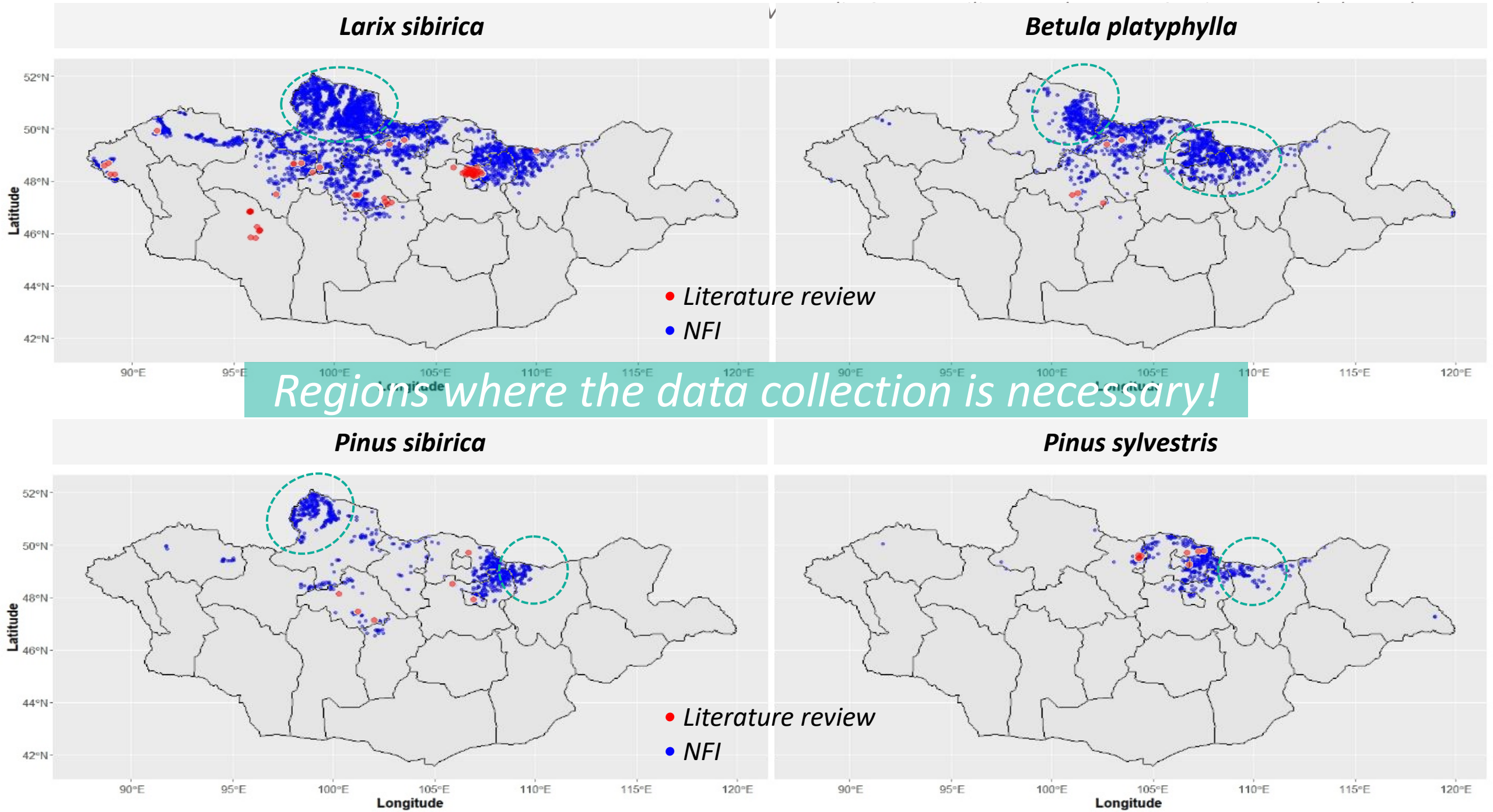
No.	Author	Year	Title
1	Altanzagas et al.	2019	Allometric equations for estimating the above-ground biomass of five forest tree species in Khangai, Mongolia
2	Battulga et al.	2013	Equations for estimating the above-ground biomass of Larix sibirica in the forest-steppe of Mongolia
3	Dorjsuren	2017	Estimation of aboveground biomass and carbon stock in Mongolian boreal forest
4	Dorjsuren & Khongor	2018	Allometric model development for above ground biomass of saxaul (Haloxylon ammodendron (C.A.May) Bunge.)
5	Dulamsuren et al.	2016	Carbon pool densities and a first estimate of the total carbon pool in the Mongolian forest-steppe
6	Gerelbaatar	2018	Estimating the belowground biomass and root/shoot ratio of larch forest in northern Mongolia
7	Gerelbaatar et al.	2023	Allometric equations for the estimation of above- and below-ground biomass for Larix sibirica Ledeb. in Northern MN
8	Government of MN	2018	Mongolia's forest reference level submission to the United Nations Framework Convention on Climate Change
9	Nyamjav et al.	2018	Allometric equations for estimating above-ground biomass of Nitraria sibirica Pall. in Gobi Desert of Mongolia
10	Usoltsev et al.	2019	Aboveground biomass of Mongolian larch (Larix sibirica Ledeb.) forests in the Eurasian region
⋮			⋮

