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NATIONAL FEDERATION
OF PASTURE USER
GROUPS OF HERDERS

The JORNADA
Rangeland Research Programs

NATIONAL REPORT ON THE RANGELAND HEALTH OF MONGOLIA

Ulaanbaatar, Mongolia
2018

NATIONAL REPORT ON THE
RANGELAND HEALTH OF MONGOLIA
Second Assessment

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ABBREVIATIONS

MoFALI	- Ministry of food, agriculture and light industry
ALMGaC	- Agency for land, management, geodesy and cartography
NAMEM	- National agency for meteorology and environmental monitoring
MULS	- Mongolian university of life science
AFPUG	- Aimag federations of pasture user groups
APUG	- Associations of pasture users group
GAVS	- General authority for veterinary services
IARRMA	- Inter aimags reserve rangeland management administration
LRMT	- Livestock raw material traceability database/system
NAEC	- National agricultural extension center
PUG	- Pasture users group
ESD	- Ecological site descriptions
ESG	- Ecological site group
MNFPUG	- Mongolian national federation of pasture user groups
STM	- State and transition model
DIMA	- Database for inventory, monitoring and assessment
RC	- Recovery classes
RUA	- Rangeland use agreement
SALMP	- Soum annual land management planning

EXECUTIVE SUMMARY

As one of the few remaining countries with a robust, nomadic pastoral culture supported by extensive natural rangelands, Mongolia is well positioned to offer sustainable, rangeland-based goods and services to its citizens and to global consumers who place a premium on sustainable products. The primary challenge to sustainable livestock production in Mongolia is that rangeland health, the set of environmental conditions that sustain the productivity and biodiversity of rangelands is in decline in many areas. National livestock numbers, at 110.8 million sheep units in 2018 according to the National Statistical Office, are unprecedented in the historical record. As a first step toward sustainable rangeland management, the Swiss Agency for Development and Cooperation's Green Gold project collaborated with government ministries and universities to develop new assessment, monitoring, and management procedures to understand and improve rangeland health across Mongolia. A nationally standardized methodology for rangeland monitoring provides robust evaluations of long-term changes in rangeland health. The National Agency for Meteorology and Environmental Monitoring (NAMEM) now has the capacity to continue the new monitoring procedures and report to the nation on these trends. New tools for interpreting rangeland health and developing spatially-explicit management recommendations called Ecological Site Descri ptions (ESDs) were developed by scientists and professionals from universities, research institutes and the agencies such as Agency of Land Management, Geodesy and Cartography (ALMGaC) and NAMEM. The new procedures for monitoring and interpretation were implemented beginning in 2011 by NAMEM at its 1516 long-term monitoring sites.

Based on 2016 monitoring data, forty two percent of monitoring sites were judged to be in a "reference" or non-degraded state; 13.5 % in slightly degraded, 21.1 % in moderately degraded; 12.8 % in heavily degraded and 10.3 % in fully degraded level.

Compared to the conditions assessed in 2014, the previous reporting year, the degree of degradation has increased in the last two years. The proportion of sites that were classified to a non to slightly degraded level has decreased by up to 10% while sites classified to heavily or fully degraded level has increased by 4.3-5.9%.

Based on an evaluation of the ecological processes causing degradation, the previous National Report concluded that changes to grazing management could result in complete recovery or significant improvement within 10 years for a majority of monitoring sites, representing more than half of Mongolian rangelands. Based on 2016 data, there is still a great opportunity for recovery through improved grazing management, but the number of monitoring sites that will require more than 10 years for recovery, or that may prove to be irrecoverable, has been increased by 5 percent.

A new, comprehensive approach called resilience-based rangeland management was introduced to initiate management changes leading to recovery of desired rangeland states. Resilience-based rangeland management is focused on the sustainable production of meat, fiber, and other environmental goods and services in the face of environmental and societal variability. Implementing resilience-based rangeland management requires national coordination among the Ministry of Food and Agriculture, Ministry of Environment, and Tourism, and Ministry of Urban Development and Construction as well as collaboration among herders and local government.

The structure of herder communities provides a solid platform for the resilience-based rangeland management approach and "rangeland use agreements" were introduced as a tool to operationalize the approach through adoption and enforcement of grazing and herd management plans.

An increasing number of herders accept the conditions of the agreement and manage rangeland using stocking rate adjustments needed to sustain or improve rangeland condition. The agreements also serve as a tool to resolve conflicts between herders and manage land conversion.

As of the 2018, 830 Pasture Users Groups (PUGs) in 11 aimags have a rangeland use agreement that is signed by the local governor and herders. These agreements are typically for 15 years. More than 15000 herder families work to fulfill the conditions of the agreement to manage 16 million hectares of rangeland.

Most herders indicate the need to reduce and regulate animal numbers, but do not know how to start and what to do with excess animals. Technical support for herders is needed in addition to policies that incentivize stocking rate reductions. Surveys indicate that many herders support a permitting system such as a grazing fee or animal tax.

In order to promote strategies to improve management and increase herder prosperity, pilot projects were initiated on i) a voluntary grazing fee policy at the local level; ii) linkage of herder cooperatives to processing companies, and iii) development of international markets built on a traceability system of livestock products such as yak wool, baby camel wool, meat and milk. These projects, described below, illustrate the utility of tracing technologies, the potential benefits of grazing fees for sustainable rangeland use, and the ability of cooperatives to reach lucrative markets.

At present, there are ample opportunities for changes in management and policy that improve rangeland health, that enable adaptation to climate and land use changes, and that secure the future of pastoral production and food security in Mongolia. But it is important to act decisively and promptly before those opportunities are lost.

CHAPTER 1.

TOOLS FOR ASSESSMENT, MONITORING, AND MANAGEMENT OF RANGELAND HEALTH

1.1. Assessment and monitoring of rangeland health at the national level

The National Agency for Meteorology and Environmental Monitoring (NAMEM) is the institution responsible for nationwide rangeland monitoring covering 1516 monitoring sites representing all baghs in Mongolia. NAMEM has achieved significant progress to i) institute measurement of internationally-accepted core indicators that are standardized nationally; ii) develop a reference database of different rangeland types that provides a basis for interpreting monitoring data and determining what is "healthy" or "degraded"(ecological site descriptions); and iii) build capacity to produce a timely outlook on rangeland health based on monitoring data.

Comparisons of existing rangeland monitoring methodologies used by different Mongolian institutions (Research institutes; Universities; Ministry of Environment and Tourism; Ministry of Food, Agriculture and Light Industry; National Agency for Meteorology and Environmental Monitoring and the Agency for Land Management, Geodesy and Cartography) led to an **agreement on a unified set of core indicators that will reduce controversy in assessments of rangeland health into the future**. Core indicators include foliar canopy cover, species composition, and basal gaps of perennial plants, plant height, and biomass. Measurement methods include line-point intercept, gap intercept, air dry biomass at 1 cm clipping height, and photo points. A methodology for rapid characterization of soils to identify ecological sites and a concept for developing simplified ecological site descriptions that match existing herder concepts (see below) were also agreed upon. The newly standardized methodology is repeatable, precise, and simple enough for easy use. The method can not only be used to report rangeland health at a point in time (assessment), but also provide precise estimates of rangeland change over the long-term (monitoring). As of 2011, the new methodology and indicators were approved by the Government as a nationwide monitoring methodology.

Monitoring sites at the NAMEM are able to fully represent the ecological and administrative boundaries of Mongolia (Fig.1.1).

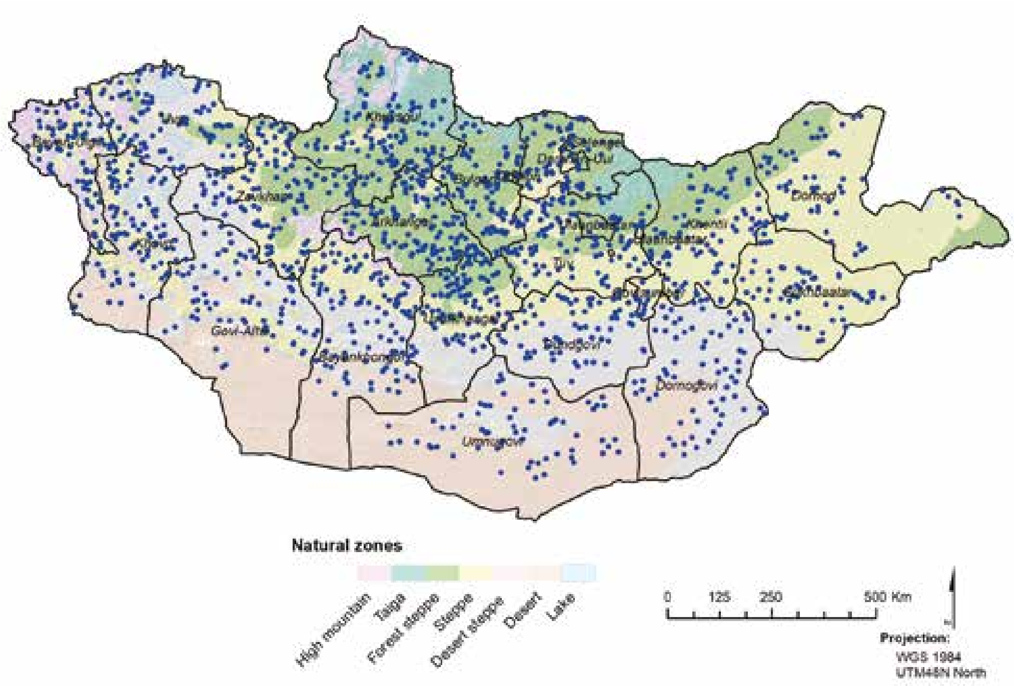


Figure 1.1. Dot map for the rangeland monitoring sites

Meteorology technicians in 320 soums collect the primary data yearly at 1516 sites using the new standardized methodology since 2011. Aimag engineers ensure quality control and enter the monitoring data into the National Rangeland Monitoring Database (Fig. 1.2). The national database is modified and adapted to Mongolia from the Database for Inventory, Monitoring and Assessment (DIMA) developed by the U.S. Department of Agriculture (USDA), Jornada Experimental Range. The database can accommodate all core indicators and new indicators as needed. Customized reports for interpretation of assessment and monitoring data can be produced.

Data compilation: Soum technicians collect the primary data yearly. Aimag engineers ensure quality control and enter the monitoring data into the National Rangeland Monitoring Database (DIMA)

National database for rangeland monitoring: Customized reports for interpretation of assessment and monitoring data can be produced.

Products for public service:

- Rangeland state outlook.
- Carrying capacity & grazing pressure map
- Rodents and Grasshopper damage map and Other products

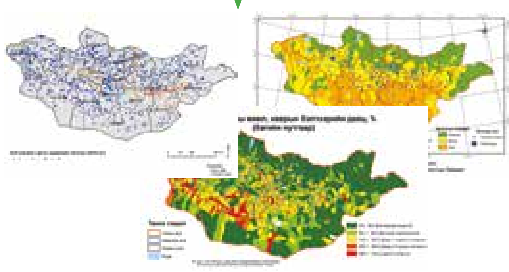


Figure 1.2. NAMEM monitoring data collection workflow

Rangeland monitoring results have been used primarily for defining the current state of rangeland health, hotspots of degradation, and opportunities for rangeland restoration at the national level based on ecological site descriptions.

1.2. Grazing impact monitoring and rangeland assessment at the local level

The national monitoring effort of NAMEM provides highly precise, detailed information suitable for interpreting long-term trends in vegetation, ground cover, and that can be linked to erosion models (Herrick et al. 2017). The density of observations, however, is not sufficient for management decisions at the local (bag, pasture) levels. Thus, based on the results of testing in pilot soums, a photo point monitoring method (Booth and Cox 2008) was developed to provide information on the cover of plant functional groups that is adequate for grazing management decisions and to report vegetation trends at the functional group level. This method is simpler to implement and requires less training than monitoring methods used by NAMEM. The Agency for Land Management, Geodesy and Cartography made a decision to adopt this method and implement it nationally as a basis for assessing grazing management impacts. The photo point monitoring system covers 4200 sites in total representing different pasture user's groups (PUGs) and different seasonal pastures (Fig 1.3).

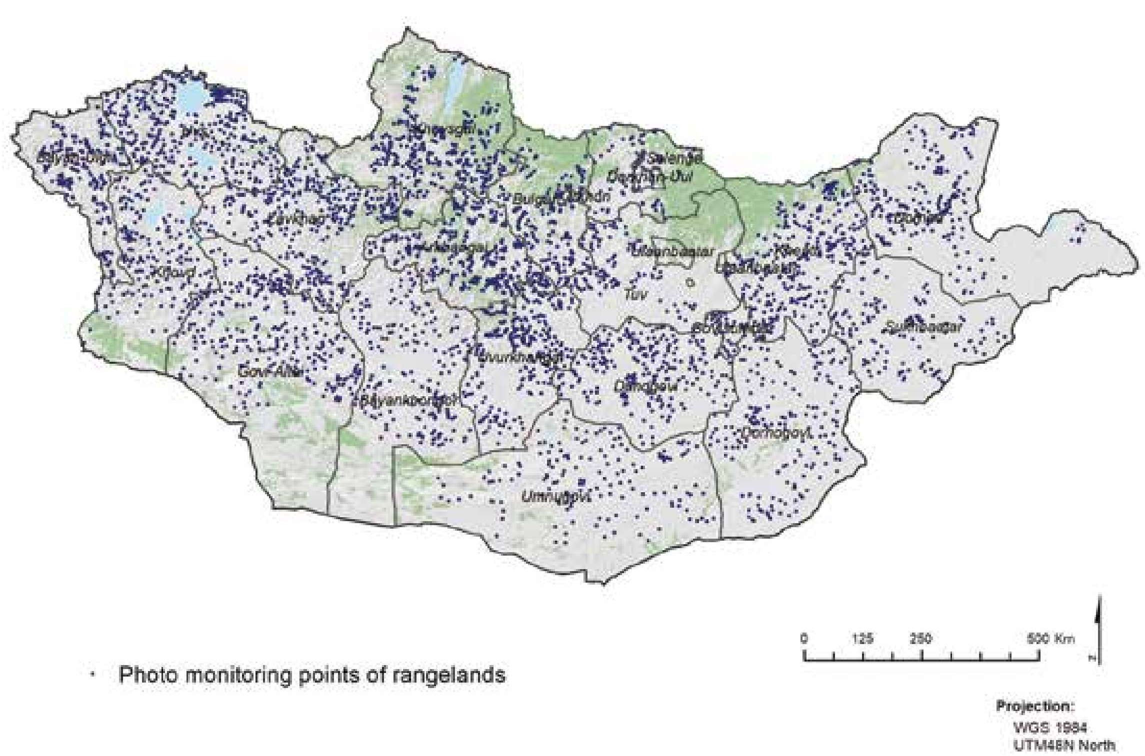


Figure 1.3. Distribution of the Photo point monitoring sites at the ALMGaC across Mongolia, 2018.

Photo images were collected annually at 5 meter intervals along two parallel 50 meter long tapes by soum land managers and the soum leader of the Association of Pasture User Groups (APUG). Analysis is performed using Sample Point software that facilitates manual, pixel-based, image analysis from nadir digital images of any scale, and automatically records data to a spreadsheet (J. Cagney, S. E. Cox and D. T. Booth, 2011). Cover was estimated for key functional groups and resulting data are managed by ALMGaC in a national-level database (Fig. 1.4). As of today, the database houses monitoring records and supporting photos from 4200 sites. These sites represent all of the seasonal pastures within baghs and PUGs in 278 soums.

