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2.1.

HISTORY OF DEVELOPING THE METHODOLOGY FOR ASSESSING RANGELAND QUALITY AND CONDITION

Elaboration of the methodology for assessing Mongolian rangeland condition and quality has evolved over time. It began with a traditional approach that assessed rangelands mainly through carrying capacity, annual forage yield or general field inspections, and gradually developed into a more comprehensive assessment system that requires long-term monitoring over the ecological potential, states and transitions occurred, and natural potentials for recovery. This evolution is directly linked to the need for better understanding the changes in rangeland ecosystems, identifying degradation risks more accurately, and planning the sustainable use, protection and restoration measures.

In the early stages, rangeland assessment was relatively fragmented. It relied mainly on current vegetation yield, vegetation cover, livestock numbers and general carrying capacity estimates. Such assessments were limited in their ability to capture the dynamic nature of rangeland conditions, including long-term changes in ecosystem structure, recovery and the impacts of use. As a result, rangeland degradation was often interpreted through simplified measures, such as whether carrying capacity had been exceeded or whether vegetation cover had declined. Over time, it became increasingly clear that this approach was not sufficient to explain the real condition of rangelands, especially in Mongolia's diverse natural zones, where precipitation variability, drought, 'dzud' (explanation: Dzud is the Mongolian term for an exceptionally severe winter characterized by heavy snowfall, extreme cold and ice formation that prevents livestock from accessing forage) and other risks strongly influence ecosystem dynamics.

At a later stage, new internationally renowned concepts in rangeland ecology began to be introduced into rangeland assessment in Mongolia. These included ecological potential, State-and-Transition Models and management approaches based on recovery potential. In 2018 the first national report highlighted this shift and reviewed rangeland condition assessment, monitoring and management methodology at the national level. The structure of that report reflected the transition towards linking quantitative monitoring data with ecological sites and their potential concept, vegetation states and community phases, distinguishing between levels of degradation and recovery potential, and connecting new management approaches with practical evidence.

A major methodological milestone was the introduction of rangeland photo monitoring at the national level. In 2015, Order No. A/105 of the Director of the Agency for Land Administration and Management, Geodesy and Cartography approved the



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“Procedure for Assessing Rangeland Change through Photo Monitoring” and the “Methodological Guideline for Conducting Photo Monitoring on Rangelands.” This established the legal and methodological basis for the standardized application of photo monitoring. As a result, a national system was created to observe rangeland change at fixed monitoring points and at a fixed time each year, and to assess annual results against reference levels. This marked a transition from one-time field observation towards a scientifically grounded system based on multi-year historical data.

Since 2015, the photo monitoring network has expanded, making it possible to regularly monitor rangeland condition at national, aimag and soum levels. At present, regular assessments are conducted at more than 5,100 monitoring points across the country to evaluate the impacts of rangeland use, condition and change. This expansion is not only an increase in data volume. It also strengthens representativeness, spatial coverage and the basis for comparison. At the same time, the practical use of monitoring results has become clearer, including their application in soum land management plans, rangeland use agreements, the selection of priority restoration areas and policy decision-making.



*The evaluation of
rangelands has
transitioned from a
singular observation
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based system that relies on
multi-year historical data.*



Another important stage in the development of the methodology has been the improvement of the logic used to process and interpret photo monitoring information. In this regard, photo monitoring data are processed using the “SamplePoint” software. Vegetation is classified by functional group, and the results are linked to the “State-and-Transition Models for Mongolia’s Rangelands.” Annual photo monitoring results are then compared with reference levels for the relevant rangeland type. In other words, the methodology has advanced from describing rangeland condition only through numerical indicators to interpreting it in relation to ecological potential, natural capacity and the direction of change. This is particularly important for management, as it helps answer not only “what is the condition of the rangeland?” but also “why has it reached this condition?” and “what management measures are needed next?”

The most recent stage of methodological development is characterized by institutionalization, digital transformation and the combined use of different technologies. The “Procedure for State Verification of Land Condition and Quality,” approved by Government Resolution No. 92 of 2024, allows the combined use of photo monitoring results and remote sensing methods and technologies in the assessment of rangeland condition. This represents an important step in formally linking photo monitoring with the state land quality verification system. In 2025, new methodologies were also approved for establishing new monitoring points, mapping the representative area of photo monitoring points, identifying land degradation, and improving land condition and quality. These developments have further strengthened methodological precision and expanded the practical application of the system.

At the same time, digital solutions such as the mobile application named “Belcheer” and statistical dashboards have been developed. These tools have made the collection, transmission and use of photo monitoring data faster, more integrated and more accessible to users. The “Belcheer” application, introduced in 2025, allows users to locate monitoring points more easily, complete paper-based forms electronically, transmit photos directly to the server and work in areas without mobile network coverage. This represents a new technological stage in the methodology. It not only simplifies data collection, but also improves data quality, control and accessibility, enabling local managers, herders and decision-makers to use the results more directly.

2.2.

METHODOLOGICAL BASIS OF RANGELAND PHOTO MONITORING

To regularly monitor rangeland condition and the impacts of use, the “Procedure for Assessing Rangeland Change through Photo Monitoring” and the “Methodological Guideline for Conducting Photo Monitoring on Rangelands” were approved by Order No. A/105 of the Director of the GALAGC in 2015. This established the legal and methodological foundation for a national system that assesses rangeland change at fixed points, at fixed times and using a standardized methodology.

The main advantage of photo monitoring is that it allows changes in land surface cover, vegetation cover, biomass and plant community composition to be compared at the same point over many years. It provides essential information for identifying rangeland degradation, recovery, grazing pressure, and changes in vegetation structure and composition over both short and long time periods.



When the photo monitoring assessment was initially launched in 2015, it encompassed over 2,600 sites across the country. Currently, the database includes a total of 5,322 sites, and since 2020, surveys and analyses have been systematically carried out at more than 5,100 sites. This network expansion has enhanced the ability to evaluate rangeland conditions comparatively at national, regional, aimag, and soum levels.



FIGURE 1. Compilation of Land Monitoring Procedures, Methodologies and Guidelines

2.3.

FIELD SURVEY METHODS

Rangeland photo monitoring field surveys are conducted annually during the peak growing season, at a relatively consistent time of year. During the field survey, information is collected on the general surroundings of the monitoring point, land surface cover, vegetation composition, biomass and related descriptive observations.

THE FIELD SURVEY IS CARRIED OUT THROUGH THE FOLLOWING MAIN STEPS:

- ▶ **First**, general landscape photographs are taken. Standing at the central point of the marked monitoring plot, photographs are taken in four directions. These photographs are used to compare the general condition of the site in subsequent years, including land-use patterns, water sources, roads, settlements, livestock concentration and other surrounding changes. When taking photographs, a 50-metre measuring tape is placed and fixed in each of the four directions from a point five metres from the centre. The information board for the monitoring point is positioned so that its markings are clearly visible in the lower centre of the photograph.
- ▶ **Second**, land surface cover photographs are taken. A 50-metre measuring tape is placed in a designated direction from the central point, and photographs of surface cover are taken vertically from above every five metres along the line. These images provide the main data for determining the percentage of vegetation cover, bare ground, stones, litter and other surface cover components.
- ▶ **Third**, the monitoring point information form is completed. After the landscape and surface cover photographs are taken, information on the location, rangeland type, form of use, general vegetation condition, observed changes and livestock impacts is recorded using a standard form.