8. Data Gap Analysis for Data Collection and Data Improvement Plan

- *The table below shows the summary of data from literature review by species*
  - *Most studies have been conducted on Larix sibirica*
  - *Almost no data for bark and root except Larix sibirica: those bark and root data also small sample size*

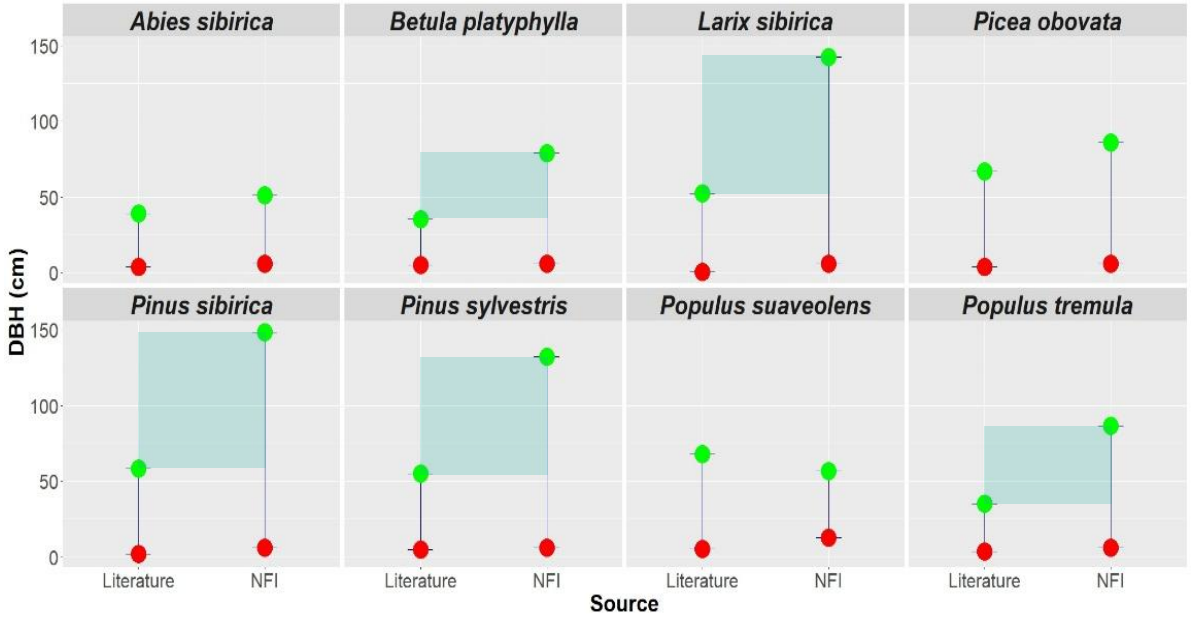
Species	Sample size	Biomass Components						DBH (cm)		Height (m)	
		Stem	Branch	Foliage	Bark	Root	Fruit	Min	Max	Min	Max
Abies sibirica	19	O	O	O				4.0	39.0	3.23	27.6
Betula platyphylla	27	O	O	O				6.0	35.4	6.2	22.5
Larix sibirica	187	O	O	O	O	O		0.5	52.5	1.5	31.4
Picea obovata	22	O	O	O				5.6	43.7	5.8	27.0
Pinus sibirica	23	O	O	O				2.0	42.0	2.5	17.6
Pinus sylvestris	35	O	O	O				4.7	55.0	4.6	23.0
Populus suaveolens	37	O	O	O				5.2	68.0	5.1	25.5
Populus tremula	9	O	O	O				3.8	35.0	5.62	20.6
Populus sibirica	135	O	O	O		O		77.6* ± 4.40		384.3 ± 30.88	
Ulmus pumila		O	O	O		O		44.28* ± 2.73		217.8 ± 12.25	
Haloxylon ammodendron	46	O	O	O				0.71	25.5	0.22	5.65
Nitraria sibirica Pall.	35	O	O	O			O	0.19	0.67	0.4	1.94