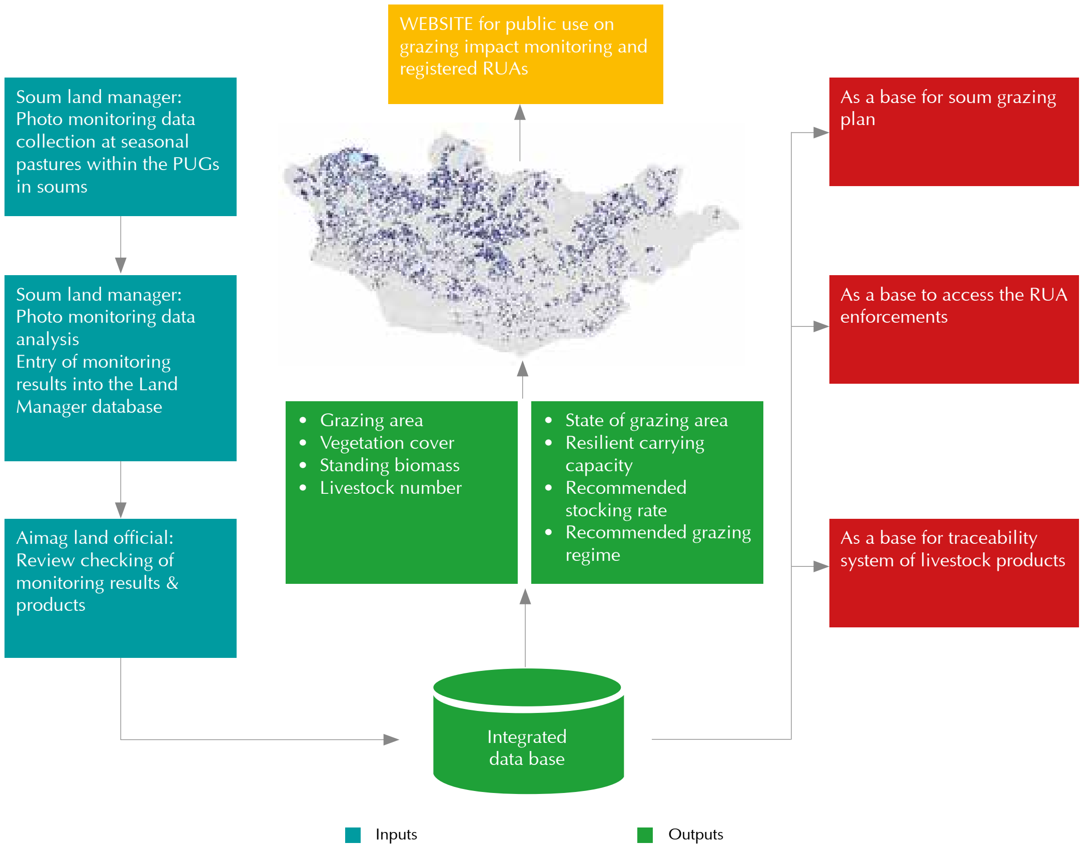


Figure 1.4. Photo point monitoring system functioning at the ALMGaC

Comprehensive reports on vegetation cover by key functional groups and standing biomass for each PUG can be produced from the national database. This database serves as the main platform for assessing rangeland state and trends, grazing management impacts, and to estimate animal carrying capacities for upcoming winter and spring seasons and make recommendations for animal off-take rates.

CHAPTER 2.

INTERPRETING RANGELAND HEALTH USING MONITORING DATA

2.1. A review of recent climate

According to the outlook maps and report on climatic conditions from NAMEM, the year 2016 was an average year comparable to the 30-year average; the average air temperature in June, the beginning of growing season was slightly higher by 1,1-5,4 degrees Celsius.

The total precipitation in growing season of 2016 was comparable to average except in August when it was lower than average (Fig. 2.1).

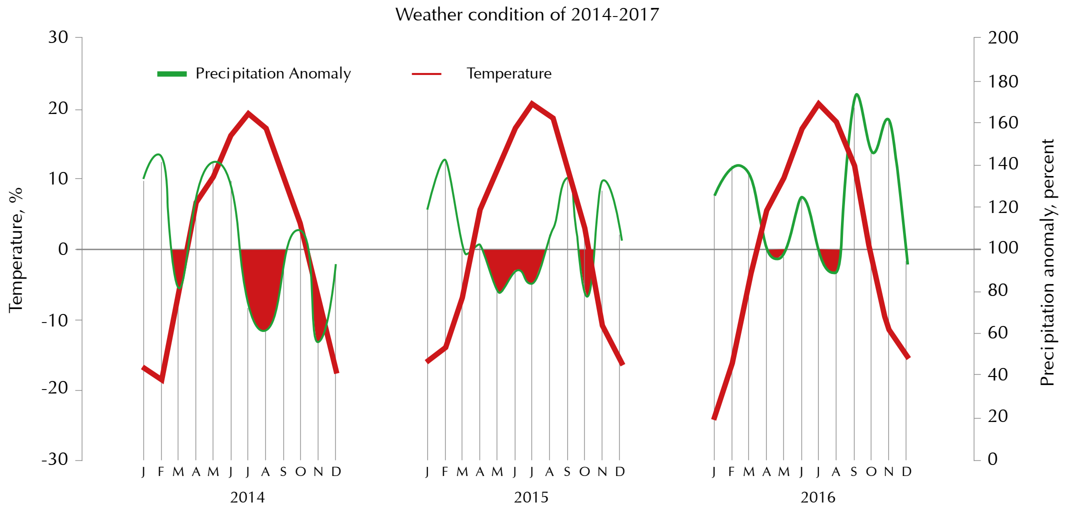


Figure 2.1. Climadiagram for 2014-2016.

As described in outlook map, the vegetation growth was in moderate condition in percent of 40% the country, whereas 55% was in good condition and 5% was in bad condition (Fig. 2.2).

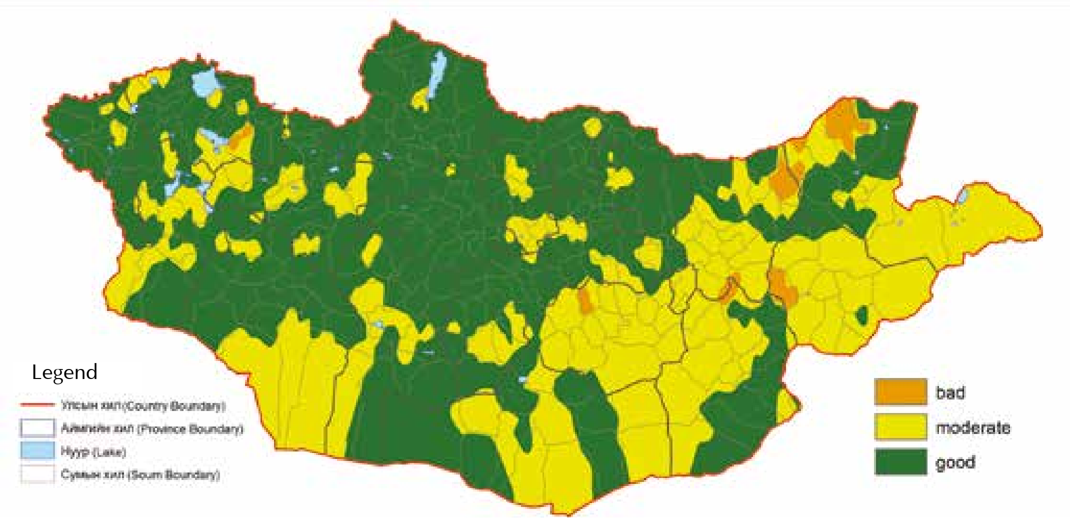


Figure 2.2. Map of vegetation growing state for 2016

2.2. Methodologies and analyses used for assigning the monitoring sites:

2.2.1. How monitoring data were matched to Ecological Site Groups and states/phases

The "State and Transition Models for Mongolian rangelands" catalogue is a primary tool for monitoring and assessment data analysis and interpretation (Fig. 2.3). Monitoring data were first used to characterize the plant community based on the cover of key species groups. In 2014, the monitoring point was assigned to a "natural zone" based on geographic location with respect to climate and indicator plant species in some cases. The points were also assigned to land units called Ecological Site Groups (ESG) within each natural zone, which are soil-based land types (Ecological Sites) that are grouped according to landforms, traditional land classification concepts, and similarities in management needs (Bestelmeyer et al. 2016). Data on soils and indicator species were used for these assignments in 2014. For each year of monitoring, the plant cover data and soil surface indicators are used to assign the plant community to an ecological state or community phase of a "state and transition model (STM) (Fig. 2.4). The "states" (large boxes) represent large changes in rangeland conditions that can be difficult to reverse and "phases" (smaller boxes within states) represent specific plant community types within states that may shift easily from one to another (if there are more than one). For example, in the "Small bunch grass-forb mountain steppe rangeland in Loamy fan" ESG (Forest steppe natural zone), has a reference state and 3 alternative states such as "Grass thinned", "Dominant species replaced", and "Degraded" states that differ in the abundance of perennial grasses and *Carex duriuscula*. Threshold values for these key species or groups are used to assign monitoring points to states or phases. Each state or phase is then linked to a degradation level and recovery class in the STM. The ESG and STM associated with each monitoring site can be explored using web-based maps (WebAnnex 1).

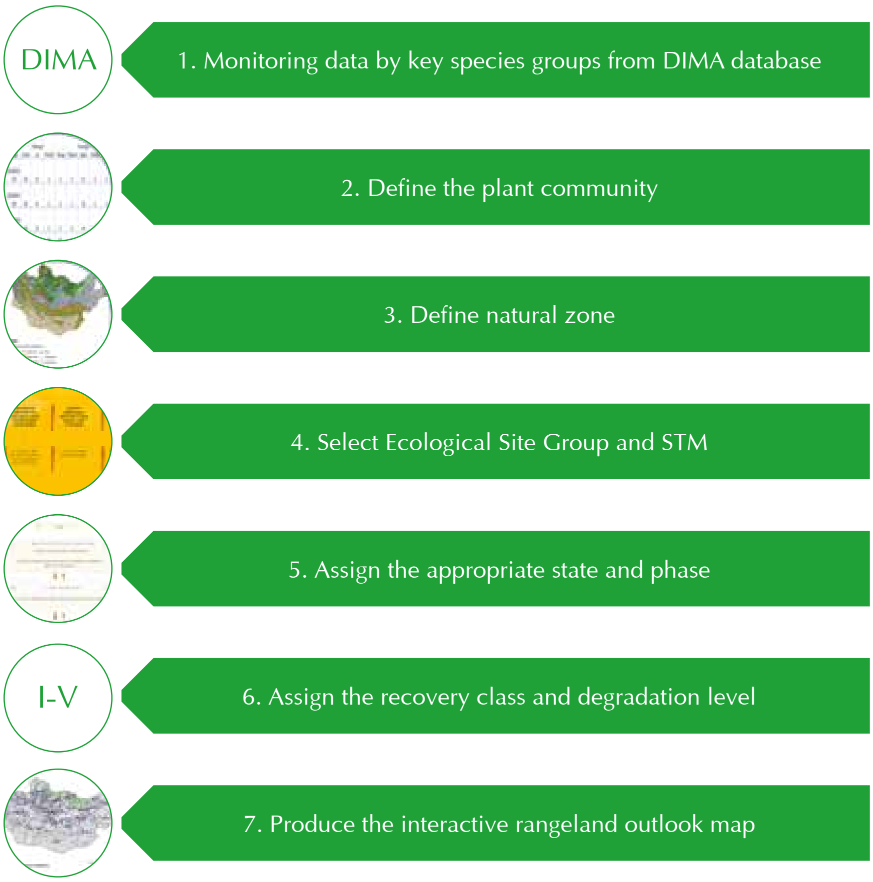


Figure 2.3. Steps of monitoring data processing at the NAMEM

2.2.2. The use and differences between degradation and recovery classes

Degradation is represented by 5 levels describing a sequence of changes from healthy/productive/ desirable conditions toward unproductive states featuring unpalatable species or soil erosion. Determination of "healthy" conditions (nondegraded; level 1) is based on information and assumptions about the species composition of a reference or potential community of an ESG, such as extant minimally disturbed/well-managed plant communities and historical accounts. Degradation level has been commonly used for interpreting the current state of rangelands in Mongolia. Key criteria for degradation level are species composition, total species number, bare soil cover, the proportion of palatable and degradation indicator species, litter accumulation, and aboveground biomass.

Recovery classes, on the other hand, provide a general descri ption of the processes and timelines needed for recovery of healthy states (see below). Recovery classes are used for planning of grazing management and other restoration actions.

2.2.3. How states and phases are classified as reference vs altered.

In each STM, phase 1.1 is considered as the reference and non-degraded condition. All other states and phases are considered to be "altered" from the reference to varying degrees.

Figure 2.4. State and transition model for the Small bunch grass -forb rangeland in Loamy fan ESG, Forest steppe zone

2.2.4. How states and phases are classified to degradation classes

States and phases were classified to degradation level following the basic criteria described in Table 2.1. The red Roman numerals to the left of the state boxes designates the degradation level.

Table 2.1. Rangeland degradation criteria by O.Chognii, 2018

Degradation levels	Criteria
I. Non degraded	All dominants are in place.
II. Slightly degraded	Key dominant are still dominating, some grazing sensitive forbs are in decline and grazing resistant species are in increase.
III. Moderately degraded	Dominants are in decline and replaced by other subdominants, number of species drops down.
IV. Heavily degraded	Remnants of key species are thinning, and abundance of degradation indicator species increases.
V. Fully degraded	Total vegetation cover is reduced or dominated by very few degradation indicator species.

The primary expression of rangeland degradation in Mongolia is via species shifts toward more grazing tolerant plants and reductions in valuable forage species. Rangeland degradation associated with continuous heavy grazing pressure causes the following sequence of changes:

- Graminoid cover thins overall and dominant species are replaced by subdominants
- Graminoids are replaced by rhizomoids (sedges)
- Rhizomoids are replaced by semi-shrubs, shrubs, and annuals
- Overall vegetation cover thins; annuals may be abundant in rainy years but bare soil cover increases, especially in the forest steppe and steppe zone

For example, the decline in mean graminoid foliar cover and increases in sedges and *Artemisia adamsii* (semi-shrub), a key rangeland degradation indicator, is depicted for a set of monitoring sites. Aboveground biomass, however, may not vary significantly along this degradation sequence if increases in grazing-tolerant species compensate declines in grazing-sensitive species.

2.2.5. How states and phases are classified to recovery classes

The recovery class hypothesizes timelines to recovery of the reference state based on vegetation cover and composition data interpreted according to expert knowledge and existing studies when available (Table 2.2). For example, the presence of remnant perennial grasses suggests that recovery can occur with several years. The recovery classes allow standardized interpretations across multiple state and transition models to allow for reporting and visualization of rangeland restoration needs.

Table 2.2. Recovery class criteria

Recovery classes	Criteria
Class I.	The plant community is at or near reference conditions (non-degraded) or requires 1-3 growing seasons for recovery from minor changes (slightly degraded); match stocking rate to forage supply and use temporary seasonal deferment as needed.
Class II.	The plant community is altered and may be rapidly recovered (3-5 growing seasons) with favorable climatic conditions or a change in management (e.g., stocking rate reduction, seasonal deferment, rotation). The nature of alteration is not regarded as a significant long-term threat to the provision of forage and other ecosystem services.
Class III.	The plant community is altered and may take 5-10 growing seasons to recover with changed management (stocking rate reduction, seasonal deferment, and long-term rest). Alteration represents a significant loss of important ecosystem services (and are clearly related to anthropogenic drivers), but recovery is possible in time.
Class IV.	The plant community is altered due to the local loss of key plant species, invasion of noxious plant species, or alteration of hydrology that is unlikely to be recovered for over a decade to many decades without intensive interventions such as species removal, seeding, or manipulations to recover historical hydrological function (i.e. an ecological threshold was crossed). Previous ecosystem services have been lost and are usually costly to recover.
Class V.	The plant community is altered due to extensive soil loss, accelerated erosion rates, or salinization. Altered plant-soil feedbacks or permanent changes in the soil profile maintain the degraded state. Previous ecosystem services have been lost and it is usually impractical to recover them (often regarded as true desertification).

CHAPTER 3.

THE CURRENT STATE OF RANGELAND HEALTH IN MONGOLIA

3.1. State of rangeland health

The national rangeland monitoring program and managed by NAMEM was initiated in 2011 and is continuing as of 2016 at 1516 sites. Data from 2011-2013 are continuing to be updated due to changes to database structure that were finalized in 2014. Consequently, only 2014 data were analyzed and presented in the inaugural 2015 National Report. In the current report, we focus on data from 2016, which are the most recent, quality-assured data available at the time of report production. We draw comparisons to the 2014 data, treated here as a baseline. A subsequent report will describe trends across the complete time series of available data (2011-2017).