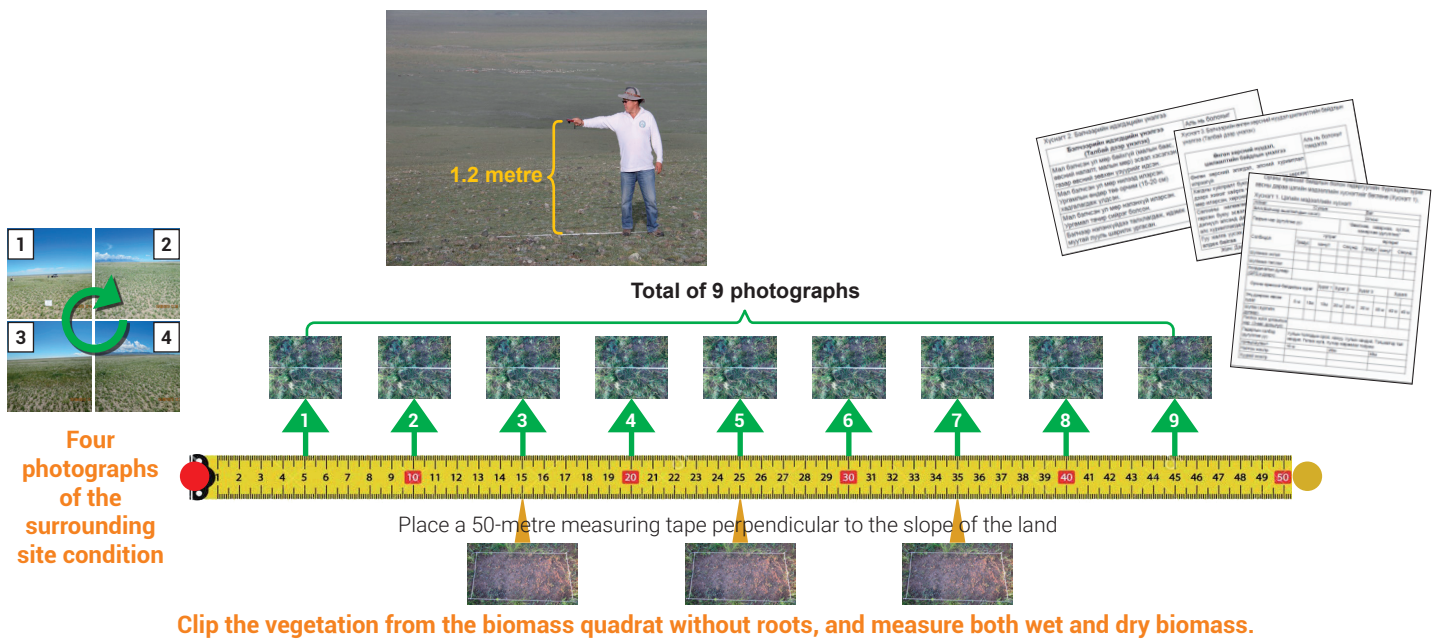


FIGURE 2. Field Survey Scheme for Photo Monitoring

- **Fourth,** biomass is measured. To determine rangeland biomass, a one-square-metre quadrat is selected, and the grass and vegetation within that area are clipped close to the ground surface. After drying the sample, the dry weight is measured and converted to a per-hectare value by multiplying it by 10,000 square metres. This provides the biomass estimate for the monitoring point.



FIGURE 3. Land Officers In the Field Survey

2.4.

METHODOLOGY FOR PROCESSING RANGELAND PHOTO MONITORING DATA

The SamplePoint software is used to process rangeland photo monitoring data. The results are linked to the "State-and-Transition Models for Rangeland Condition and Quality Change in Mongolia." Annual photo monitoring results are then compared with the reference condition of the corresponding rangeland type to determine change.

Surface cover photographs stored for each monitoring point are processed in the "Sample Point" software. The total percentage of vegetation cover is classified by functional group and calculated. The photograph taken at the monitoring point is uploaded into the software, and 100 point-intercepts are used for the analysis. The resulting data are then processed to estimate cover by category.

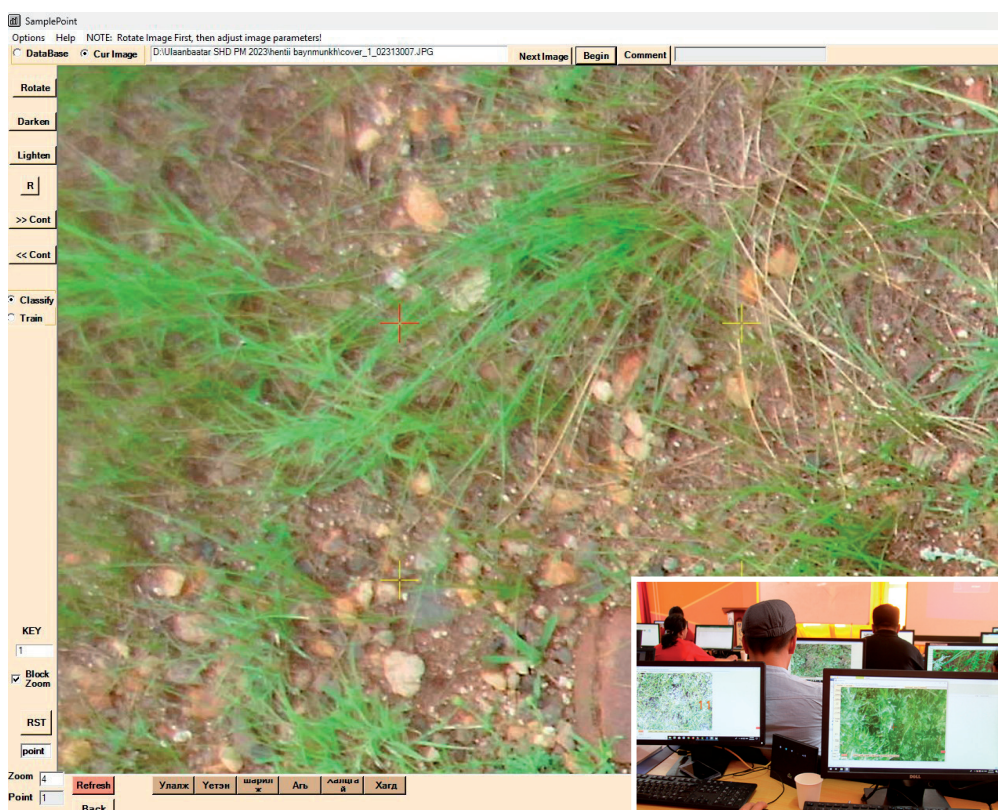
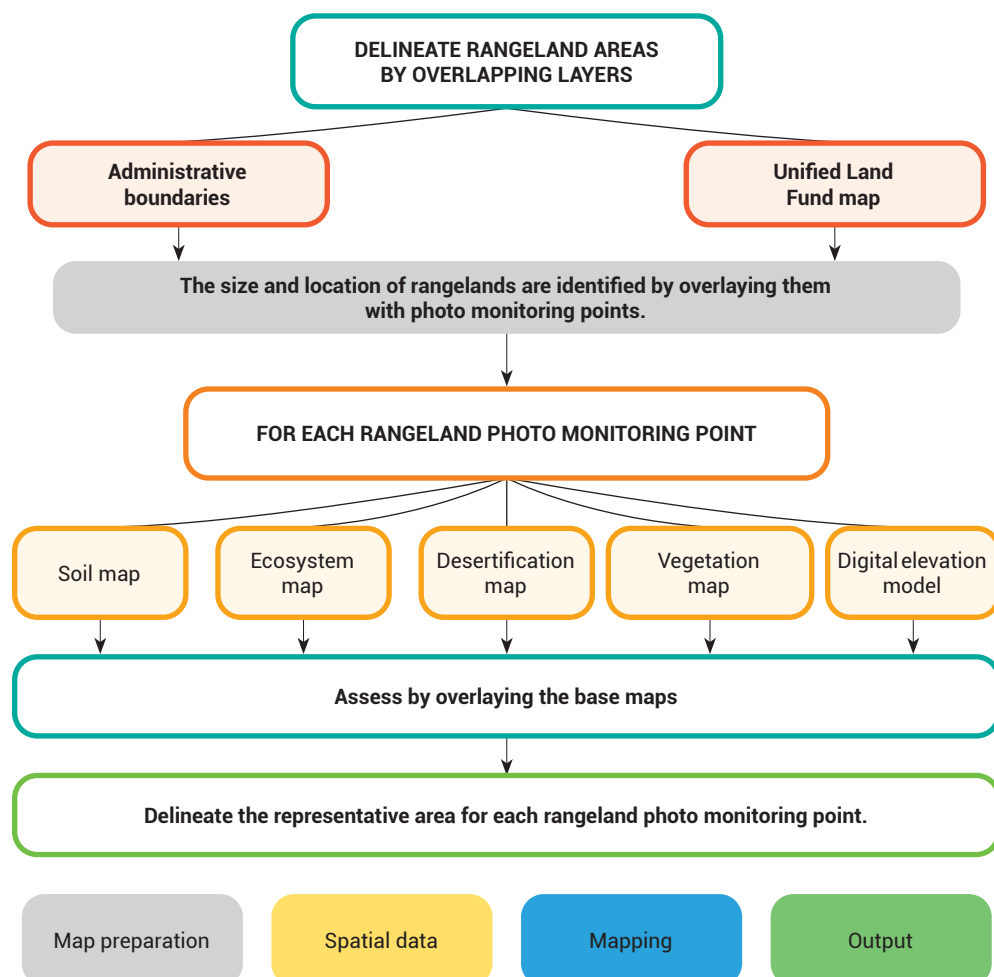


FIGURE 4. The Use of "SamplePoint"

In 2024–2025, work was carried out nationwide in stages to establish rangeland photo monitoring points and map the areas represented by those points in accordance with the “Methodological Guideline for Mapping the Representative Area of Rangeland Photo Monitoring Points.” In cooperation with the FAO-implemented “Promoting Dryland Sustainable Landscapes and Biodiversity Conservation in the Eastern Steppe of Mongolia” project, the representative areas of 168 rangeland photo monitoring points covering 6,341,514 hectares in nine soums of Dornod, Khentii and Sukhbaatar aimags were mapped in 2024. In cooperation with the Capital City Land Management Office, the representative areas of 42 rangeland monitoring points covering 98,764 hectares in six districts of the capital city were also mapped as an initial pilot exercise to test the methodology.