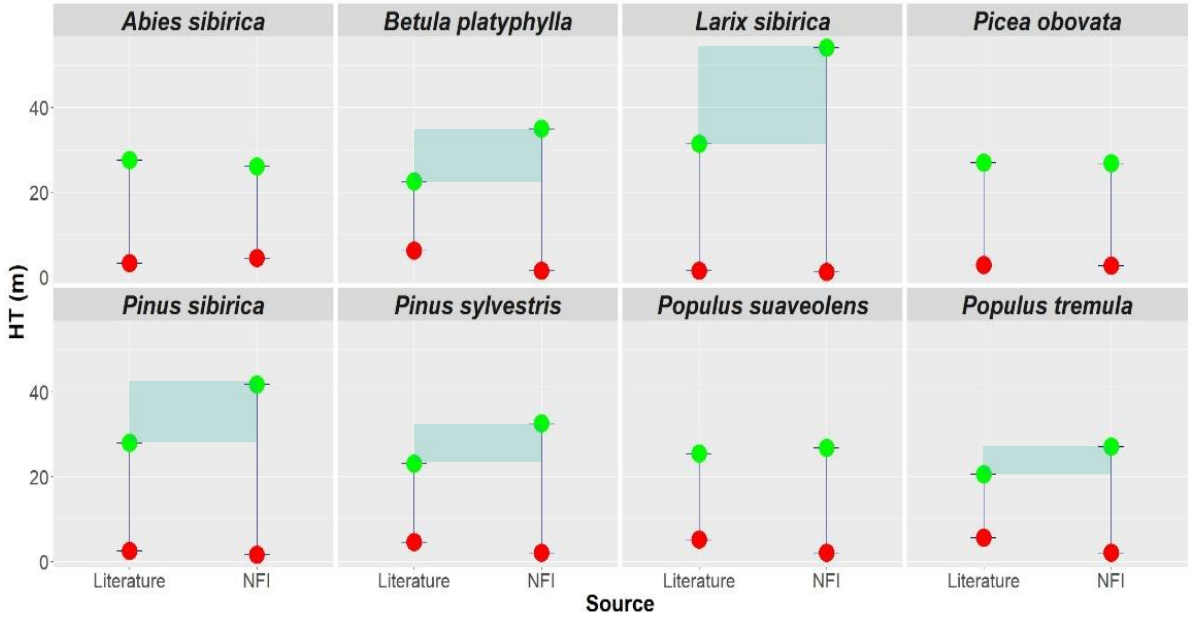
*Diameter at Root Collar


Larix sibirica
Betula platyphylla
Pinus sibirica
Pinus sylvestris
Literature review
NFI
Regions where the data collection is necessary!
Latitude
Longitude
52°N
50°N
48°N
46°N
44°N
42°N
90°E
95°E
100°E
105°E
110°E
115°E
120°E

8. Data Gap Analysis for Data Collection and Data Improvement Plan

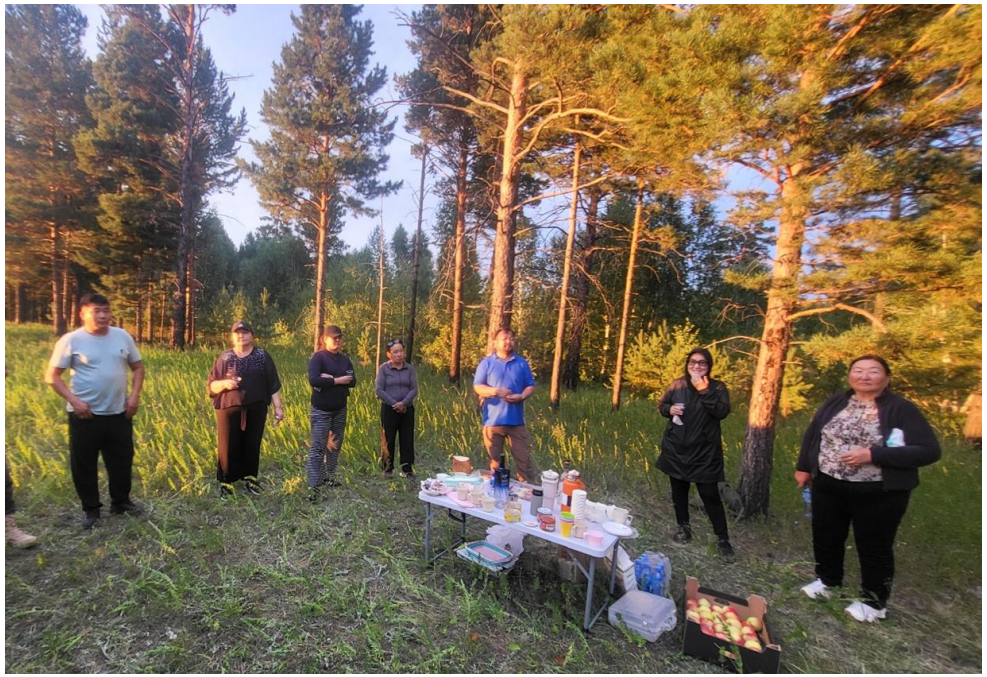
- *Comparing the ranges of DBH and tree height from literature review and NFI*
  - *Found a lack of data on large trees (even for Larix sibirica with the largest sample size)*
  - *Hard to evaluate range of saxaul because there are no saxaul data in NFI – Also needs to be improved*
- *Larix sibirica accounted for 80% of basal area based on NFI, followed by Betula platyphylla (8.3%), Pinus sibirica (6.1%), and Pinus sylvestris (3.6%)*