Fifty-seven percent of the sites monitored in 2016 are altered from reference plant communities (Fig. 3.1). This value is 8% lower than the results from 2014 and indicates improvement in rangeland conditions, in particular, a shift from slightly degraded to non-degraded states. Other monitoring sites, however, became more severely degraded over the past 2 years.

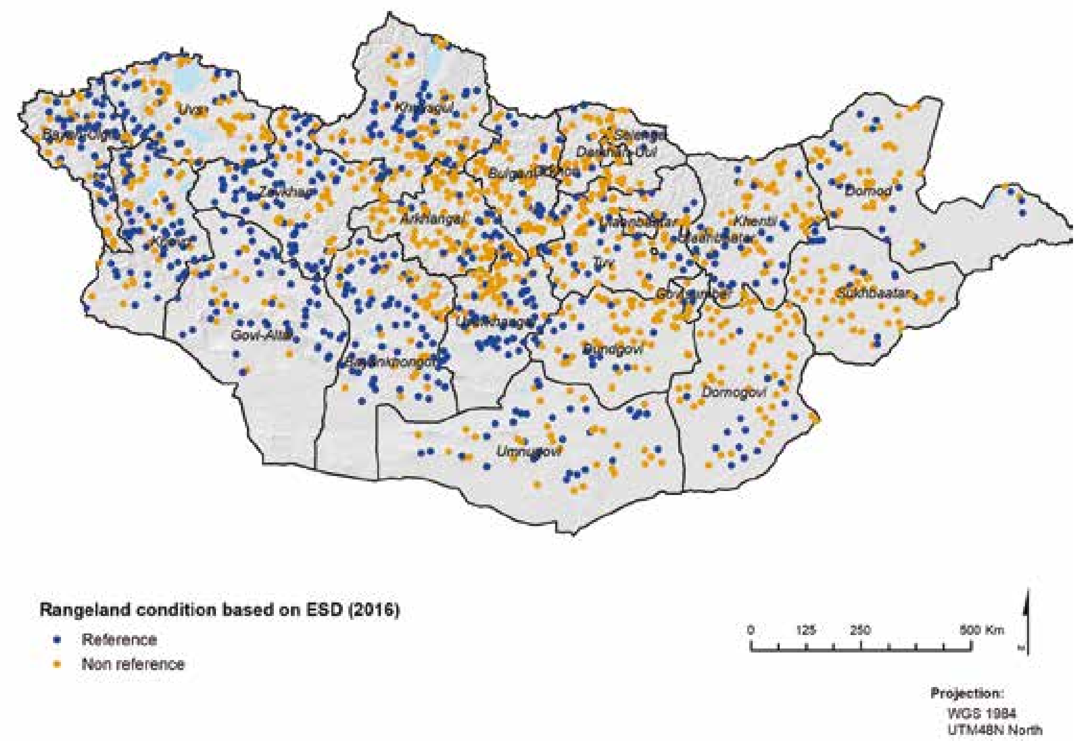


Figure 3.1. Monitoring sites classified to reference or non-reference rangeland conditions in 2016 based on the ESDs

In 2016, according to the classification by degradation level, 42.4 % of sites were in a non-degraded state; 13.5 % in slightly degraded, 21.1 % in moderately degraded; 12.8 % in heavily degraded and 10.3 % in fully degraded level. Compared to the conditions in 2014, the proportion of sites that were at a heavily to fully degraded level has increased by 5.9 and 4.3 percent, respectively (Fig 3.2).

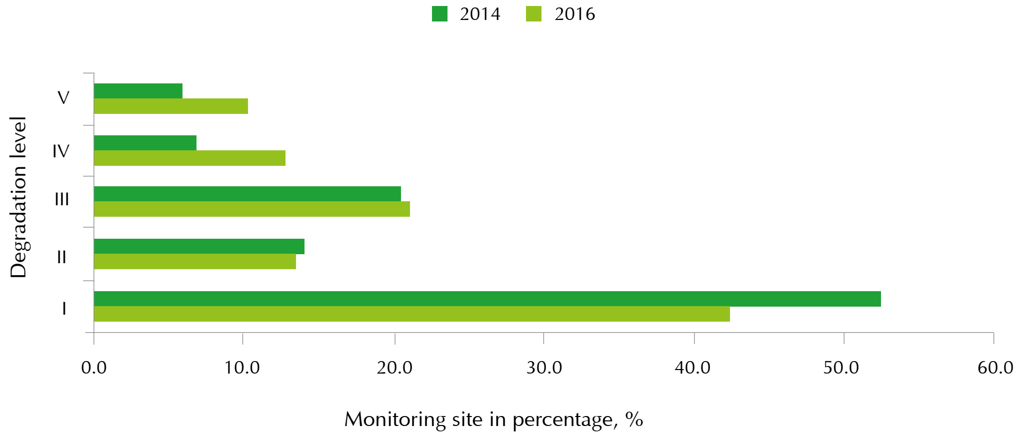
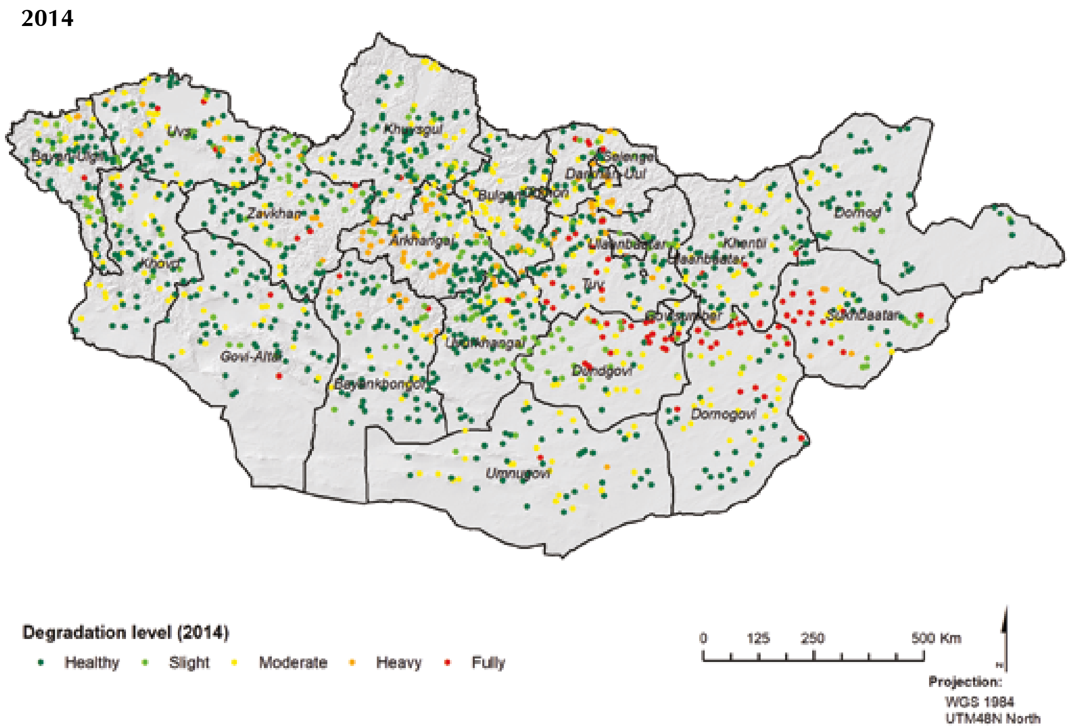


Figure 3.2. Comparison of degradation level among monitoring sites between 2014 and 2016.

A high proportion of sites in Arkhangai, Tuv, Selenge and Dundgobi aimags shifted to higher degradation levels, and the aimags featuring the highest proportion of highly degraded (IV, V) sites were Sukhbaatar and Dornogobi (Fig. 3.3.).



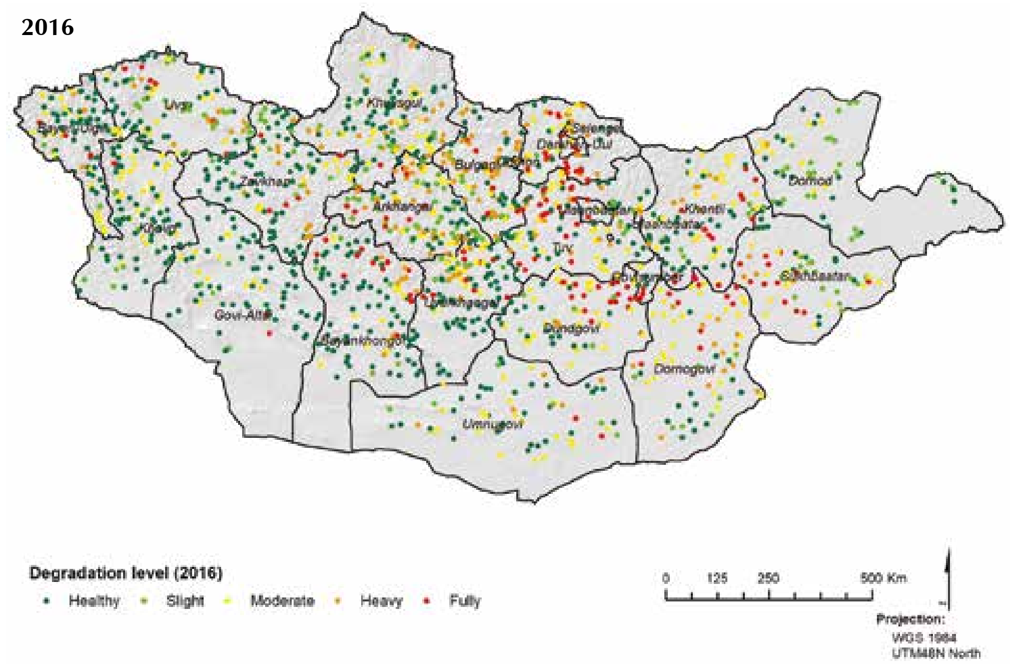


Figure 3.3. Rangeland degradation dot map by degradation level I-V from non to fully degraded, 2014 and 2016

While the degradation levels communicate the severity of plant community departure from reference conditions, the recovery classes communicate the management needs and timelines for recovery. National-scale patterns of degradation levels and recovery classes might appear similar, but are not identical because sites with the same degradation level may have different restoration timelines depending on the ESG, plant species involved, and levels of soil degradation.

In 2016, 43 % of sites were in Class I; 29 % in Class II; 16 % in Class III; and 12 % in Class IV (Fig. 3.4.). Sites with very different recovery classes were intermingled, indicating that great variability in rangeland condition exists within soums. No monitoring sites were located in areas with Class V, but localized areas featuring severe soil degradation have been observed.

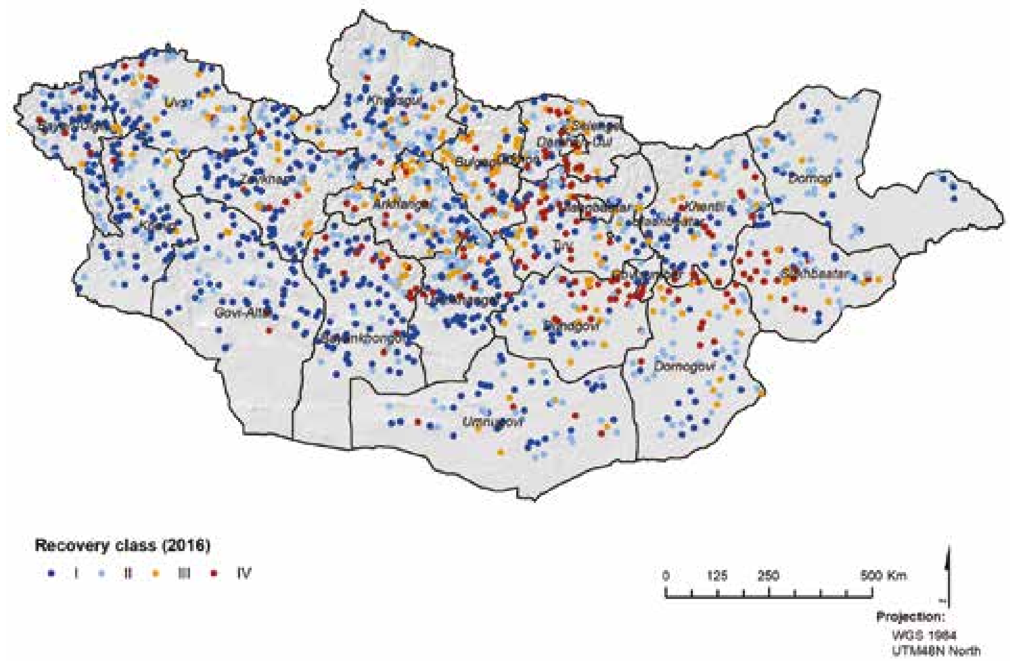


Figure 3.4. Monitoring sites classified to Recovery classes based on the ESDs in 2016

Most monitoring sites in High mountainous and Desert ecological zones are at reference condition or could recover rapidly (Class I). A high percentage of sites requiring more than 3 years of management for recovery (Class II-IV) were observed in forest steppe, steppe and desert steppe zones (Fig. 3.5.).

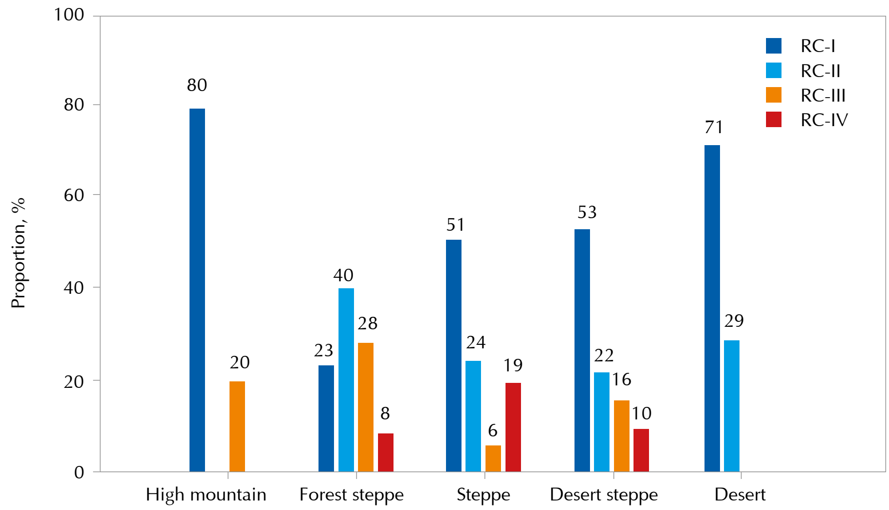


Figure 3.5. The percentages of NAMEM monitoring sites classified to different Recovery Classes for each ecological zone, 2016

Rangelands of different ESGs may have differing resilience and recover at different rates in response to grazing management. ESGs featuring sandy loam to sandy soils, including the "Festuca-Forbs mountain steppe rangeland in Gravelly hills and fan" (ESG 1); "Stipa krylovii-grass with Caragana steppe rangeland in Deep sandy alluvial plain" (ESG 8); and "Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland in Sandy plain" (ESG 12), are more vulnerable to grazing especially the slopes of alluvial fans that are vulnerable to erosion (Fig. 3.6).