With the support of the “Promoting Dryland Sustainable Landscapes and Biodiversity Conservation in the Eastern Steppe of Mongolia” project, the representative areas of photo monitoring points in other aimags and soums were also mapped in detail nationwide in 2025 and entered into the database of the Land Monitoring Digital System. Mapping the representative areas of photo monitoring points and integrating them into the Land Monitoring Digital System database has made it possible to calculate rangeland carrying capacity more accurately and to plan and implement rangeland protection, sustainable use and restoration measures with greater precision.

DIAGRAM 1. Scheme for Mapping the Representative Area of Rangeland Photo Monitoring Points



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The yearly outcomes of photo monitoring are associated with the Rangeland state-and-transition model and evaluated against the reference condition of the respective rangeland type.

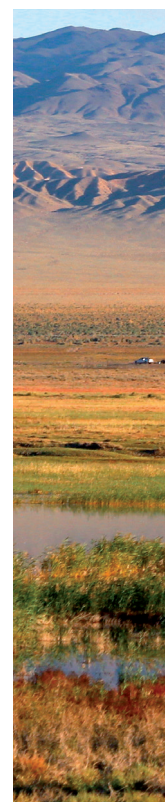
2.5.

RANGELAND STATE-AND-TRANSITION MODELS

Rangeland ecosystems are dynamic systems that are constantly changing under the influence of natural factors and human activities. In the past, rangeland degradation was often explained mainly through the theory of linear succession. However, studies in many countries have shown that changes in rangeland ecosystems do not always follow a linear pathway. Instead, once certain thresholds are crossed, rangelands may shift into a different state³.

Based on this understanding, State-and-Transition Models have become widely used in rangeland ecological research. These models describe the possible states of a rangeland ecosystem and the mechanisms through which transitions occur between them. A state refers to a relatively stable unit characterized by vegetation composition and structure, soil conditions and ecosystem functions. A transition refers to the process through which an ecosystem shifts from one state to another under the influence of factors such as natural disasters, climate variability and grazing pressure⁴.

This model provides a more realistic explanation of ecosystem change and is highly important for rangeland management decision-making. For example, it is used to identify which states are ecologically stable and which states represent stages of degradation, and to plan the necessary restoration measures⁵.



³ L. Gillson and M. T. Hoffman, "Rangeland ecology in a changing world," *Science* (1979), vol. 315, no. 5808, pp. 53–54, 2007.

⁴ T. K. Stringham, P. Novak-Echenique, D. K. Snyder, S. Peterson, and K. A. Snyder, "Disturbance response grouping of ecological sites increases utility of ecological sites and state-and-transition models for landscape scale planning in the Great Basin," *Rangelands*, vol. 38, no. 6, pp. 371–378, 2016.

⁵ S. K. Guttikunda, S. Lodoysamba, B. Bulgansaikhan, and B. Dashdondog, "Particulate pollution in Ulaanbaatar, Mongolia," *Air Qual. Atmos. Health*, vol. 6, no. 3, pp. 589–601, 2013.



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When planning rangeland use and protection management, as well as implementing measures included in management plans, it is essential to understand how a given rangeland may change as a result of use, what risks of degradation and erosion may arise from inappropriate use, and what potential exists for recovery when use is properly adjusted. The State-and-Transition Models for Mongolia's rangelands describe and model, through quantitative indicators, the natural and altered states of the country's dominant rangeland types and the transitions between them. In addition to identifying the key plant species that indicate each state and providing information on potential productivity, the models also offer recommendations on appropriate grazing regimes and management technologies. This classification makes it possible to interpret rangeland assessment and monitoring results in accordance with the ecological characteristics of each region. It also provides a scientific basis for planning rangeland use policy and management at the regional level. Research and relevant institutions have confirmed and formalized that the State-and-Transition Models for Dominant Rangeland Types of Mongolia can be fully used for processing rangeland monitoring data from the national meteorological and land administration monitoring networks, assessing rangeland condition and recovery potential, and planning, implementing and monitoring the effectiveness of soum-level rangeland management.



The state-and-transition model for rangelands delineates the various states of a rangeland ecosystem along with the processes that facilitate transitions among these states

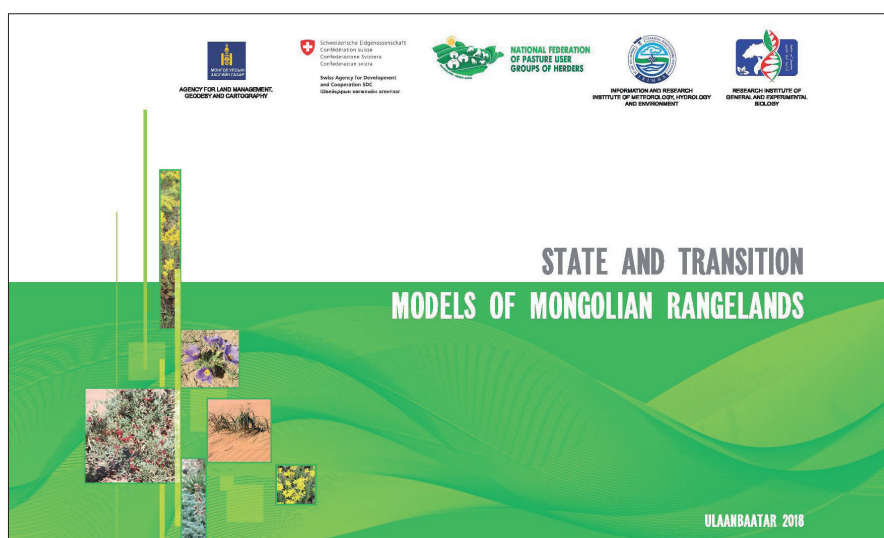


FIGURE 5.
State-and-
Transition Models
for Dominant
Rangeland Types of
Mongolia

In Mongolia's dry and harsh climatic zones, where ecosystem resilience varies, fertile soil layers are thin, and moisture availability is limited, this science-based methodology is well suited to⁶

- ✓ distinguishing degradation from temporary fluctuations in rangeland condition;
- ✓ identifying realistic recovery potential;
- ✓ directing policy and investment more effectively; and
- ✓ protecting ecosystem resilience.

DIAGRAM 2. State and Transition Model of a Dry Steppe Rangeland Dominated by Mixed Forbs, Cleistogenes and *Stipa krylovii* on Sandy Loam Soils

STATE	DOMINANT SPECIES	KEY CRITERIA	
I 1. Reference state I 1.1 <i>Stipa grandis</i> – <i>Elymus chinensis</i> –forbs community	Dominant: <i>Stipa grandis</i> Sub-dominant: <i>Elymus chinensis</i> , <i>Cleistogenes squarrosa</i> , <i>Potentilla acaetifolia</i> , <i>Serratula centauroides</i> , <i>Allium senescens</i> , <i>Haplophyllum dahuricum</i>	<i>Stipa grandis</i> >25% <i>Elymus chinensis</i> >20% Forbs >20%	<i>Stipa grandis</i> >35% <i>Elymus chinensis</i> >30% Forbs >25%
II 2. Forb decreased state II 2.1 <i>Stipa grandis</i> – <i>Elymus chinensis</i> community 2.2 <i>Stipa grandis</i> – <i>Cleistogenes squarrosa</i> community	Dominant: <i>Stipa grandis</i> Sub-dominant: <i>Cleistogenes squarrosa</i> , <i>Elymus chinensis</i> , <i>Serratula centauroides</i>	<i>Stipa grandis</i> >25% <i>Elymus chinensis</i> >15% <i>Cleistogenes squarrosa</i> >15%	<i>Stipa grandis</i> >35% <i>Elymus chinensis</i> >20% <i>Cleistogenes squarrosa</i> >20%
III 3. <i>Stipa grandis</i> decreased state III 3.1 Grass– <i>Artemisia frigida</i> – <i>Stipa grandis</i> community	Dominant: <i>Cleistogenes squarrosa</i> , <i>Elymus chinensis</i> Sub-dominant: <i>Artemisia frigida</i> , <i>Stipa grandis</i> , <i>Carex duriuscula</i>	Grass >20% <i>Artemisia frigida</i> >20% <i>Stipa grandis</i> <15%	Grass >30% <i>Artemisia frigida</i> >40% <i>Stipa grandis</i> <20%
IV 4. Degraded state IV 4.1 Degradation indicator species dominated community 4.2 <i>Ephedra</i> spp. with annuals community	Dominant: <i>Artemisia frigida</i> , <i>Ephedra sinica</i> , <i>Kochia prostrata</i> , <i>Artemisia adamsii</i> , <i>Carex duriuscula</i> , <i>Potentilla bifurca</i> , <i>Convolvulus ammannii</i> , <i>Chenopodium viride</i> , <i>Chenopodium acuminatum</i> , <i>Salsola collina</i>	Degradation indicator species	

⁶ D. D. Briske, S. D. Fuhlendorf, and F. E. Smeins, "Vegetation dynamics on rangelands: a critique of the current paradigms," *Journal of Applied Ecology*, pp. 601–614, 2003.