9. Co-benefit Assessment Tools

- *To ensure that co-benefit assessment reflects both national priorities and local realities, a grounded understanding of context-specific needs is essential*
  - *Stakeholder consultations and field assessments guide the selection of appropriate standards and frameworks for monitoring these outcomes* * *A survey would be required for this purpose*



*9. Co-benefit Assessment Tools – **National Priorities***

- ***The regional development policy of 2024–2028 Government of Mongolia***

  - ✓ ***Strengthening sustainable local economic foundations**: By developing industrial bases utilizing agriculture, livestock, and mineral resources, and by expanding vocational education infrastructure, the policy seeks to link local production with employment and enhance regional economic self-reliance*

  - ✓ ***Promoting tourism based on natural and cultural assets**: By developing specialized tourism sites that leverage natural landscapes (e.g., lakes and mountains) and historical and cultural heritage, along with supporting infrastructure, the policy aims to diversify regional economies and attract external visitors*

  - ✓ ***Developing green energy and environmentally friendly infrastructure**: By expanding renewable energy production (e.g., hydropower, solar, and wind) and strengthening energy transmission infrastructure to improve energy accessibility and support climate-resilient development*

*9. Co-benefit Assessment Tools – **Local Realities***

- ***Community-Level Interview with Forest User Group***

  - ✓ ***Securing livelihoods and food resources through non-timber forest products (NTFPs)**: By utilizing NTFPs such as herbal tea, blueberry, sea buckthorn, and apples, some community members have recently begun to generate income; These activities were regarded as important not only for supplementing household income but also for securing locally available food resources*

  - ✓ ***Anticipated economic benefits from forest restoration*** ★ ★ *: By producing seedlings in local nurseries, income-generating activities have been initiated; however, limited market demand continues to constrain profitability. Following some income generated through the recent BTNM initiative, the need to establish a more stable and sustainable demand base has been recognized*

*9. Co-benefit Assessment Tools – **Local Realities***

- ***Community-Level Interview with Forest User Group***

  - ✓ ***Need to enhance awareness and capacity for local participation**: The community is ready to act but lacks knowledge of mechanisms and markets, highlighting the need for targeted capacity-building*

  - ✓ ***Recognition of the importance of land restoration and water resource protection**: Through their experience of improved soil quality from past tree planting and repeated emphasis on water and riparian protection, the local community demonstrated a clear awareness of long-term environmental values*

10. Bridging Data Gaps for Forest Carbon Initiatives in Mongolia

Field survey scheduled for coming July

- Key input parameters and improvement needs for carbon projects in Mongolia

Parameter	Data Availability in Mongolia	Remarks / Improvement Needed
Average carbon stock in aboveground woody biomass	Partial (limited species)	• Expand DBH-height datasets, include more species • Further investigation is needed for Populus and Ulmus
Average carbon stock in belowground woody biomass	Modeled with limited local data	• Field data on root biomass needed for major species
Average biomass of dead wood	Largely unavailable	• Field surveys needed
Litter	Not systematically measured	• Field surveys needed
Soil Organic Carbon (SOC)	Very limited, not included in NFI	• Baseline sampling and lab analysis needed in key regions

"Our research has confirmed the significant carbon potential of Mongolia's BTNM.

To realize this potential, Mongolia will need to strengthen forest carbon data and develop tools for accurate, cost-efficient measurement.

Our upcoming work will focus on building such tools, and their success will rely on your continued support and collaboration."

Thank You

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