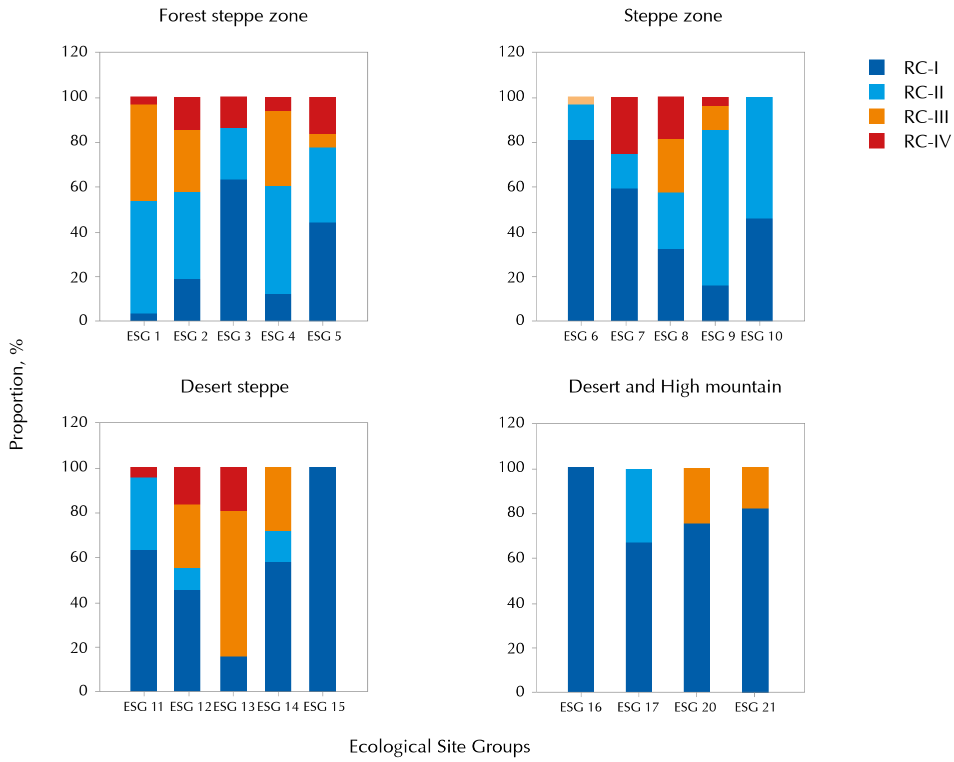


Figure 3.6. Percent of NAMEM monitoring sites classified to each recovery class in different Ecological site groups through different ecological zones.

Comparing the recovery classes of 2014 and 2016, 51% of the monitoring sites have not changed over the past 3 years with respect to the expected timeline to recovery, while 15% of sites are on a path to more rapid recovery and 34% will now take even longer to recover (Fig. 3.7).

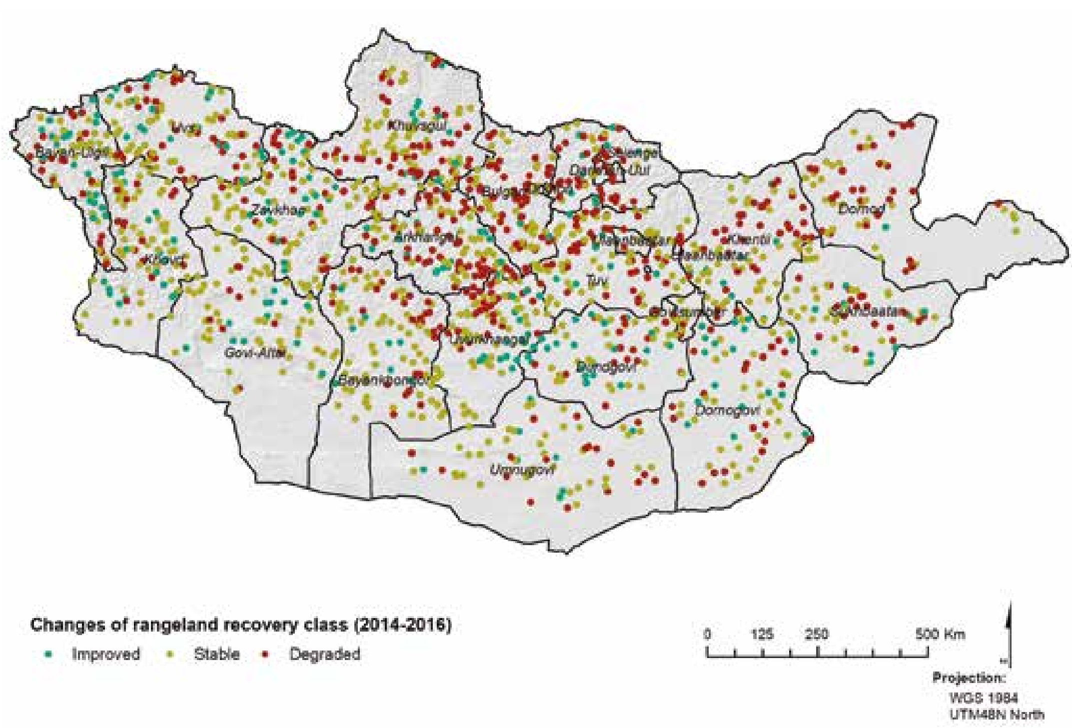


Figure 3.7. Dynamics of shifts in monitoring sites among different states; Green dots: sites that will now recover more quickly; Yellow dots: sites were recovery time has not changed; and Red dots: sites where recovery has been prolonged.

Due to continued high grazing pressure in the central region, a higher proportion of sites in Selenge, Arkhangai, Khuvsgul, Tuv, Khentii and northern part of Bayankhongor and Uvurkhangai will have longer recovery times when grazing management is implemented. Rangelands with sandy loam to sandy soils across Forest steppe, Steppe and Desert steppe are on the path to more rapid recovery, especially given years with high rainfall.

CHAPTER 4.

A NEW APPROACH TO RANGELAND MANAGEMENT IN MONGOLIA

4.1. Resilience-based rangeland management: experiences and evidence

Resilience-based rangeland management is focused on the sustainable production of meat, fiber, and other environmental goods and services in the face of environmental and economic variability. The term "resilience" denotes the goal of managing and restoring pasture vegetation, soils, and animal health such that herder livelihoods can persist in the face of drought, dzud, climatic change, and market disruptions. Resilience-based rangeland management enables managers and herders to identify management problems and to recommend and implement solutions to those problems at the local level via herder's customary organizations (such as Pasture Users Groups [PUGs], herder groups, and khot ail) and soum government.

The rangeland management framework used by ALMGaC is described in the Soum Annual Land Management Planning (SALMP) manual. The SALMP process has been improved via i) involvement of PUG, herder group, and herder participation in developing and implementing; ii) establishment of grazing management impact monitoring programs at the local level, providing information on rangeland condition and expected carrying capacity to inform adaptive management and preparations for winter; iii) an increasing number of PUGs adopting Rangeland Use Agreements (see below) that are officially registered in the Land Manager database at the ALMGaC; and iv) activities related to herd management and improving market access.

Six important steps are used in resilience-based rangeland management that rely on interactions mainly between MOFALI, ALMGaC and NAMEM at the national level and PUGs and soum government at the local level (Fig. 4.1). These steps are a critical part of Rangeland Use Agreements (RUAs) that create a platform on which herders and local government can negotiate and agree on mutual rights and responsibilities to maintain rangeland health. RUAs are used to enforce community-led grazing and herd management plans, including grazing schedules and stocking rate adjustments.

The resilience-based rangeland management process begins with the establishment of PUGs (or other governance mechanisms) that organize herder communities (PUGs, herder groups) according to traditional grazing areas (step 1). Pasture boundaries are mapped and agreed upon by herders within the PUGs and with neighboring groups. Spatial information on ecological sites, seasonal pasture use, and rangeland state are added to the map. The soum land manager, rangeland specialist, and PUG representatives use ESDs to evaluate pasture areas within each PUG (step 2). Using the map and information in ESDs, yearly grazing plans are developed by herders and soum government officers including stocking rates, seasonal use schedules, and other restoration actions (step 3). Plans are implemented via herders following the technical recommendations provided by rangeland and animal breeding officers (step 4). Recent experience indicates that this is the most complex step because a variety of decisions must be made on activities including rotational grazing, fodder preparation, animal breeding, animal health management, and marketing. The impact of management in different seasonal pastures is assessed by the land manager at the PUG level using the recently-implemented photopoint method and observations of pasture use (step 5a, 5b). Based on the assessment, the land manager updates a map of ecosystem states and recovery classes that provide a spatially-explicit representation of management needs. This map is an important tool to adjust or enforce management actions. Long-term monitoring data by NAMEM and ALMGaC at their respective monitoring sites are delivered to aimag and national offices and trends are reported to herders, soum government, and the national public (step 6). New information about rangeland change can be used by NAMEM and ALMGaC to periodically update ESD documents.

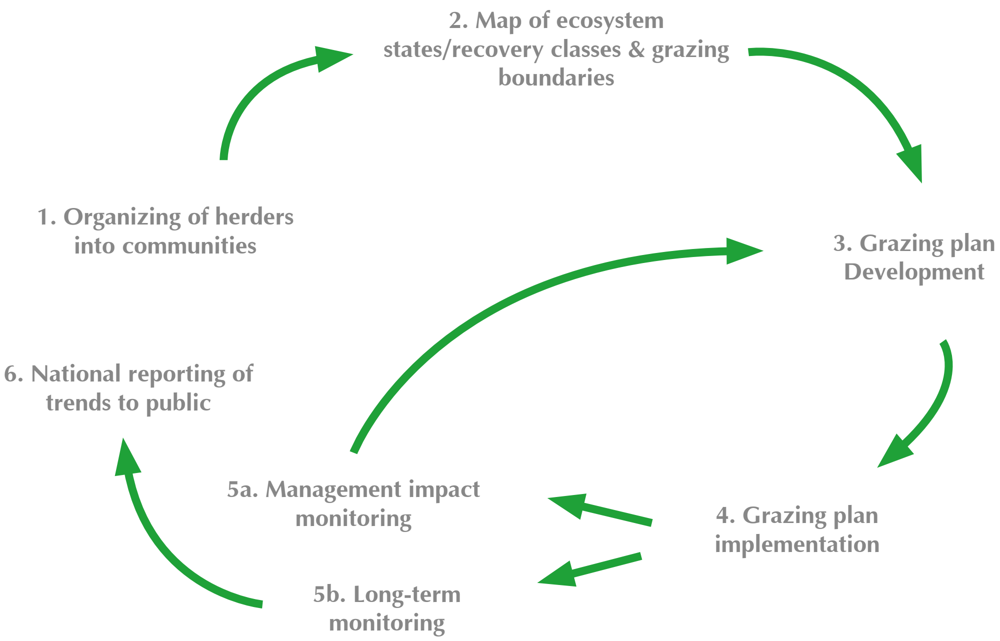


Figure 4.1.Steps in the resilience-based management approach are revised under the implementation process.

These steps involve a number of organizations at national and local levels, so coordination between these actors is crucial, including;

- Herder Institutes; PUGs, Soum Associations of Pasture User Groups (APUGs), Aimag Federations of Pasture User Groups (AFPUG) and Mongolian National Federation of Pasture User Groups (MNFPUG)
- Government agencies: NAMEM, ALMGaC, Inter Aimags Reserve Rangeland Management Administration (IARRMA), General Authority for Veterinary Services (GAVS), National Agricultural Extension Center (NAEC)
- Private sector; processing companies, Banks, Business groups
- Universities, Research Institutes
- Environmental projects, NGOs

Rangeland management working groups chaired by Deputy Governors at aimag and soum level have been established to provide coordination. These groups ensure the effective linkage between management steps described above, efficient collaboration of different actors, and provide policy support in enforcement of all steps and related measures such as Rangeland Use Agreements.

Manuals, technical guides, and user-friendly, simple catalogues featuring information in ESDs to support management have been approved by the Professional and Management Board of agencies including ALMGaC, NAMEM, Scientific committees at the Research Institute of General and Experimental Biology of the Mongolian Academy of Sciences and Mongolian University of Life Sciences. These technical documents can be used as a roadmap not only for grazing management, but also for wildlife conservation and environmental restoration programs.

As of 2018, more than 15000 herder families belonging to 740 PUGs are using 16 million hectare grazing area by the condition of agreement and approximately 60 percent of them are registered in state Land manager data base. Number of herders who accepts the condition of the agreement to carry responsible management through stocking rate adjustments into resilient carrying capacity and appreciate as a tool to solve the conflicts between herders and empower the social pressure. Rangeland use agreement has an important role in enforcement of grazing and herd management plans including the grazing timing and grazing pressure adjustments to the carrying capacity.

In order to improve the enforcement and positive impacts of RUAs, several annexes providing baseline information for contracted rangeland and rangeland trends are included with RUAs and are used to update grazing plans and assess compliance with agreements:

Annex 1. List of herder families in herder group or PUG that agreed to the RUA and a tally of their livestock numbers.

Annex 2. Map of the contracted rangeland, location, seasonal boundaries.

Annex 3. Ecological site map, related STMs, and carrying capacity information for contracted rangeland.

Annex 4. Assessment sheets having baseline and annual monitoring information.

Together, these annexes allow RUAs to not only legitimize herder's traditional user rights and ownership, but also highlight the herder's responsibility to sustain rangeland health. In addition, Annex 4 is used in evaluating the application of recommended management practices and their impacts that are considered in long-term adaptive management.

Most herders indicate the need to reduce and regulate animal numbers, but do not know how to start and what to do with excess animals. Technical support for herders, including professional extension services, are needed in addition to policies that incentivize stocking rate reductions. Professional extension specialists would be able to advance management from general recommendations toward, locally-tailored solutions. Surveys also indicate that many herders support a permitting system, such as a grazing fee or animal tax, as a tool to manage rangeland use and health.

4.2. Initiatives that support resilience-based rangeland management

To improve the competitiveness and unique selling points of Mongolian livestock products on the international market, the Mongolian National Federation of PUGs has identified the need to setup a traceability and marketplace system with innovative and user-friendly technology that allows for validation of product origin and increased accessibility of sustainably-sourced products..

The Mongolian National Federation of PUGs, with technical support from the Green Gold Animal Health Project in cooperation with key national stakeholders, have been developing a raw material traceability system. The Livestock Raw Material Traceability database/system (LRMT) is linked to the rangeland health monitoring and assessment databases at the National Agency of Meteorology and Environmental Monitoring (NAMEM) and the Agency for Land Management, Geodesy and Cartography (ALMGaC). Livestock raw material quality tracing is based on PUGs and cooperatives of National federation of PUGs. The Mongolian Wool and Cashmere Association and Mongolian Leather Association is facilitating the incorporation of domestic processors into the system. The goal of this effort is to incorporate information on all elements of livestock production systems, including rangelands, animal welfare, animal health, quality of livestock and raw materials and herder gate price (i.e. herder income per kg of raw materials), into the LRMT. The ultimate goal is to improve market access and income of herder households and PUGs by providing a platform to verify the source of origin for raw materials and track their pathways through the supply chain, both downstream and upstream. The first trial has been carried out in Arkhangai and Bayanhongor aimags to trace wool and meat products from yaks and camels. In order to support measures to adjust animal numbers toward a resilient carrying capacity, the National Federation of PUGs in cooperation with the General Authority for Veterinary Services (GAVS) has upgraded the veterinary certificate issuance system with a focus on animal sales, which facilitates traceability of animal origin and health. The main project partners are meat processors, herders' marketing cooperatives, soum departments for animal health, soum private veterinarians and the State Inspection Agency (control posts). As a result of this project, the rate of animal off-take has increased and there are new marketing opportunities based on price premiums for certified products.

Figure 4.2. A recently developed web and mobile traceability application that assists consumers in making environmentally and socially-responsible product choices.

4.3 Case studies of the management impacts of resilience-based rangeland management

Resilience-based rangeland management has been implemented recently. The rate of improvements to rangeland health will necessarily depend on initial rangeland states and variations in the time needed for recovery, weather, and the successful implementation of management plans by herder communities. The management process itself is new in the context of Mongolia and must be improved over time. A key question among herders and scientists is whether or not grazing deferment and rest can promote recovery of desired forage species. Although monitoring for the effects of grazing management is only short-term at this point in time, the case studies below indicate promising responses.

4.3.1 Case of Bayan Uul PUG in Tsahir soum of Arkhangai aimag

In order to implement the grazing management plan of the Bayan Uul PUG, a decree was issued at the bagh citizen's meeting on 16th of April, 2018 to rest several of the PUG's pastures for the period between 15th of May and 20th of August.