By integrating the dominant patterns of Mongolia’s rangeland states, transitions between plant communities, and the factors driving those transitions into a unified model, it becomes possible to assess in greater detail the current functioning of rangeland ecosystems and their short- and long-term changes.

Based on the quantitative and qualitative indicators that define the reference and altered states in the State-and-Transition Models for Dominant Rangeland Types of Mongolia—including key indicator plant species, their cover and biomass—the condition of a given rangeland and the corresponding plant community phase can be determined. For example, the mixed forb–Festuca–mountain steppe rangeland on stony mountain slopes, ridges and rocky hillsides, which is common in the forest steppe zone, may occur in four states: reference, sub-dominant altered, dominant species altered, and degraded. Based on threshold values such as the cover of key indicator species or the boundaries between community phases, monitoring points can be assessed according to a specific state and community phase. Each state and community phase is then evaluated, in accordance with the model, in terms of its degree of degradation and level of recovery potential⁷.

The State-and-Transition Model provides detailed information not only on the current condition and productivity of rangelands, but also on the risk of degradation and the possible recovery pathways of degraded rangelands.

FIGURE 6. Example of the Rangeland Transition (Dry Steppe Rangeland Dominated by Mixed Forbs, Cleistogenes spp. and Stipa spp. on Sandy Loam Plains)



⁷ S. Sainnemekh, I. C. Barrio, B. Densambuu, B. Bestelmeyer, and Á. L. Aradóttir, “Rangeland degradation in Mongolia: A systematic review of the evidence,” *J. Arid Environ.*, vol. 196, p. 104654, 2022.

2.6.

RANGELAND ECOLOGICAL SITE GROUPS

Mongolia's rangelands consist of ecologically diverse zones that differ in climate, topography, soil and vegetation composition. When used appropriately, they have the ecosystem capacity to recover naturally. Taking this into account, Mongolia's rangelands have been classified into 22 ecological site groups. Ecological site groups refers to the potential vegetation composition, structure and productivity of a given area under its natural environmental conditions⁸.

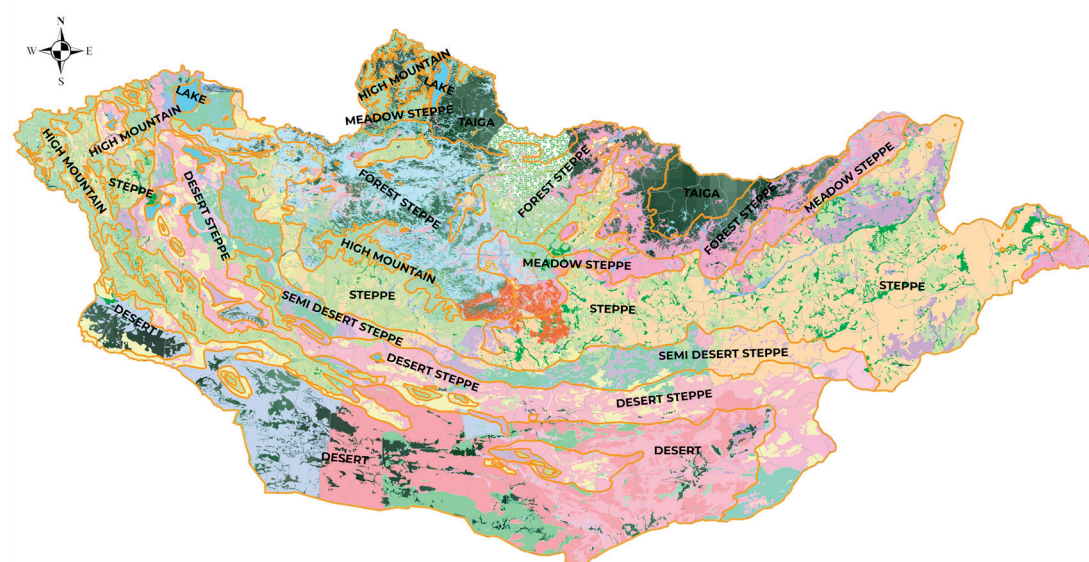
These 22 ecological site groups reflect the differences among Mongolia's main ecological zones, including the high mountain, forest steppe, steppe, dry steppe, desert steppe and desert zones. For each group, a State-and-Transition Model has been developed to define the reference or potential state of the ecosystem, the stages of degradation, and the transitions between them⁹.

The 22 ecological site groups of Mongolia's rangelands are generally defined and applied on the basis of ecological zone, dominant vegetation, and soil and climatic conditions.



Ecological potential refers to the possible composition, structure, and productivity of vegetation at a site when it is in its natural state.

MAP 1. Rangeland Ecological Site Groups Distribution



⁸ B. Densambuu, S. Sainnemekh, B. Bestelmeyer, and U. Budbaatar, "National report on the rangeland health of Mongolia: Second Assessment," Green Gold-Animal health project, SDC, vol. 62, 2018.

⁹ S. Sainnemekh, "Rangeland degradation in Mongolia: A systematic review of the evidence".

TABLE 1. Ecological Site Groups of Mongolia's Rangelands

No.	Natural zone	Landform	Ecological Site Groups
1	Forest steppe	Mountain and rocky hilltops and slopes	Stony mixed forb–Festuca mountain steppe rangeland on mountain slopes and rocky hilltops and slopes with stony soils
2		Mountain and rocky hilltops and slopes	Mixed forb–small bunchgrass mountain steppe rangeland on mountain slopes and foothills with loamy soils
3		Mountain slopes and valleys	Carex–grass–rich mixed forb meadow steppe rangeland with shrub cinquefoil on mountain slopes with loamy soils
4		Mountain slopes and valleys	Mixed forb–Siberian needlegrass meadow steppe rangeland on mountain foothills and valleys with loamy soils
5		River floodplain	Mixed forb–grass floodplain meadow range-land
6	Steppe	Mountain and hilltops and slopes with stony soils	Stony mixed forb–small bunchgrass–Krylov needlegrass rangeland
7		Mountain slopes and rocky hills with light loamy soils	Grass–Krylov needlegrass rangeland on mountain slopes and rocky hills with light loamy soils
8		Undulating plains with sandy loam soils	Grass–Krylov needlegrass rangeland with Caragana on sandy loam undulating plains
9		Level plains with sandy loam soils	Mixed forb–Cleistogenes–large needlegrass rangeland
10		Depressions and low-lands with shallow groundwater	Achnatherum splendens saline meadow rangeland
11	Desert steppe	Low mountains and hills with gravelly-stony soils	Semi-shrub–feather needlegrass desert steppe rangeland
12		Plains with sandy loam soils	Shrub–wild onion–grass–feather need-legrass desert steppe rangeland
13		Plains with saline clayey soils	Wild onion–semi-shrub–feather needlegrass desert steppe rangeland
14		Depressions and low-lands with alkaline and saline soils	Yellow and red Anabasis–Achnatherum splendens saline meadow rangeland
15		Semi-fixed sands	Psammochloa villosa rangeland on semi-fixed sands
16	Desert	Low mountains and hills with gravelly-stony soils	Anabasis brevifolia–Salsola laricifolia desert rangeland
17		Gravelly-stony plains	Semi-shrub desert rangeland
18		Fixed and semi-fixed sands	Tall Haloxylon ammodendron desert range-land
19		Saline depressions	Haloxylon ammodendron–Nitraria desert rangeland
20	High mountain	High mountain summits and ridges	Small bunchgrass–cold-resistant mixed forb high mountain steppe rangeland
21		Dry conditions in the high mountain belt	Cold-resistant mixed forb–Festuca high mountain steppe rangeland
22		Moist conditions in the high mountain belt	Shrub-associated dry-mesic to mesic mixed forb–large bunchgrass high mountain mead-ow rangeland

2.7.

ASSESSING RANGELAND CONDITION BASED ON RECOVERY CLASS

Assessing rangeland condition not only on the basis of current vegetation cover and forage biomass, but also in relation to ecosystem resilience and recovery potential, is an important direction in modern rangeland ecology¹⁰.

According to the definition of the Intergovernmental Panel on Climate Change, recovery refers to the capacity of an ecosystem to maintain its basic structure and functions and to restore after being affected by external pressures such as drought, dzud or overuse¹¹.

The FAO guidelines on rangeland management recommend the use of State-and-Transition Models in degradation assessment, as these models make it possible to identify recovery thresholds¹².

Therefore, when assessing rangeland condition, it is necessary to consider several factors in an integrated manner: (1) current vegetation structure, (2) soil quality, (3) ecosystem functioning, (4) level of degradation and (5) recovery potential¹³.

When assessing the impacts of rangeland use, indicators such as vegetation cover, biomass, species composition, the share of dominant plant species and the distance between plant bases are used. Among these indicators, vegetation cover and biomass reflect short-term changes that are directly influenced by the climatic conditions of a given year. In contrast, species composition, the share of dominant species and the distance between plant bases are more useful for monitoring long-term changes in rangelands¹⁴.