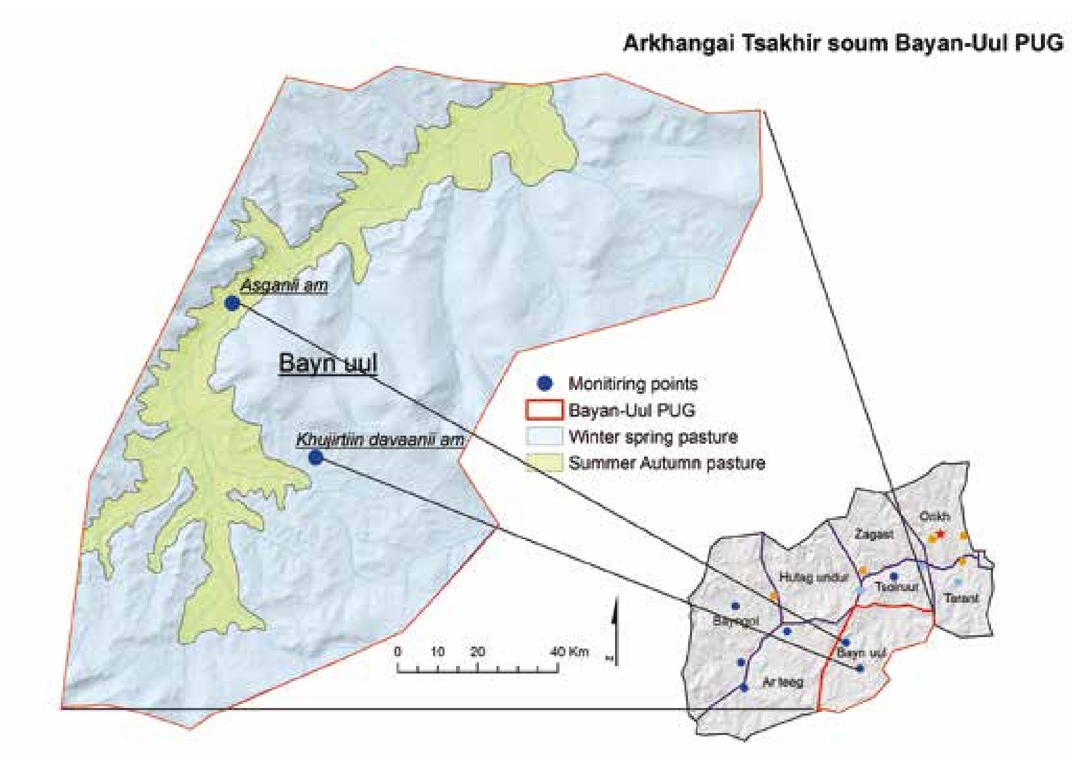


Figure 4.3. Map of Bayan Uul PUG of Tsahir soum, Arkhangai aimag

Bayan Uul PUG has 44,550 ha of rangeland and 8400 ha is used for summer/fall grazing and 36,400 ha is used for winter/spring grazing. As in many other soums, the winter/spring pasture in Khujirtiin davaanii is not rested during the growing season because several herder families from neighboring areas use the area out of season to graze their animals. In response to consultancy meetings initiated by the local government with those herder families, 8573 livestock (23,189 sheep units), were moved to other areas including Zagastiin ekh, Nuuriin ekh and Buurgiin baruun ekh.

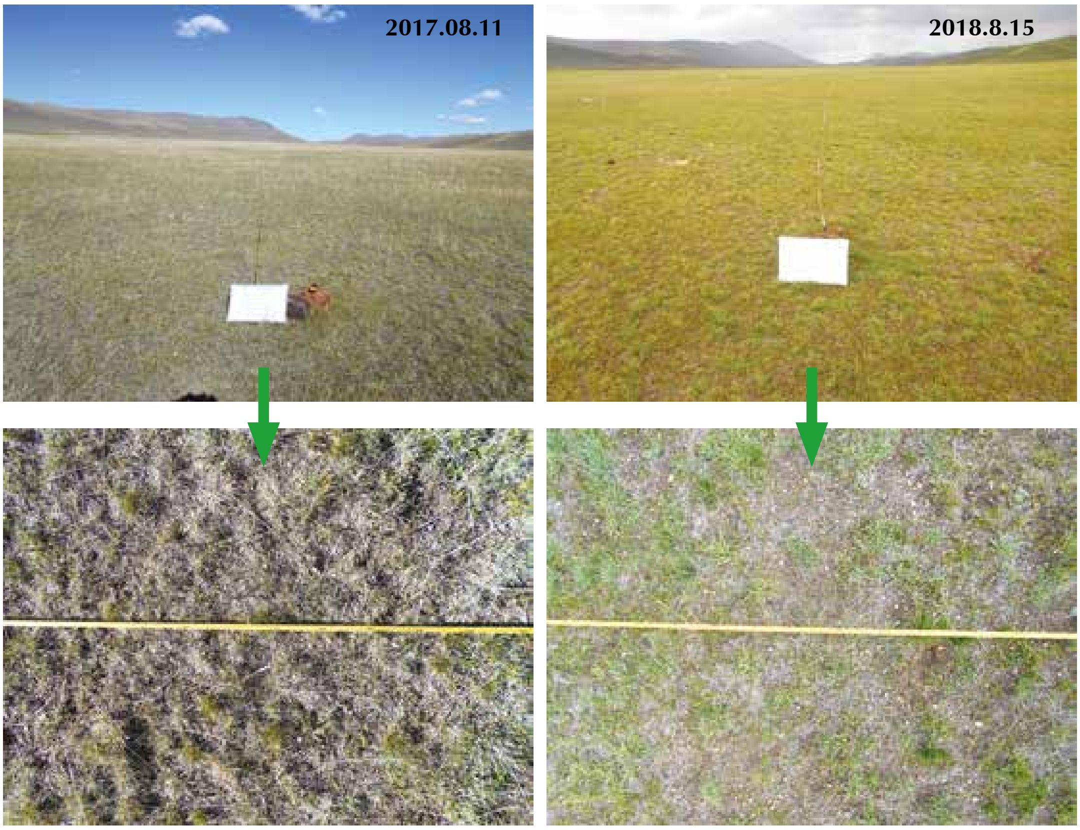


Figure 4.4. "Khujirtiin davaanii ar" photo monitoring site representing winter/spring pasture (photos by D.Batsaikhan, land manager).

The photo monitoring results of 2018 indicate that the cover of perennial grasses and high value, palatable forbs has increased over a single year (Figure 4.5).

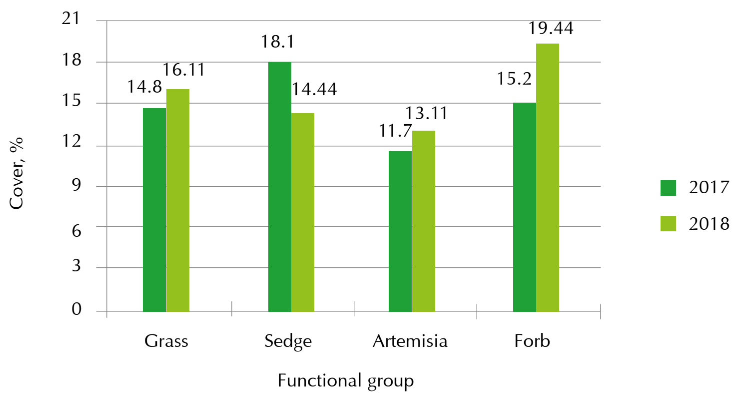


Figure 4.5. Photo monitoring results from 2017 and 2018 in the winter/spring pasture of "Khujirtiin davaanii ar".

4.3.2 Case of the Tokhoi PUG in Zuungobi soum of Uvs aimag

Tokhoi PUG herders have been resting a 12,210 ha winter/ spring pasture for 2 years, from 2016-2017. As a result, the total cover has increased by 10.6 percent while Stipa cover increased by 18.8 percent. The above ground biomass increased from 264 to 412 kg per ha, which translated into a 35.9 percent increase in fodder from 3199.7 to 4993.47 ton per ha.

Figure 4.6. General view of the photo monitoring site of Tokhoi PUG, Zuungobi soum, Uvs aimag in a winter/spring pasture

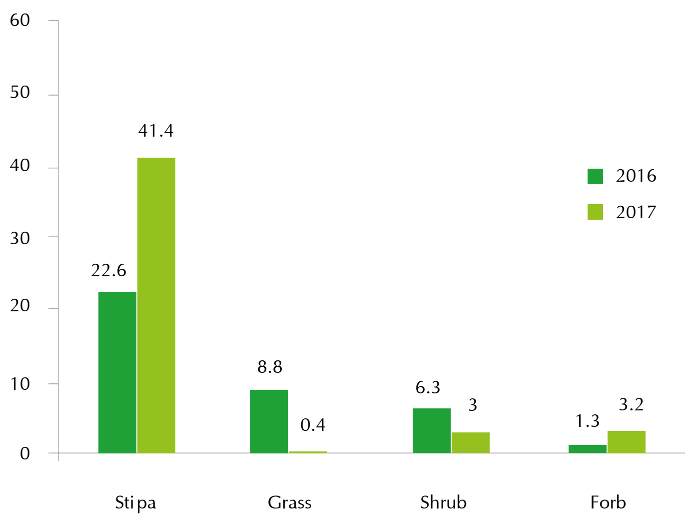


Figure 4.7. Results of 2 years resting as assessed by annual photo monitoring.

4.3.3 Case of Khan Taishir PUG in Khaliun soum of Gobi Altai soum

Herders of the Khan Taishir PUG have been resting 16,700 ha of winter/spring pasture for 2 years, 2016-2017. As a result, the total cover increased by 8,9 percent while Sti pa cover increased by 4.9 percent. The above ground biomass increased from 115 to 236 kg per ha that translates to a 51.2 percent increase in fodder from 1923.1 to 3946.6 ton per ha (Fig.4.8; 4.9; 4.10).

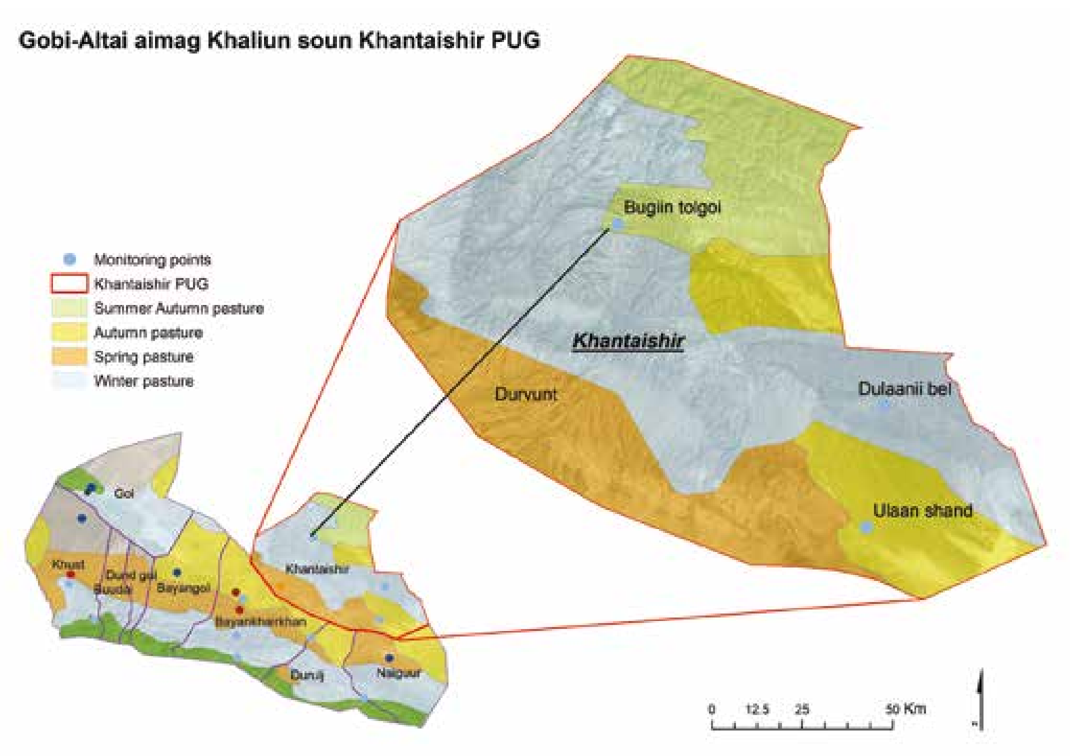


Figure 4.8. Map of Khantaishir PUG of Khaliun soum, Gobi Altai aimag

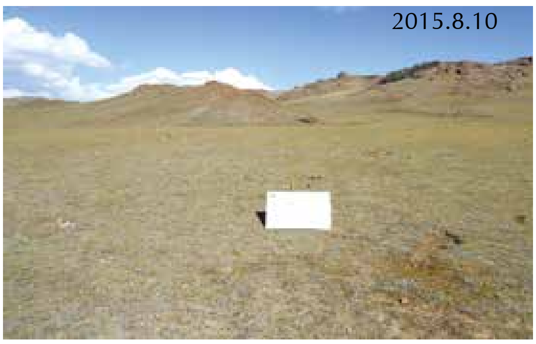


Figure 4.9. General view of photo monitoring sites of Khan Taishir PUG, Khaliun soum, Gobi Altai aimag.

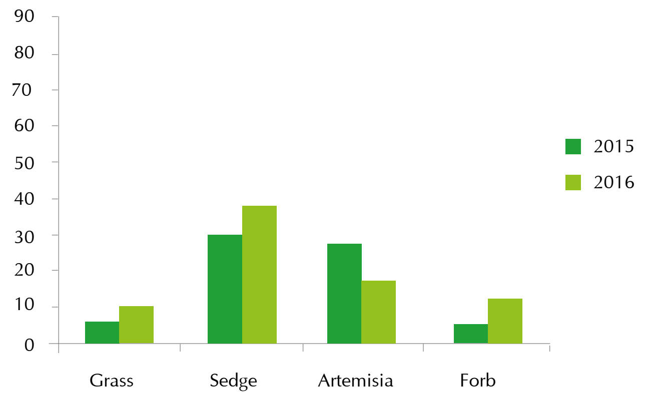


Figure 4.10. Results of 2 years resting as assessed by annual photo monitoring.

CHAPTER 5.

POLICY CONSIDERATIONS FOR RANGELAND HEALTH

5.1 Rangeland health indicators provide a sound basis for herders and local stakeholders to discuss and agree on the relationship between stocking rates, grazing management, and rangeland conditions. They often used to make decisions to adjust animal numbers and enforce rotational grazing plans by organizing sales of extra animals, preparation of additional forage and reserve rangelands for winter. Herders increasingly agree that stocking rate adjustments are needed to sustain or improve rangeland condition. However, because of poor animal health and limited market access, opportunities for off-take are limited. There is an urgent need to improve the quality and marketing of animal and meat products.

5.2 The Ministry of Food, Agriculture, and Light Industry with the support of FAO Mongolia and the Swiss Agency for Development and Cooperation has carried out consultations among herders and local specialists from different regions of Mongolia in 2016 and 2018 on rangeland management issues. Seventy percent of herders and local specialists responded that the most pressing challenge is that number of livestock exceeds rangeland carrying capacity. About 75% of respondents indicate that laws to regulate the use of rangelands are needed. Demand from the grassroots level needs to be addressed urgently in order to curb rangeland degradation.

5.3 The sustainable production of meat, fiber, and other environmental goods and services in Mongolia requires polycentric governance of rangelands, involving local, regional, and national institutions with expertise in rangelands, animal health, marketing, policy, and technology. The organization of herder communities in the form PUGs, the affiliation of PUGs to marketing cooperatives facilitated by the Mongolian National Federation of PUGs, and the use of Rangeland Use Agreements provides a solid platform operationalize a sustainable supply of livestock products from Mongolian rangelands.

5.4 In the relatively short period, the magnitude of rangeland degradation has increased, and the proportion of monitoring sites that were non- to slightly degraded level has decreased by up to 10% while sites classified to a heavily or fully degraded level has increased by 4.3-5.9% t. There is an urgent need to initiate management changes leading to the maintenance and recovery of desired rangeland states. At present, there are opportunities for changes in management and policy that improve rangeland health, that enable adaptation to climate and land use changes, and that secure the future of pastoral production and food security in Mongolia. It is important to act decisively and promptly before those opportunities are lost.

CONCLUSIONS

- Based on the 2016 national rangeland health monitoring data, 57 percent of monitoring sites are altered from a reference condition to some degree and 79 percent of sites have the potential to be recovered within 10 years with reduced stocking rates and changes in grazing and herd management.
- The degradation level of many monitoring sites has increased from 2014-2016, particularly near cities and settlements. The number of highly degraded monitoring sites in which recovery will be prolonged has doubled in the past three years.
- Several steps can be taken to reverse rangeland degradation trends and safeguard herder livelihoods, including targeted reductions of livestock numbers, community adoption of grazing and herd management strategies, management to promote hay and fodder preparation, marketing and policy support to increased animal off-take, increase herd quality, and increased profits, and development of government policies that enable rangeland management.
- A legal environment for establishing community-led resilience-based rangeland management programs is needed to realize the long-term benefits of management.