In terms of recovery potential, not all rangelands are the same. Assessment should take into account the natural baseline conditions of each area, including region, soil type, moisture regime, climate and plant community. This approach and methodology are consistent with the concept and model of ecological site potential developed by the United States Department of Agriculture.

When the condition of a rangeland ecosystem crosses a certain threshold, its capacity for natural recovery declines sharply. For example, recovery may slow down, and in some cases external support such as reseeding, resting or protection from use may become necessary, when:

¹⁰ C. S. Holling, "Resilience and stability of ecological systems," 1973, International Institute for Applied Systems Analysis Laxenburg.

¹¹ J. Sharma and N. H. Ravindranath, "Applying IPCC 2014 framework for hazard-specific vulnerability assessment under climate change," *Environ. Res. Commun.*, vol. 1, no. 5, p. 051004, 2019.

¹² L. Odom et al., "Assessing and managing for soil health on rangelands and pasture lands," 2017, The Foundation for Food and Agriculture Research. <https://foundationfar.org>

¹³ J. E. Herrick, P. Shaver, D. A. Pyke, M. Pellant, D. Toledo, and N. Lepak, "A strategy for defining the reference for land health and degradation assessments," *Ecol. Indic.*, vol. 97, pp. 225–230, 2019.

¹⁴ M. H. Friedel, "Range condition assessment and the concept of thresholds: a viewpoint," 1991.

- ✓ perennial species and key species of the main plant community continue to decline or disappear;
- ✓ the proportion of bare ground increases excessively;
- ✓ soil erosion and degradation intensify.

Depending on the condition of a given rangeland ecosystem, its recovery potential may vary, as shown below.

TABLE 2. Rangeland Recovery Class

Recovery Class	Rangeland Condition	Description	Recovery Potential
I	Retains its natural reference condition	Perennial key plant species are maintained	High
II	Slightly changed from its natural reference condition	Perennial plants have become sparse	Moderate
III	Considerably changed in terms of vegetation structure, composition and productivity	Bare ground has increased	Limited
IV	Strongly degraded, with native plant species lost and increaser species expanded	Key plant species have declined or disappeared	Very low
V	Very strongly changed	The ecosystem has shifted to a new state	Natural recovery is not possible

The development of the Rangeland Recovery Classification suited to Mongolia's conditions was based on knowledge and assumptions related to the reference condition, or ecological site potential, of rangelands that is, the relatively undisturbed state of a plant community expected for a given site, and the possibility of improving rangeland condition through changes in use and management.

In essence, the Rangeland Recovery Classification is similar to the classification of overgrazing or degradation levels that has long been used in Mongolia. Its main distinction is that it is based on quantitatively determined recovery potential and information on the ecological site groups. To assess rangelands using this classification, information such as vegetation cover and surface soil condition needs to be compared with the ecological site potential of the rangeland¹⁵.

Mongolia's rangelands can be classified into the following five levels according to their recovery potential.



Once a rangeland ecosystem surpasses a specific threshold, its ability to recover naturally diminishes significantly.

¹⁵ S. S. B. B. U. and E. B. D. Densambuu, National report on the rangeland health of Mongolia, vol. I. Ulaanbaatar : TEPE LLC, 2018.

Mongolia's rangelands can be classified into the following five levels according to their recovery potential.

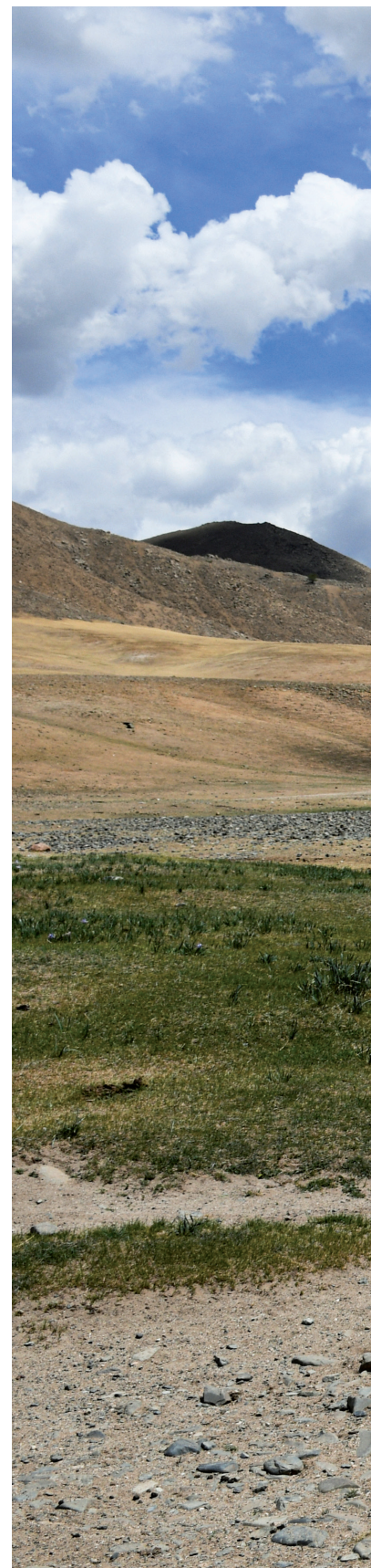
► **Level I:** The plant community is very close to the reference condition, meaning that it is essentially not degraded, although the composition of the community may have changed slightly. A transition from the current condition back to the reference condition would require one to three growing seasons. Grazing intensity is generally aligned with available forage resources, or carrying capacity, although seasonal rotational use is still required.

► **Level II:** The plant community has changed slightly in a negative direction. If precipitation conditions are favourable, or if the form of use is properly adjusted through reduced grazing pressure, seasonal rotation or temporary resting, recovery is possible within a short period, usually three to five growing seasons. The changes have not yet reached a level that would seriously affect long-term forage availability or other ecosystem services.

► **Level III:** The plant community has changed considerably in terms of species composition. However, if precipitation conditions are favourable, or if grazing methods and management arrangements are adjusted sufficiently through reduced grazing pressure, seasonal rotation or temporary resting, vegetation can recover within five to ten growing seasons. Some important ecosystem services have been lost as a result of these changes, clearly linked to inappropriate human activities, but recovery remains possible over a defined period of time.

► **Level IV:** Dominant plant species have disappeared, harmful or undesirable species have expanded strongly, and hydrological conditions may have changed. As a result, the likelihood of natural recovery is very low. The degradation has crossed the ecological site threshold, although recovery may still be possible through intensive interventions such as reseedling, control of increaser species and restoration of the water regime. Core ecosystem services have been largely lost, and substantial financial and labour inputs would be required for restoration.

► **Level V:** The plant community has changed severely towards a degraded state due to loss of topsoil, intensive erosion and salinization, and key plant species have disappeared. Plant–soil interactions and soil properties have been substantially degraded and altered, creating conditions that allow the degraded state to persist. Core ecosystem services have been lost completely. Recovery potential is essentially absent, and the area may be considered to have undergone true desertification.





©Photo by: Gerlee.P, WCS-Mongolia

2.8.

THE NATIONAL MONITORING NETWORK AND ITS SIGNIFICANCE

In accordance with the Law of Mongolia on Land, a land monitoring network has been established to determine the condition and quality of land across all categories of the national land fund and to monitor and assess changes at the national level. To support land protection and restoration, incorporate relevant measures into land management plans, and monitor their implementation, the land monitoring digital system has been developed and its database established.

Work is ongoing to expand the land monitoring digital system, establish a national land monitoring network covering all categories of the national land fund, improve inter-sectoral information exchange, create a web-based shared database, and fully digitalize land protection and restoration activities, including their implementation, by combining them with remote sensing methods and technologies.

Over the past more than 30 years, important progress has been made through research conducted by universities, scientific institutions, and international projects and programmes on rangeland degradation and the impacts of use, as well as through efforts to strengthen the national monitoring network for assessing the impacts of rangeland use. The expansion of the national monitoring network has created the conditions to identify the location and level of rangeland degradation, as well as opportunities for restoration and improvement, in relation to regional characteristics.

Strengthening the national land monitoring network will make it possible to:

- ✓ assess degradation levels by region;
- ✓ monitor vegetation composition and soil indicators;
- ✓ identify opportunities and limits for restoration and improvement;
- ✓ carry out planning based on carrying capacity;
- ✓ monitor the implementation and effectiveness of rangeland use plans;
- ✓ introduce unified principles, models and methodologies for processing results; and
- ✓ train and build the capacity of relevant specialists.

These efforts will make an important contribution to strengthening the sustainable use of rangelands.

FIGURE 7. Schematic Representation of The Current Land Monitoring Network¹⁶



LAND MONITORING NETWORK

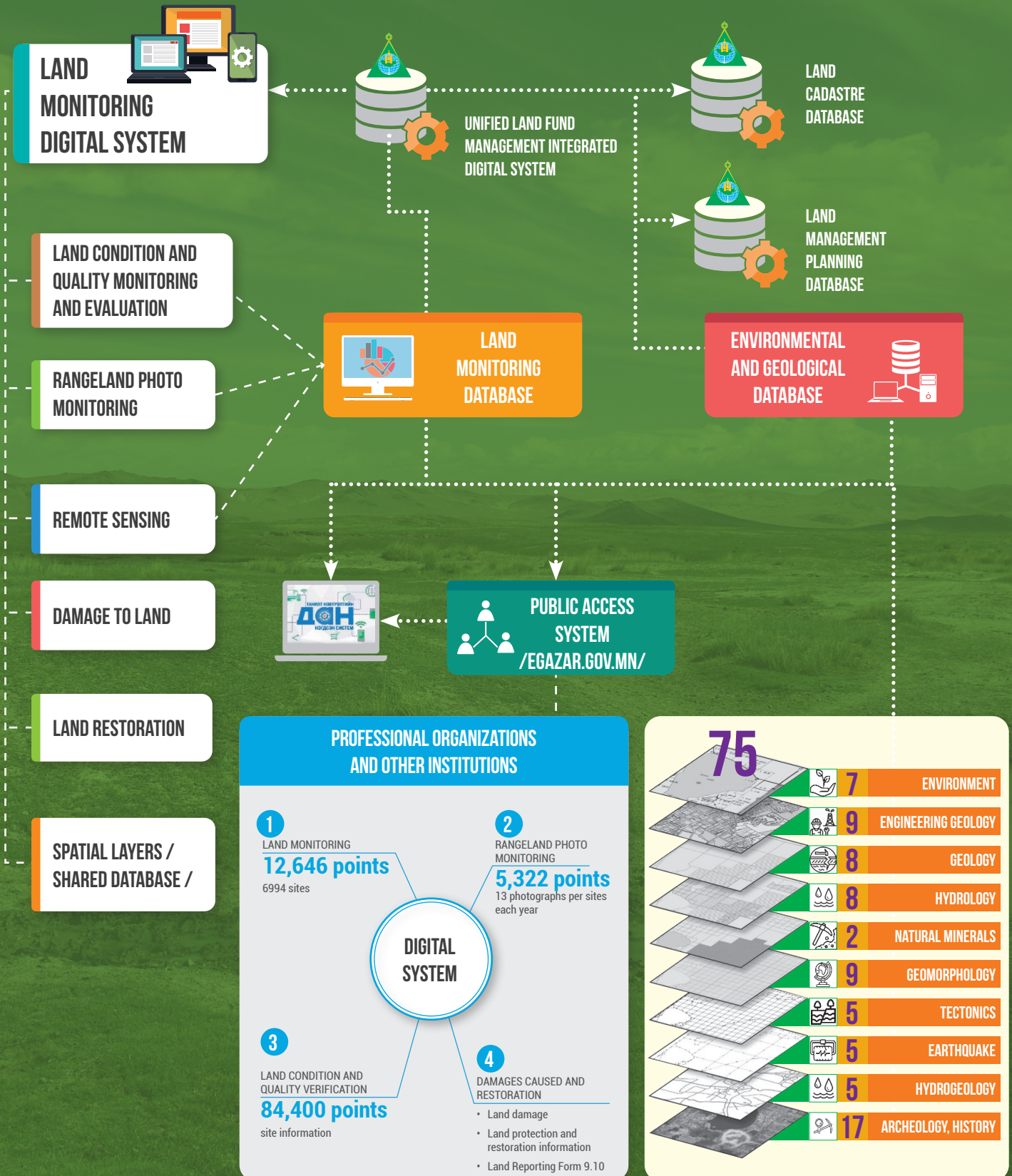
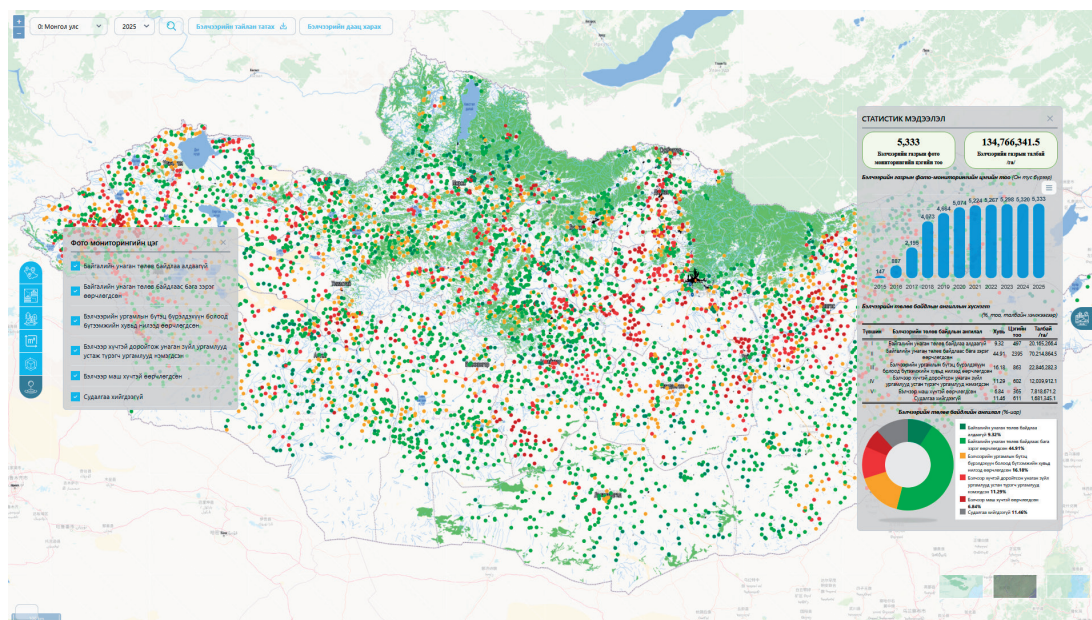


FIGURE 8. Rangeland Photo Monitoring Digital System ¹⁷



● ● ●

The incorporation of rangeland condition change in NDC 3.0 as a target associated with greenhouse gas emissions and removals enhances the significance and future potential of rangeland photo monitoring.

Strengthening the national monitoring network is helping to establish a unified basis for assessing degradation levels by region, monitoring vegetation and soil indicators, identifying opportunities and limits for restoration, planning based on carrying capacity, and monitoring the effectiveness of rangeland management.

¹⁷ www.egazar.gov.mn

2.9.

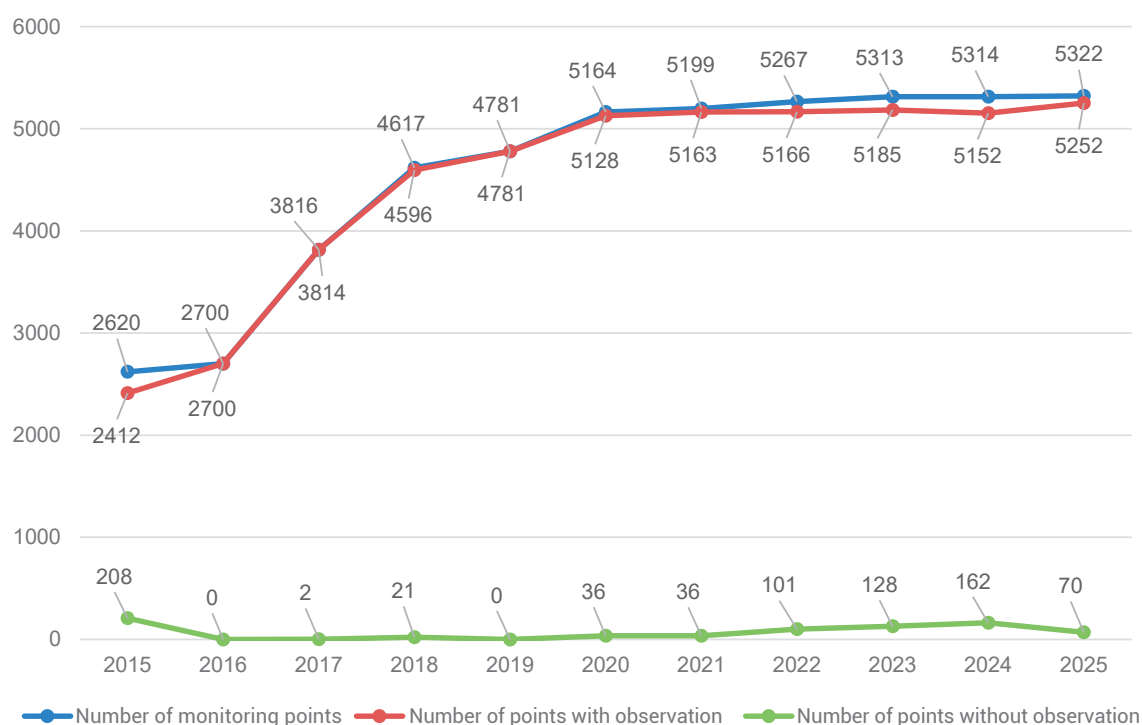
RANGELAND PHOTO MONITORING DATABASE

In accordance with the Law on Land, the GALAGC is working with relevant institutions to establish a permanent monitoring network covering the entire territory of Mongolia. The purpose of this network is to determine land condition and quality, identify changes, monitor and assess those changes, and establish a system for the efficient, appropriate use, protection and restoration of land.