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ANNEXES

Web annexes
http://tsag-agaar.mn
http://jornada.nmsu.edu/esd/international/mongolia
Web Annex 1. Web based information about conditions of NAMEM monitoring plots.

ANNEX 1.

ECOLOGICAL SITE GROUPS OF FOREST STEPPE ZONE IN MONGOLIA

1. Characteristics of Forest steppe zone

The forest steppe zone covers about 238 108.0 km^{2}, 15.2 percent of the territory of Mongolia, and is one of the most heavily populated areas in Mongolia (Dash D 2003). Forest steppe zone located in north and center of Mongolia (Figure 1).

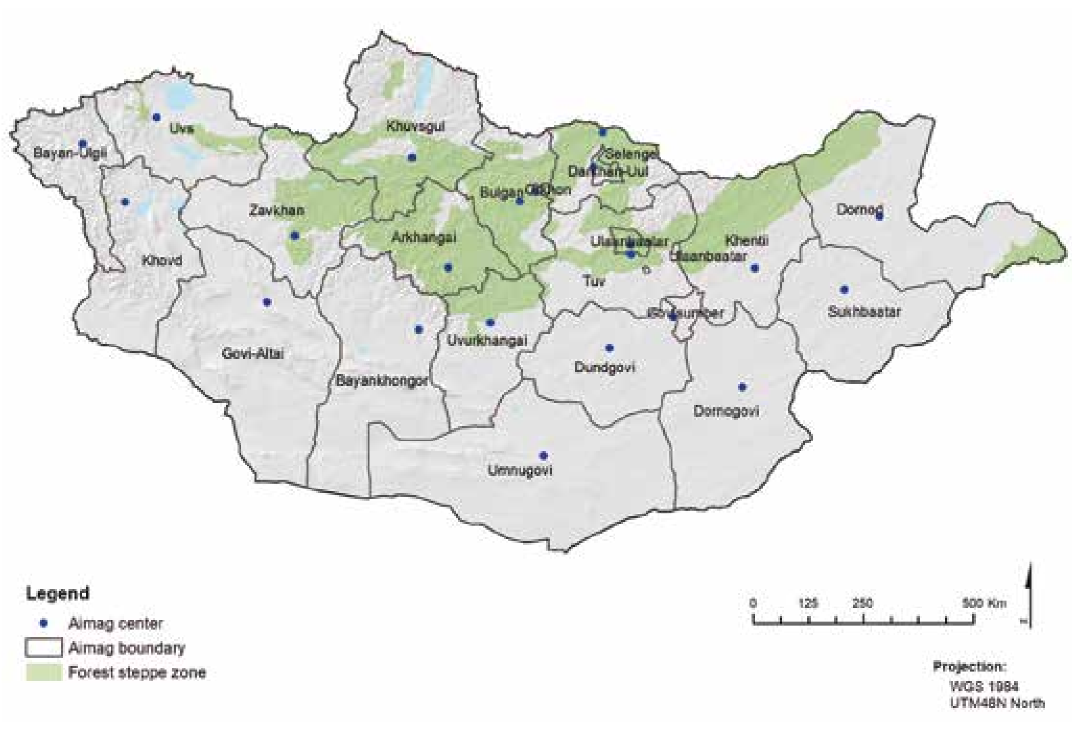

Figure 1. Map of showing location of forest steppe natural zone.

The forest steppe is mainly dominated by perennial grasses Stipa Krylovii, Agropyron cristatum, Cleistogenes squarrosa, Koeleria macrantha, and Festuca lenensis, forbs and sub-shrubs Bupleurum bicaule, Thermopsis dahurica, Artemisia frigida. Wet meadows are located along the rivers. Forest steppe zone is suitable for intensive animal husbandry (Jigjidsuren & Johnson 2003).

1.1 Climatic features

The dissected forest steppe is considered to have a mainland climate. Precipitation is distributed throughout the year with more than about 70% of the annual precipitation occurring during the growing season (from May through August) in Forest steppe. The frost-free period averages about 80 days (growing season). Generally, a very cold winter, spring is windy and dry.

Based on long term data of Tsetserleg station of Arkhangai aimag, annual mean temperatures range from 1.3°C to –7.2°C and the total annual precipitation is approximately 371.25 mm in the forest steppe zone (Table 1; 2).

Some climatic parameters

	Minimum	Maximum
Frost free days:	60	100
Annual precipitation (mm):	263.6	477.1
Annual air temperature (°C)	0.2	2.6

Table 1. Monthly precipitation (mm) and temperature (°C) distribution

	Jun	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Avg	2.2	1.8	3.4	8.6	18.6	52.1	82.5	68.8	28.7	9.7	4.5	3.2
Temp Max	-18.2	-14.7	-6.6	3.8	11.5	17.2	19.5	17.3	10.2	1.1	-9.0	-15.8
Temp Min	-31.5	-27.7	-17.5	-2.5	4.9	10.1	12.2	10.5	4.5	-3.7	-17.7	-27.7

Table 2. Annual precipitation (mm) and annual air temperature (°C) in Tsetserleg soum of Arkhangai aimag (2010-2018).

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Annual precipitation (mm)	340.9	365.6	330.7	263.6	387.3	401.9	428.5	345.7	477.1
Annual air temperature,°C	0.451	0.882	0.172	1.808	0.236	2.028	1.338	2.597	3.282

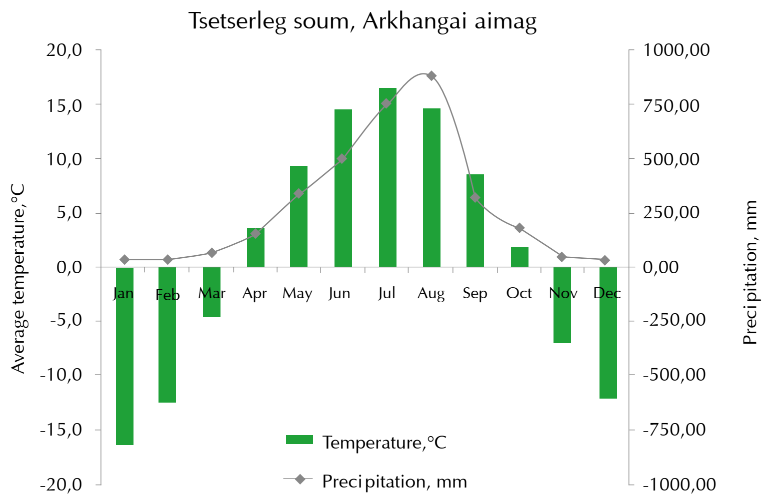

Figure 2. *Climadiagram of Forest steppe zone (2010-2018)*

2. Small bunch grass-Forbs mountain steppe rangeland in Loamy fan ecological site group

2.1 Physiographic features

Landscape position and relatively stable soil characteristics, specially soil physical characteristics texture, structure and depth are used to determine the capacity of the land (Herrick et al. 2013). The Loamy ecological site group is majority occurs through slightly sloping alluvial fans, mountain valleys (Figure 3).

Predominant Landforms: (1) Alluvial fan

(2) Alluvial plain

(3) Mountain valley

Figure 3. Example of landscape position in **Small bunch grass-Forbs mountain steppe rangeland in Loamy fan** ecological site group (Numrug soum, Zavkan aimag).

Table 3. Physiographic features of loamy ecological group

	Minimum	Maximum
Elevation (m)	1,700	2,100
Slope (percent)	0%	20%
Water Table Depth (cm)	>100cm	
Flooding:		
Frequency:	None	None
Duration:	None	Extremely brief

2.2 Representative soil features

Soil core resources of rangeland, soil has developed over time from the parent material, landscape, topography, and climate. These factors are the main factors that determine the ability of ecological sites (Stringham et al. 2003). Soil and landform properties are basic important factors to describe the potential of ecological sites, soil fertility and properties are controlled by of the differences between ecological sites (Duniway et al. 2010).

These soils are typically very deep, well-drained soils that formed in mostly alluvial deposits. Soil texture is very important soil characteristic that drives rangeland plant production and field management (D.Avaadorj, 2014). Because soil texture defines the available moisture and infiltration that is the main factor limits the production in Mongolia.

Surface textures (< 2 mm) usually range from very fine sandy loam to clay loam, and clay content is 18-35%. Soil may contain gravel and/or cobbles, but they will not exceed an average of 35% by volume in the 25-50cm layer. Where an argillic horizon is present, the clay content of the argillic is < 35%.

Figure 4. Example of soil profile and samples from different horizon in the shovel, shows the color of the soil. (Numrug soum, Zavkan aimag).

Table 4. Soil features of loamy ecological group

Soil Depth	>50 cm
Surface texture	FSL - SL - L - SiL - SCL (18 -35% clay, or if <18% clay then < 45% sand)
Sub-surface texture (but within 50 cm)	FSL – SL – L – SiL - SCL (18-35% clay)
Pedoderm (0-3 cm) % volume rock fragments	<35%
Surface horizons % volume rock Fragments	<15%
Sub-surface horizons % volume rock fragments	<35%
Surface effervescence (0-30 cm)	Non – slightly
Subsurface effervescence (30-50 cm)	Non – strongly
Permeability Class (mm/hour)	Moderately slow 50 - Moderately rapid 150

2.3 Plant community characteristics

Small bunch grass-Forbs mountain steppe rangelands (Figure 5) mainly dominated *by grasses such as Festuca lenensis, Koeleria macrantha, Poa attenuate* and *forbs,* for instance *Filifolium sibiricum.* Composition of forbs vary depending on geographical locations; *Polygonum anguistifolium, Eremogone meyerii* are more common in Mongol Altai; while *Eremogone capillaris* in Khangai, Khentii and *Filifolium sibiricum, Potentilla acaulis, P.sericea, Sausurea salicifolia, Stellera chamaejasme, Scutellaria baicalensis* are in Khuvsgul, Mongol Dauria and Khyangan (Tuvshintogtokh, 2014).

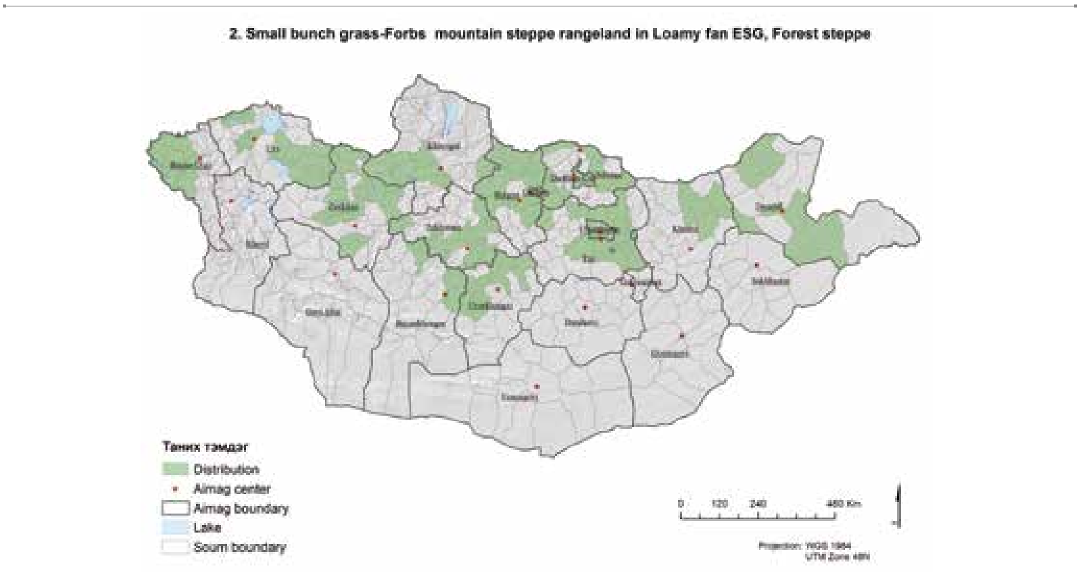

Figure 5. Distribution of the **Small bunch grass-Forbs mountain steppe** rangelands (Source: "State and Transition models for Mongolian rangelands" catalogue)

This type of rangelands cover majority of soums in Khuvsgul, Bulgan, Arkhangai, Uvurkhangai, Tuv, Darkhan, Selenge and east north part of Zavkhan, Bayan Ulgii and eastern soums of Khentii, Dornod. Based on literature reviews and extensive field data the shifts of community phases and states of the **Small bunch grass-Forbs mountain steppe** rangelands with triggers and restoration recommendations are modelled (Fig.6).

Figure 6. State and transition model of the Small bunch grass-Forbs mountain steppe rangeland. Red numbers (I-V): degradation level; Green numbers (I-V): recovery classes; Green lines: restoration paths; Dotted green lines: when the restoration measures are not certain; Red lines: triggers

States of the Small bunch grass-Forbs mountain steppe rangelands

1. Reference state of Small bunch grass-Forbs mountain steppe rangelands

Dominant species: *Koeleria macrantha, Festuca lenensis, Poa attentuata* and *Cleistogenes squarrosa*

Sub dominant species: *Aster alpinus, Bupleurum scorzonerifolia, Ptilotrichum canescens, Pulsatilla turczaninovii*

Key criteria of this state: proportion of dominant perennial grasses > 30 percent by Line-Point Intercept method (Fig.7).

Figure 7. Reference state of ***Small bunch grass-Forbs mountain steppe*** rangelands (Site name: Chirenget in Bayanzurkh bagh, Numrug soum, Zavkhan aimag)

Species composition

Species code	Scientific name	Common name	Foliar Cover %	Basal Cover %
POAT	*Poa attenuate Trin.*	Sunagar bieleg	35.5	8.0
CXDU	*Carex duriuscula C.A.Mey.*	Shireg ulalj	27.0	2.0
VEIN	*Veronica incana L.*	Buural gandbadraa	12.0	8.5
HEHI	*Heteropappus hispidus (Thunbg.) Less.*	Arzgar sogsoot	11.0	0.0
KOMA	*Koeleria macrantha (Ldb.) Schult.*	Tom tsetsegt daagan suul	11.0	3.5
POTBI	*Potentilla bifurca L.*	Imt gichgene	9.5	0.0
ARCH	*Artemisia changaica Krasch.*	Hangain sharilj	9.0	0.0
SMAL	*Smelovskia alba (Pall.) Rgl.*	Tsagaan avlis	8.0	0.0
STKR	*Stipa Krylovii Roshev.*	Kryloviin hyalgana	6.0	1.5
ARFRI	*Artemisia frigida Willd.*	Agi	5.5	2.5
PUBU	*Pulsatilla Bungeana C. A. Mey. var.*	Bungiin yargui	5.0	0.0
POTAC	*Potentilla acaulis L.*	Ishgui gichgene	4.5	3.0
AGCR	*Agropyron cristatum (L.) P. B.*	Saman erhug	3.0	1.5
DRBU	*Dracocephalum Bungeanum Schischk et Serg.*	Bungiin shimeldeg	2.0	0.0
HEAL	*Heteropappus altaicus (Willd.) Novopokr*	Altain sogsoot	1.0	0.0

2. Grass thinned state of Small bunch grass-Forbs mountain steppe rangelands

Dominant species: *Koeleria macrantha, Festuca lenensis, Poa attentuata* and *Cleistogenes squarrosa.* Grass cover is reduced and vary between 20 and 30 percent.
Subdominants: Forbs such as *Veronica incana, Cymbaria dahurica, Potentilla acaulis* and cover of *Carex duriuscula* has a slight increase (Fig. 8).