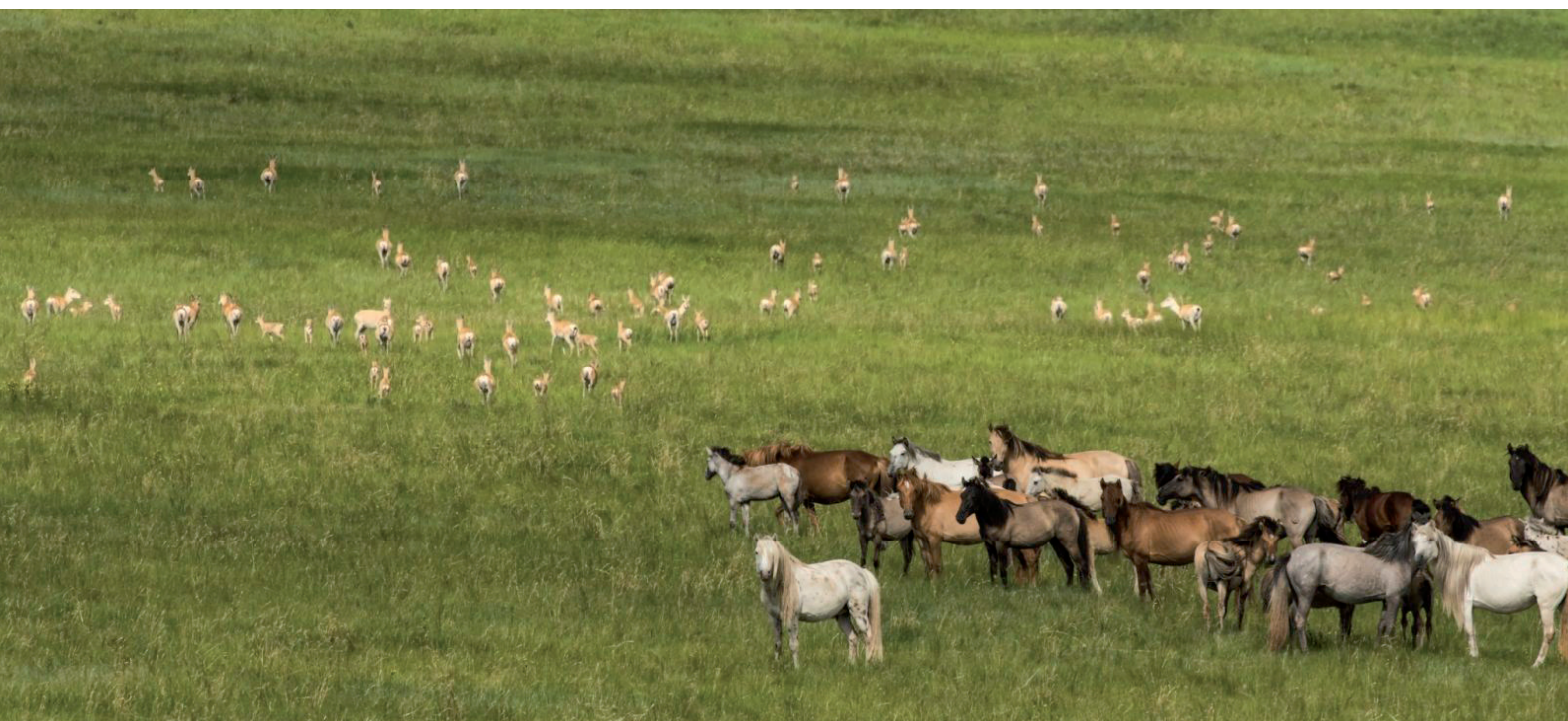
The introduction of rangeland photo monitoring assessment in 2015 saw the establishment of over 2,600 points across the nation. Currently, the database contains a total of 5,322 registered points, with surveys and analyses being conducted regularly at more than 5,100 points since 2020.

DIAGRAM 3. Number of Photo Monitoring Points



2.10.

QUALITY CONTROL AND DATA VALIDATION



The reliability of rangeland photo monitoring assessments depends not only on field measurements, but also directly on data quality control. Although relevant officials had previously reviewed the data to some extent during photo monitoring assessments, a comprehensive and systematic data quality check had not been carried out before.

In 2025, the GALAGC, in cooperation with the STREAM+ Sustainable Resilient Ecosystem and Agriculture Management in Mongolia project, conducted a quality review of photo monitoring data for 2020–2024. As a result, data and information from monitoring points with identified errors and inconsistencies were checked one by one against the original photographs from the relevant period and corrected. In particular:

- ✓ in 2020, among data from 5,383 points, 515 cover errors, 235 biomass errors and 37 recovery class errors were identified and corrected;
- ✓ in 2021, among data from 5,922 points, 872 cover errors, 253 biomass errors and 139 recovery potential errors were identified and corrected;
- ✓ in 2022, among data from 5,121 points, 369 cover errors, 416 biomass errors and 78 recovery potential errors were identified and corrected;
- ✓ in 2023, among data from 5,312 points, 991 cover errors, 750 biomass errors and 363 recovery potential errors were identified and corrected;
- ✓ in 2024, among data from 5,312 points, 597 cover errors, 414 biomass errors and 170 recovery potential errors were identified and corrected.

The national-level corrections are shown in Tables 3 and 4.

TABLE 3. Corrections Made to Photo Monitoring Data for 2020–2022

№	Aimag name	2020				2021				2022			
		Total number of points checked	Number of points with corrected cover data	Number of points with corrected biomass data	Number of points with corrected RC	Total number of points checked	Number of points with corrected cover data	Number of points with corrected biomass data	Number of points with corrected RC	Total number of points checked	Number of points with corrected cover data	Number of points with corrected biomass data	Number of points with corrected RC
1	Arkhangai	412	51	0	0	456	12	25	10	326	42	23	14
2	Bayankhongor	324	31	0	0	441	70	15	0	312	47	25	8
3	Bayan-Ulgii	291	52	10	2	374	250	0	0	327	16	0	0
4	Bulgan	213	35	12	0	222	23	21	12	208	28	13	14
5	Govi-Altai	370	29	0	0	466	74	25	14	343	33	24	7
6	Govisumber	46	5	6	0	46	15	0	0	48	0	0	0
7	Darkhan-Uul	7	0	1	0	28	10	5	3	27	10	5	5
8	Dornod	281	22	13	0	282	14	8	10	240	0	0	0
9	Dornogovi	224	12	10	0	228	12	6	5	228	12	10	13
10	Dundgovi	221	15	11	0	243	8	5	9	233	10	18	17
11	Khentii	340	26	10	0	352	18	7	46	353	19	8	0
12	Khovd	267	46	12	0	285	45	16	0	203	6	37	0
13	Khuvsgul	341	24	39	0	365	94	5	0	338	45	40	0
14	Selenge	109	16	0	0	112	43	16	0	101	14	16	0
15	Sukhbaatar	382	13	22	0	383	42	21	13	249	0	15	0
16	Tuv	243	45	19	28	286	37	9	0	266	47	45	0
17	Umnugovi	199	15	16	0	198	23	16	0	192	5	86	0
18	Uvs	328	28	14	0	358	19	15	0	347	13	24	0
19	Zavkhan	440	17	7	7	448	22	16	12	440	16	12	0
20	Orkhon	5	0	0	0	8	8	4	0	8	0	0	0
21	Uvurkhangai	311	26	23	0	305	27	18	5	293	6	15	0
22	Ulaanbaatar	29	7	10	0	36	6	0	0	39	0	0	0
	Total	5,383	515	235	37	5,922	872	253	139	5,121	369	416	78



The reliability of the assessment depends not only on field measurements, but also on data quality control.