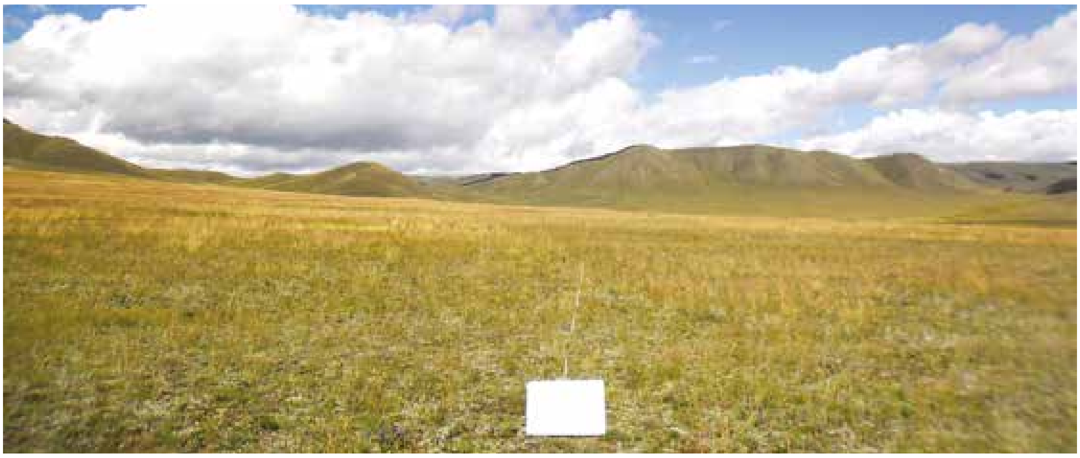

Figure 8. Carex duriuscula-grass community (Site name: Gogsog, Tsetserleg soum, Khuvsgul aimag)

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
VEIN	*Veronica incana L.*	Buural gandbadraa	2016	18.5	1.0
ARFRI	*Artemisia frigida Willd.*	Agi	2016	18.0	1.0
CXPED	*Carex pediformis C.A. Mey.*	Zogdor ulalj	2016	16.5	0.0
ASALP	*Aster alpinus L.*	Tagiin gol geser	2016	11.0	2.0
POAT	*Poa attenuate Trin.*	Sunagar bieleg	2016	10.0	1.0
KOMA	*Koeleria macrantha (Ldb.) Schult.*	Tom tsetsegt daagan suul	2016	7.0	0.0
POTBI	*Potentilla bifurca L.*	Imt gichgene	2016	7.0	0.0
STKR	*Stipa Krylovii Roshev.*	Kryloviin hyalgana	2016	7.0	0.5
POTAC	*Potentilla acaulis L.*	Ishgui gichgene	2016	4.5	0.0
EPSI	*Ephedra sinica Stapf*	Nangiad zeergene	2016	3.5	0.0
AGCR	*Agropyron cristatum (L.) P. B.*	Saman erhug	2016	1.5	0.0
LEOC	*Leontopodium ochroleucum Beauvd.*	Tsaivar shargal tsagaan-turuu	2016	1.5	0.0
TRLA	*Thermopsis lanceolata R.BR.*	Yulden tarvagan shiir	2016	1.0	0.0

3. Dominant species replaced state of Small bunch grass-Forbs mountain steppe rangelands

Dominants species: *Carex duriuscula*
Subdominant species: *Cleistogenes squrrosa, Leymus chinensis, Stipa krylovii*
Species such as *Artemisia frigida*, Potentilla *acaulis, Potentilla bifurca* has high cover.
Proportion of the *Carex duriuscula* is 15-30% and subdominants are below 15 % (Fig. 9).

Figure 9. *Carex duriuscula-Grass community* (Site name: Zuunturuu, Bulgan soum, Bulgan aimag)

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
CXDU	*Carex duriuscula C.A.Mey.*	Shireg ulalj	2016	37.5	17.0
CLSQ	*Cleistogenes squarrosa (Trin.) Keng.*	Derveen hazaar uvs	2016	32.0	27.0
ARFRI	*Artemisia frigida Willd.*	Agi	2016	17.0	12.0
STKR	*Stipa Krylovii Roshev.*	Kryloviin hyalgana	2016	13.0	4.0
HEHI	*Heteropappus hispidus (Thunbg.) Less.*	Arzgar sogsoot	2016	9.5	7.5
POTAC	*Potentilla acaulis L.*	Ishgui gichgene	2016	8.0	8.0
VEIN	*Veronica incana L.*	Buural gandbadraa	2016	3.0	3.0
ARLA	*Artemisia laciniata Willd.*	Salbant sharilj	2016	2.0	2.0
ANIN	*Androsace incana Lam.*	Buural dalan tovch	2016	1.5	1.5
TABR	*Taraxacum brevirostre Hand.-Mazz.*	Bogino shontont bagvaahai	2016	1.0	1.0
POTBI	*Potentilla bifurca L.*	Imt gichgene	2016	0.5	0.5

4. Degraded state of Small bunch grass-Forbs mountain steppe rangelands

Dominant species: *Carex duriuscula, Artemisia frigida, Artemisia adamsii, Potentilla acaulis and P.bifurca*). Proportion of the *Carex duriuscula* is higher than 20 % (Fig. 10).

Figure 10. *Carex duriuscula with degradation indicator species community* (Site name: Duganii khoid am, Bornuur soum, Tuv aimag)

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
ARAD	*Artemisia Adamsii Bess.*	Adamsiin sharilj	2016	52.5	0.5
CXDU	*Carex duriuscula C.A.Mey.*	Shireg ulalj	2016	36.5	0.0
HEHI	*Heteropappus hispidus (Thunbg.) Less.*	Arzgar sogsoot	2016	2.5	0.0
ARFRI	*Artemisia frigida Willd.*	Agi	2016	2.0	0.5
POTAC	*Potentilla acaulis L.*	Ishgui gichgene	2016	0.5	0.0
CLSQ	*Cleistogenes squarrosa (Trin.) Keng.*	Derveen hazaar uvs	2016	0.0	0.0

2.4 Reference for the Small bunch grass-Forbs mountain steppe rangelands

Table 5. Species composition of the reference community

Functional groups	Species code	Scientific names	Mongolian names	Foliar cover, %	Basal cover, %
Grass	POAT	*Poa attenuate Trin.*	Сунагар биелэг	35.5	8.0
	KOMA	*Koeleria macrantha (Ldb.) Schult.*	Том цэцэгт дааган сүүл	11.0	3.5
	STKR	*Stipa Krylovii Roshev.*	Крыловын хялгана	6.0	1.5
	AGCR	*Agropyron cristatum (L.) P. B.*	Саман ерхөг	3.0	1.5
Forb	PUBU	*Pulsatilla Bungeana C. A. Mey. var.*	Бунгийн яргуй	5.0	0.0
	SMAL	*Smelovskia alba (Pall.) Rgl.*	Цагаан авлис	8.0	0.0
	POTBI	*Potentilla bifurca L.*	Имт гичгэнэ	9.5	0.0
	ARCH	*Artemisia changaica Krasch.*	Хангай шарилж	9.0	0.0
	ARFRI	*Artemisia frigida Willd.*	Агь	5.5	2.5
	POTAC	*Potentilla acaulis L.*	Ишгүй гичгэнэ	4.5	3.0
	DRBU	*Dracocephalum Bungeanum Schischk et Serg.*	Бунгийн шимэлдэг	2.0	0.0
	HEAL	*Heteropappus altaicus (Willd.) Novopokr*	Алтайн согсоолж	1.0	0.0

Table 6. Maximum and Minimum cover of reference community

	Minimum level	Maximum level
Total cover, %	74.5	100
Total basal cover, %	0	20.1
Species richness	14	33
Bare soil, %	0	15
Litter cover, %	5.6	60.5

Table 7. Production of reference community in kg/ha by functional groups

Functional groups	Standing biomass, кg/ha	
	Min	Max
Grass	16	53.4
Shrubs, semishrubs	60	120
Artemisia frigida	74	120
Forbs	240	300
Annuals and bi-annuals	13.6	36
Sedge	3	30

3. Recovery of degraded state of Small bunch grass-Forbs mountain steppe rangelands in Forest steppe zone

As monitoring records show, rangelands degraded by different level in different regions are in recovery. Small bunch grass-forbs mountain steppe rangelands at the Arslan Tolgoi site in Yaruu soum of Zavkhan aimag had recovered in 3 years from State 3 to State 1 (Fig.11; Fig. 12).

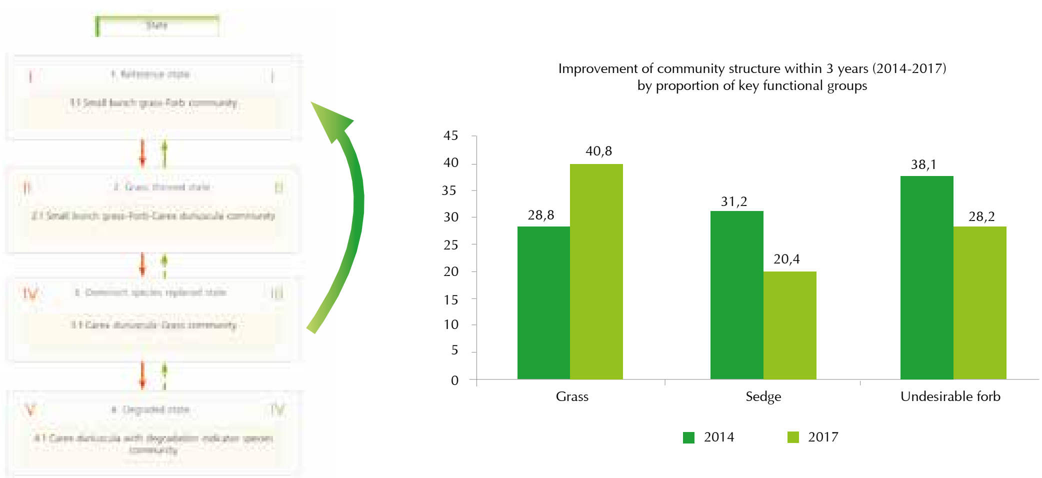

Figure 11. Recovery of degraded state of Small bunch grass-Forbs mountain steppe rangelands in 3 years.

Figure 12. Comparison of Small bunch grass-Forbs mountain steppe rangelands states in reporting years; A. Carex duriuscula-Grass community - 2014; B. Small bunch grass-Forb community- 2017

ANNEX 2.

ECOLOGICAL SITE GROUPS OF STEPPE ZONE IN MONGOLIA

1. Characteristics of steppe zone

The steppe zone covers about 22.05 percent of the territory of Mongolia, and it shares a significant area in Eurasian steppe (Figure 1).

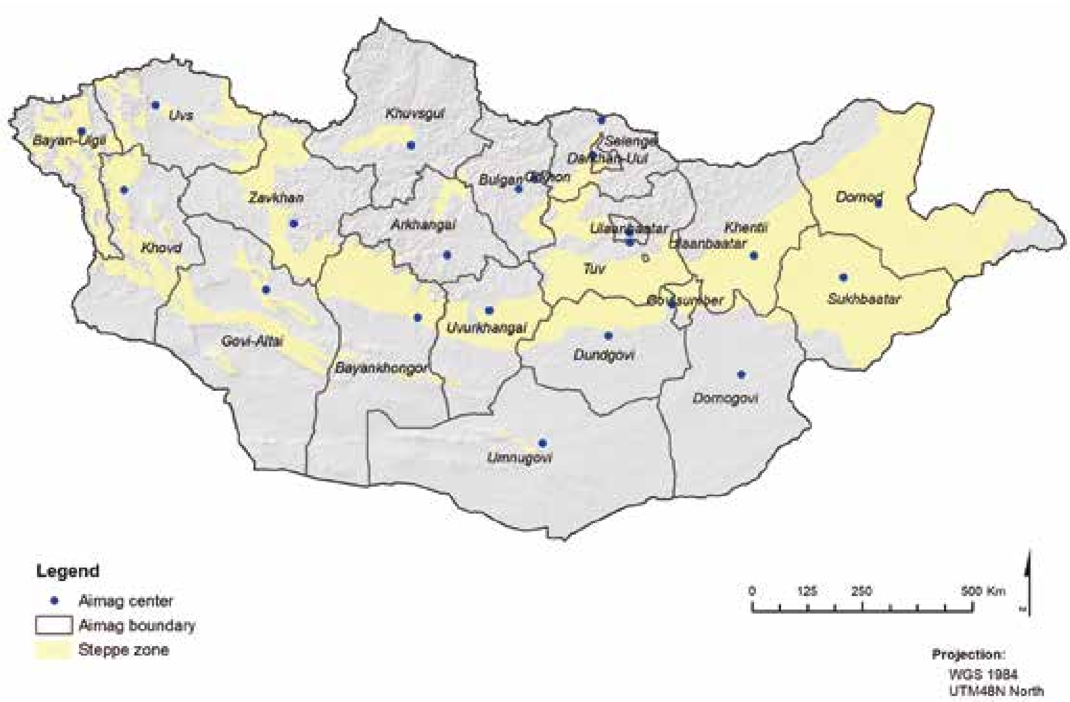

Figure 1. Map of showing location of dry steppe zone.

Mongolian dry steppe is dominated by perennial grasses *Stipa krylovii, Cleistogenes squarrosa, Stipa grandis, Leymus chinensis, Agropyron cristatum; Caragana spp. shrubs Caragana microphylla, C.stenophylla* and *C.pygmaea and semishrubs Ptilotrichum canescens, Kochia prostrata, Artemisia frigida* and *A.Adamsii.* Compare to other sedges *Carex duriuscula* is more commonly distributed. Forbs *Cymbaria dahurica, Haplophyllum dauricum, Bupleurum bicaule, Potentilla acaulis, P.bifurca, P.sericea, Convolvulus ammanii, Serratula centauroides and Allium sp* are in relatively high cover (Tuvshintogtokh, 2014).

1.1 Climatic features

Based on long term data source from Bayan soum meteorology station of Tuv aimag, annual mean temperatures ranges between 3.9°C to –1.4°C and the total annual precipitation is approximately 226.48 mm in steppe zone (Table 1; 2& Figure 2).

Some climatic parameters

	Minimum	Maximum
Annual effective precipitation (mm):	163.7	300.8
Annual air temperature (°C)	-2.325	3.96

Table 1. Annual effective precipitation (mm) and annual air temperature (°C) in Bayan soum of Tuv aimag (2010-2018).

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Annual precipitation (mm)	194.4	273.7	256	183.7	300.8	163.7	207.8	203	255
Annual air temperature,°C	-1.70	-1.33	-2.325	-1.11	0.30	0.53	-0.608	1.01	3.96

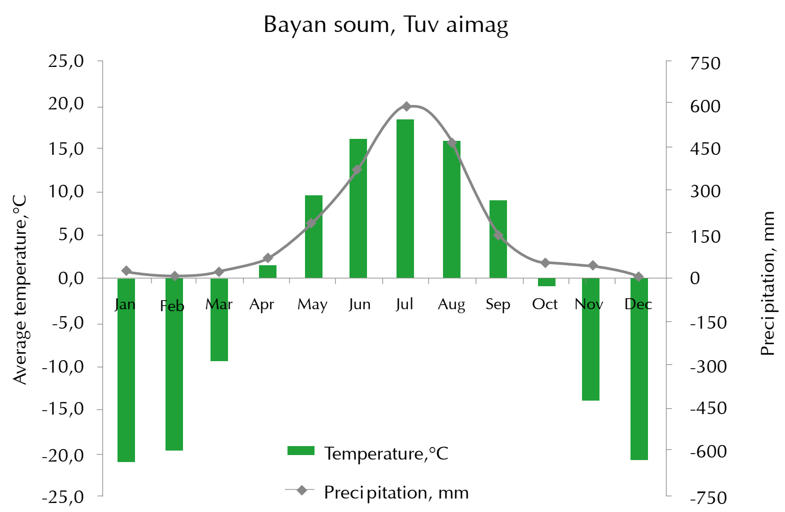

Figure 2. Climadiagram of dry steppe zone (Bayan soum, Tuv aimag; 2010-2018)

2. Stipa krylovii-grass dry steppe rangeland in sandy loam alluvial fan and plain

2.1 Physiographic features

Figure 3. Example of landscape position in Stipa krylovii-Grass dry steppe rangeland (Buren soum, Tuv aimag)

2.2 Representative soil features

Surface textures (< 2 mm) usually range from sandy loam to sandy clay loam, and clay content is less than 18% and sand is higher than 50%. Soil may contain gravel and/or cobbles, but they will not exceed an average of 35% by volume in all layer (Figure 4, Table 2).

Figure 4. Example of soil profile and samples from different horizon in the shovel shows the color of the soil. (Bayan soum, Tuv aimag).