TABLE 4. Corrections Made to Photo Monitoring Data for 2023–2024

№	Aimag name	2023				2024			
		Total number of points checked	Number of points with corrected cover data	Number of points with corrected biomass data	Number of points with corrected RC	Total number of points checked	Number of points with corrected cover data	Number of points with corrected biomass data	Number of points with corrected RC
1	Arkhangai	425	58	75	20	406	98	20	13
2	Bayankhongor	314	65	73	15	315	33	11	16
3	Bayan-Ulgii	328	78	34	10	328	26	77	14
4	Bulgan	211	83	45	56	211	25	21	23
5	Govi-Altai	345	62	93	98	345	30	7	5
6	Govisumber	48	7	5	2	48	4	-	-
7	Darkhan-Uul	30	14	2	9	28	7	1	2
8	Dornod	258	57	16	12	289	65	8	4
9	Dornogovi	228	34	61	8	228	8	10	2
10	Dundgovi	247	85	42	11	247	9	-	-
11	Khentii	360	71	15	13	360	11	10	7
12	Khovd	203	57	72		203	15	20	12
13	Khuvsgul	366	61	33	8	368	35	14	8
14	Selenge	101	36	12	7	112	13	6	4
15	Sukhbaatar	255	40	14	13	254	52	11	12
16	Tuv	264	16	6	2	266	20	4	5
17	Umnugovi	199	44	24	-	199	12	63	7
18	Uvs	348		65	47	348	45	46	11
19	Zavkhan	440	54	61	32	440	48	56	9
20	Orkhon	10	1	1	-	10	-	-	-
21	Uvurkhangai	294	52	23	17	294	28	24	13
22	Ulaanbaatar	38	16	1	4	42	13	5	3
	Total	5,312	991	750	363	5,341	597	414	170

These errors were mostly related to manual data entry mistakes, including incorrect entry of cover percentages, decimal-place errors in biomass values, or incorrect plant identification. Two key lessons can be drawn from this. First, when working with a large national database, quality control should be established as a separate process involving regular and thorough verification. Second, data-entry standardization, the use of applications, field training and automated validation algorithms need to be improved. Addressing these issues can significantly reduce error rates.

From a practical perspective, quality-checked data provide the foundation for policy-level decision-making. If there are substantial errors in vegetation cover, biomass or recovery classification, there is a risk that carrying capacity calculations, target areas for restoration, agreement conditions and planning priorities may be incorrectly determined. Therefore, quality control should be institutionalized as an integral part of the methodology.

2.11.

PRACTICAL APPLICATION, LIMITATIONS AND FUTURE IMPROVEMENTS

The main advantage of this methodology is that it allows research findings to be directly translated into practical application. By using photo monitoring, State-and-Transition Models and recovery classification together, it becomes possible to make evidence-based decisions on regulating rangeland use, adjusting grazing pressure to carrying capacity, planning rotational grazing regimes, restoring and protecting degraded areas, and introducing restrictions on use where necessary.

However, certain limitations remain. In some regions, long-term monitoring time series are still insufficient. At the local level, understanding of State-and-Transition Models and capacity to apply them are uneven. There is also a continuing need to more fully integrate herders' traditional knowledge and actual land-use decisions into methodological interpretation. In addition, climate change, drought, dzud and precipitation variability strongly influence rangeland dynamics. Therefore, models, thresholds and management recommendations need to be updated regularly.

Future improvements should focus on the following areas:

- ✓ enriching the long-term database;
- ✓ integrating photo monitoring, remote sensing, machine learning and local observations;
- ✓ strengthening the capacity of local specialists and herders;
- ✓ automating data quality control;
- ✓ systematically linking the findings of the report with land management plans, rangeland use agreements, restoration projects and responsible production standards.

In this way, the assessment of rangeland condition and quality will become not only a research report, but also a practical instrument for sustainable land management.



*The evaluation of
rangeland condition
and quality serves
not merely as a
research document,
but also functions
as a practical
instrument for
the sustainable
management of
land.*

2.12.

METHODOLOGY FOR RANGELAND MONITORING USING REMOTE SENSING

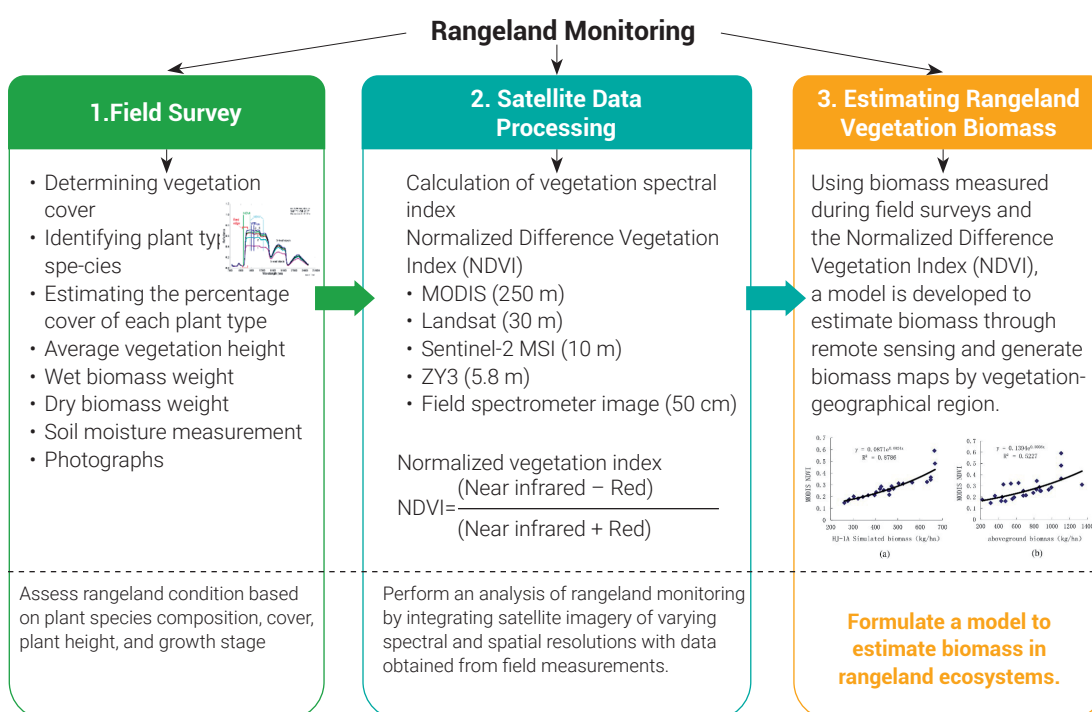
The land monitoring digital system is being used to ensure continuous state oversight of the efficient and appropriate use and protection of rangelands. It supports the combined use of remote sensing methods and vegetation field survey methods in rangeland monitoring. These methods are used to determine rangeland biomass, establish rangeland carrying capacity, assess overstocking, and provide primary and verification data for land management planning and land monitoring databases at all levels.

Within this framework, the “Methodological Guideline for Monitoring Rangelands Using Remote Sensing” was approved by Order No. 126 of the Minister of Construction and Urban Development in 2022.

This methodological guideline makes it possible to test remote sensing methods and spectrometric measurements at monitoring network points for rangeland condition and quality verification, in combination with vegetation field surveys. It enables rangeland condition to be assessed by month, season and year, and provides a basis for determining rangeland potential, impacts and carrying capacity.

MODIS, Landsat, Sentinel and other satellite data are being used in rangeland monitoring studies at the national, regional, aimag and soum levels.

DIAGRAM 4. Remote Sensing Methodology for Rangeland Monitoring



The introduction of remote sensing methods into rangeland monitoring is important for the following reasons:

- ✓ it enables the prediction, detection and assessment of changes in rangeland condition and quality by aimag, soum and vegetation-geographical region, depending on rangeland type and form of use;
- ✓ it supports the detection of changes in vegetation and rangeland condition based on continuous monitoring observations, and helps prevent further degradation;
- ✓ it makes it possible to monitor the condition of vegetation cover based on continuous rangeland monitoring observations, prevent degradation of rangeland and hayland areas, identify the causes of negative impacts, and use the information for land protection and restoration activities;
- ✓ it enables the monitoring of types of land degradation and pollution caused during agricultural production.

This methodological guideline is used to assess rangeland change through remote sensing methods and to conduct surveys at monitoring network points. It supports the implementation of rangeland condition and quality monitoring, the tracking of changes in rangeland areas, timely detection of changes, prevention of degradation and trampling, adjustment of rangeland carrying capacity and grazing pressure, preparation of assessments and conclusions, establishment of a database, and dissemination of information to users.

After determining rangeland vegetation indices, this methodological guideline makes it possible to estimate rangeland vegetation biomass at the national, regional, aimag and soum levels. Biomass is calculated using the models presented below by natural zone and belt.

TABLE 5. Rangeland Biomass Regression Models

Nº	Natural zones	Rangeland biomass, gr/sq.m
1	High mountain	$\text{Biomass} = 388.43 \times \text{NDVI}^2 - 176.42 \times \text{NDVI} + 43.054$
2	Forest steppe	$\text{Biomass} = 16.559 \times e^{(3.0014 \times \text{NDVI})}$
3	Steppe	$\text{Biomass} = 19.535 \times e^{(3.0232 \times \text{NDVI})}$
4	Desert steppe	$\text{Biomass} = 137.1 \times \text{NDVI} + 9.2753$
5	Desert	$\text{Biomass} = 336.75 \times e^{(-19.34 \times \text{NDVI})}$



The digital system for land monitoring is employed to evaluate the carrying capacity of rangelands by measuring rangeland biomass, achieved through the combination of remote sensing techniques and field-based vegetation survey methods.