Table 2. Soil features of sandy loam ecological group

Soil Depth	>50 cm
Surface texture	FSL - SL - L - SiL - SCL (18 -35% clay, or if <18% clay then < 45% sand)
Sub-surface texture (but within 50 cm)	FSL – SL – L – SiL - SCL (18-35% clay)
Pedoderm (0-3 cm) % volume rock fragments	<35%
Surface horizons % volume rock Fragments	<15%
Sub-surface horizons % volume rock fragments	<35%
Surface effervescence (0-30 cm)	Non – slightly
Subsurface effervescence (30-50 cm)	Non – strongly
Permeability Class (mm/hour)	Moderately slow 50 - Moderately rapid 150

2.3 Plant community characteristics

Stipa krylovii-Grass dry steppe rangeland in Sandy loam alluvial fan and plain mainly dominated by grasses such as *Stipa krylovii, Koeleria cristata, Cleistogenes squarrosa, Agropyron cristatum, Stipa baicalensis, Poa attenuata* forbs such as *Thalictrum foetidum, Arctogeron gramineum, Aster alpines, Chamaerhodos trifida, Potentilla sericea,* and shrubs such as *Caragana microphylla, Caragana stenophylla, Cotoneaster melanocarpa, Spiraea aquilegifolia, Ribes diacantha (Tuvshintogtokh, 2014).*

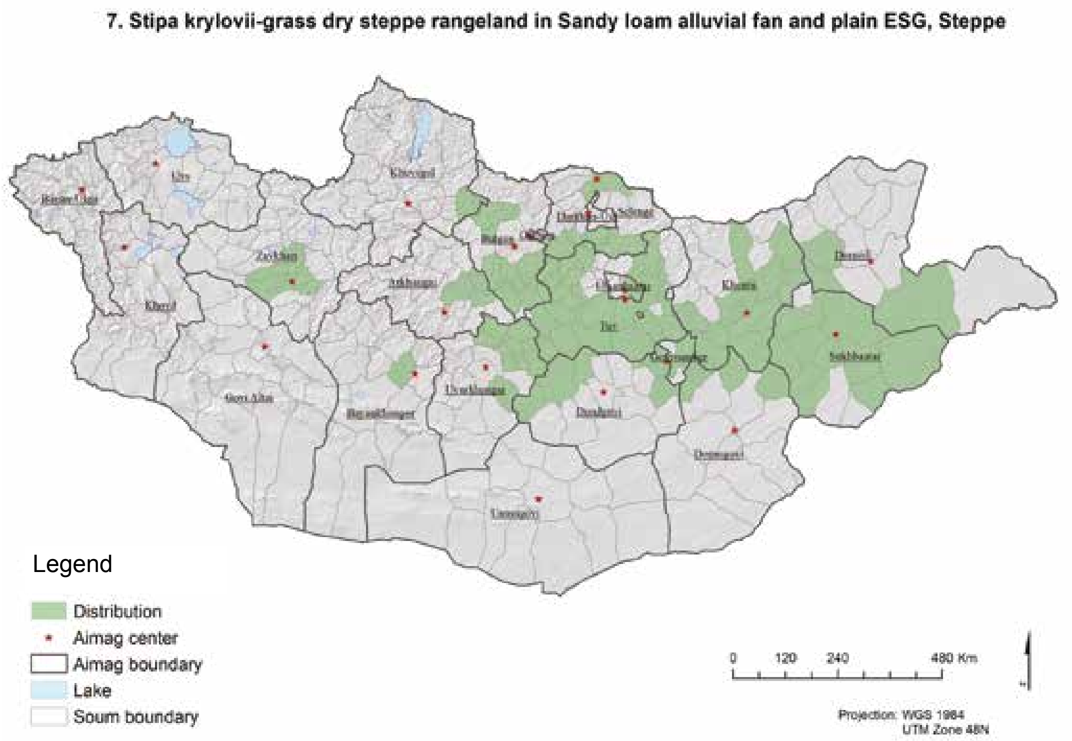

Figure 5. Distribution of the Stipa krylovii-Grass dry steppe rangeland rangelands (Source: "State and Transition models of Mongolian rangeland" catalogue)

This type of rangelands cover majority of soums in Tuv, Khentii, Sukhbaatar, Bulgan Uvurkhangai aimags. Stipa krylovii-Grass dry steppe rangeland has 4 alternative states (Fig. 5, 6).

Based on literature reviews and field data the shifts of community phases and states of Stipa krylovii-Grass dry steppe rangeland with triggers and restoration recommendations are modelled (Fig.6).

Figure 6. State and transition model of the Stipa krylovii-Grass dry steppe rangeland. Red numbers (I-V): degradation level; Green numbers (I-V): recovery classes; Green lines: restoration paths; Dotted green lines: when the restoration measures are not certain; Red lines: triggers.

States of the Stipa krylovii-Grass dry steppe rangeland in Sandy loam alluvial fan and plain ESG, Steppe

1. Stipa krylovii dominated reference state of Stipa krylovii-Grass dry steppe rangeland

Stipa krylovii: >30%.
Total Grass cover (*Agropyron cristatum, Cleistogenes squarrosa:* 10-20%. Proportion of sub shrubs (*Artemisia frigida, Kochia prostrata*) and *Convolvulus ammanii* <1%. Dominant species: *Agropyron cristatum, Cleistogenes squarrosa.* Sub dominants species*: Stipa krylovii* (Fig. 7).

Figure 7. Stipa krylovii dominated reference state (Site name: Undurshireet soum, Tuv aimag)

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
STKR	*Stipa Krylovii Roshev.*	Kryloviin hyalgana	2016	54.5	12.0
CLSO	*Cleistogenes squarrosa*	Derveen hazaar uvs	2016	16.0	8.5
ARFRI	*Artemisia frigida Willd.*	Agi	2016	14.0	5.5
CHAL	*Chenopodium album L.*	Tsagaan luuli	2016	14.0	1.0
CXDU	*Carex duriuscula C.A.Mey.*	Shireg ulalj	2016	4.0	1.0
ALLBI	*Allium bidentatum*	Shudlig songino	2016	1.5	0.5
CARST	*Caragana stenophylla Pojark.*	Nariin navchit hargana	2016	1.5	0.0
POTAC	*Potentilla acaulis L.*	Ishgui gichgene	2016	1.5	0.5
SACOL	*Salsola collina Pall.*	Tolgodiin budargana	2016	1.5	0.0
EPEQ	*Ephedra equisetina Bge.*	Shivleehei zeergene	2016	1.0	0.5
HEHI	*Heteropappus hispidus (Thunbg.) Less.*	Arzgar sogsoot	2016	1.0	0.0

2. Grass thinned state of Stipa krylovii-Grass dry steppe rangeland

Stipa krylovii: 5-10%,
Artemisia frigida: 5-15%,
Grasses (*Agropyron cristatum, Cleistogenes squarrosa*): 5-15%,
Artemisia Adamsii, *Convolvulus ammanii* : 1-5% (Fig. 8).

Figure 8. Grass-Artemisia frigida-Carex duriuscula community (Site name: Teeg, Buren soum, Tuv aimag

3. Artemisia frigida dominated state of Stipa krylovii-Grass dry steppe rangeland

Dominant species: *Artemisia frigida or Kochia prostrata* >20%,
Carex duriuscula: >15%.
Subdominant species: *Cleistogenes squrrosa, Leymus chinensis* and *Caragana pygmaea* has high presence (Fig. 9).

Figure 9. Artemisia frigida-Carex duriuscula-Grass community (Site name: Bichigt, Buren soum, Tuv aimag

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
CXDU	*Carex duriuscula C.A.Mey.*	Shireg ulalj	2016	62.0	20.0
ARFRI	*Artemisia frigida Willd.*	Agi	2016	25.0	11.0
CHAL	*Chenopodium album L.*	Tsagaan luuli	2016	20.0	6.5
STKR	*Stipa Krylovii Roshev.*	Kryloviin hyalgana	2016	11.0	1.5
CLSO	*Cleistogenes songorica (Roshev.) Ohwi.*	Zuungariin hazaar uvs	2016	8.5	3.0
SACOL	*Salsola collina Pall.*	Tolgodiin budargana	2016	1.0	0.0
CARST	*Caragana stenophylla Pojark.*	Nariin navchit hargana	2016	0.5	0.0

4. Degraded state of Stipa krylovii-Grass dry steppe rangeland

Dominant species: *Carex duriuscula, Artemisia frigida, Artemisia adamsii*. Proportion of Artemisia frigida and Artemisia Adamsii up to 20% and even 40 %. The presence of degradation indicators such as *Salsola collina, Convolvulus ammanii,* Chenopodium *album, Potentilla bifurca, Heteropappus hispidus* increases (Fig. 10).

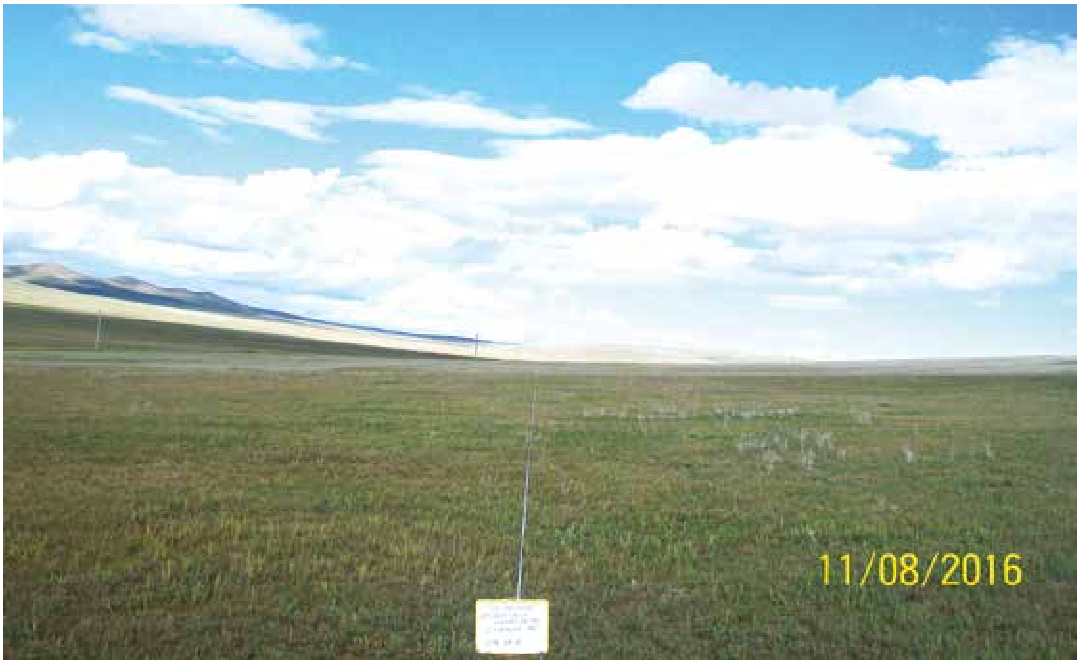

Figure 10. Artemisia-Carex duriuscula with degradation indicator species (Site name: Khogiin tolgoi, Argalant soum, Tuv aimag)

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
CXDU	*Carex duriuscula C.A.Mey.*	Shireg ulalj	2016	38.5	2.0
ARAD	*Artemisia Adamsii Bess.*	Adamsiin sharilj	2016	18.0	0.0
ARFRI	*Artemisia frigida Willd.*	Agi	2016	1.0	0.0
CHVU	*Chenopodium vulvaria L.*	Umhii luuli	2016	1.0	0.0

3. Reference for the stipa krylovii-grass dry steppe rangeland

Table 3. Species composition of the reference community

Species code	Scientific name	Mongolian name	Foliar cover %	Basal cover, %
STKL	*Stipa Klemenzii Roshev.*	Клеменцийн хялгана	13.0	3.8
STKR	*Stipa Krylovii Roshev.*	Крыловын хялгана	34.0	8.0
AGCR	*Agropyron cristatum (L.) P. B.*	Саман ерхөг	5.5	1.7
CLSQ	*Cleistogenes squarrosa (Trin.) Keng.*	Дэрвээн хазаар өвс	1.1	0.4
ELCHN	*Elymus chinensis (Trin.) Keng.*	Нангиад түнгэ	4.6	0.1
KOMA	*Koeleria macrantha (Ldb.) Schult.*	Том цэцэгт дааган сүүл	4.0	0.3
POAT	*Poa attenuate Trin.*	Сунагар биелэг өвс	1.5	1.0
CXDU	*Carex duriuscula C.A.Mey.*	Ширэг улалж	7.2	1.5
CXKO	*Carex Korshinskyi Kom.*	Коржинскийн улалж	4.0	0.0
COAM	*Convolvulus Ammanii Desr.*	Амманы сэдэргэнэ	2.3	0.8
CYDH	*Cymbaria dahurica L.*	Дагуур хатны цэцэг	0.8	0.2
ASGA	*Astragalus galactites Pall.*	Цагаан хунчир	3.0	1.0
HADA	*Haplophyllum dauricum (L.) G. Don*	Дагуур хүж өвс	0.5	0.0
HEHI	*Heteropappus hispidus (Thunbg.) Less.*	Арзгар согсоолж	1.5	0.0
POTAC	*Potentilla acaulis L.*	Ишгүй гичгэнэ	1.5	1.5
PUTU	*Pulsatilla Turczaninovii Kryl. et Serg.*	Турчаниновын яргүй	1.0	0.5
ALLBI	*Allium bidentatum Fisch. ex Prokh.*	Шүдлиг сонгино	1.4	0.4
ALLPO	*Allium polyrrhizum Turcz. ex RgL.*	Таана	1.0	0.0
ARAD	*Artemisia Adamsii Bess.*	Адамсын шарилж	3.2	0.2
ARFRI	*Artemisia frigida Willd.*	Агь	10.2	3.8
ARRUT	*Artemisia rutifolia Steph. ex Spreng.*	Шаргар шарилж	2.5	2.5
EPSI	*Ephedra sinica Stapf*	Нангиад зээргэнэ	0.5	0.5
EUCE	*Eurotia ceratiodes (L.) C. A. Mey*	Орог тэсэг	1.0	0.5
KOPR	*Kochia prostrata (L.) Schrad.*	Дэлхээ тогторгоно	11.0	1.0
PTCA	*Ptilotrichum canescens C.A.Mey.*	Бууралдуу янгиц	1.0	0.0
CARMI	*Caragana micropylla (Pall.) Lam.*	Жижиг навчит харгана	3.0	0.0
CARPY	*Caragana pygmaea (L.) DC.*	Тарваган харгана	1.4	0.1
CARST	*Caragana stenophylla Pojark.*	Нарийн навчит харгана	1.7	0.0
CHAL	*Chenopodium album L.*	Цагаан лууль	28.0	1.5
SACOL	*Salsola collina Pall.*	Толгодын бударгана	8.7	0.3
ARSC	*Artemisia scoparia Waldst. et Kit.*	Ямаан шарилж	0.5	0.0

Table 4. Maximum and Minimum cover of reference community

	Minimum	Maximum
Total cover, %	30	80
Total basal cover, %	0.5	7
Species richness	4	13
Bare soil, %	5	20
Litter cover, %	4	50

Table 5. Production of reference community in kg/ha by functional groups

Functional groups	Standing biomass, c/ha	
	Minimum	Maximum
Stipa	2.77	3.53
Sedge	0.29	0.40
Perennial grasses	0.85	0.86
Shrubs, semishrubs	0.82	1.34
Artemisia frigida	1.22	1.81
Sages	2.51	0.94
Forbs	0.84	1.00
Annuals, biannuals	0.15	0.41

4. Recovery of degraded rangelands in steppe zone

According to the long term monitoring data from sites that are properly managed (resting and stocking rate adjustment) in Undurshireet soum of Tuv aimag, the Stipa krylovii-grass with Caragana steppe rangeland in Deep sandy alluvial plain at the Kharganatiin hooloi site in Bayanbulag bagh in Undurshireet has been recovered from state 3 with moderate degradation in 5 year (2013-2018). Due to proper grazing management, cover of key functional groups had a significant increase (from 30.3 to 41.5 percent) and especially proportion of the Stipa krylovii, a key grass specie increases by more than 6 times. This result is supporting the recovery class concept that says for the State 3 ''plant community is altered and may take 5-10 growing seasons to be recovered with changed management (Fig. 11).

Figure 11. Recovery of degraded states of Stipa krylovii-grass with Caragana steppe rangeland

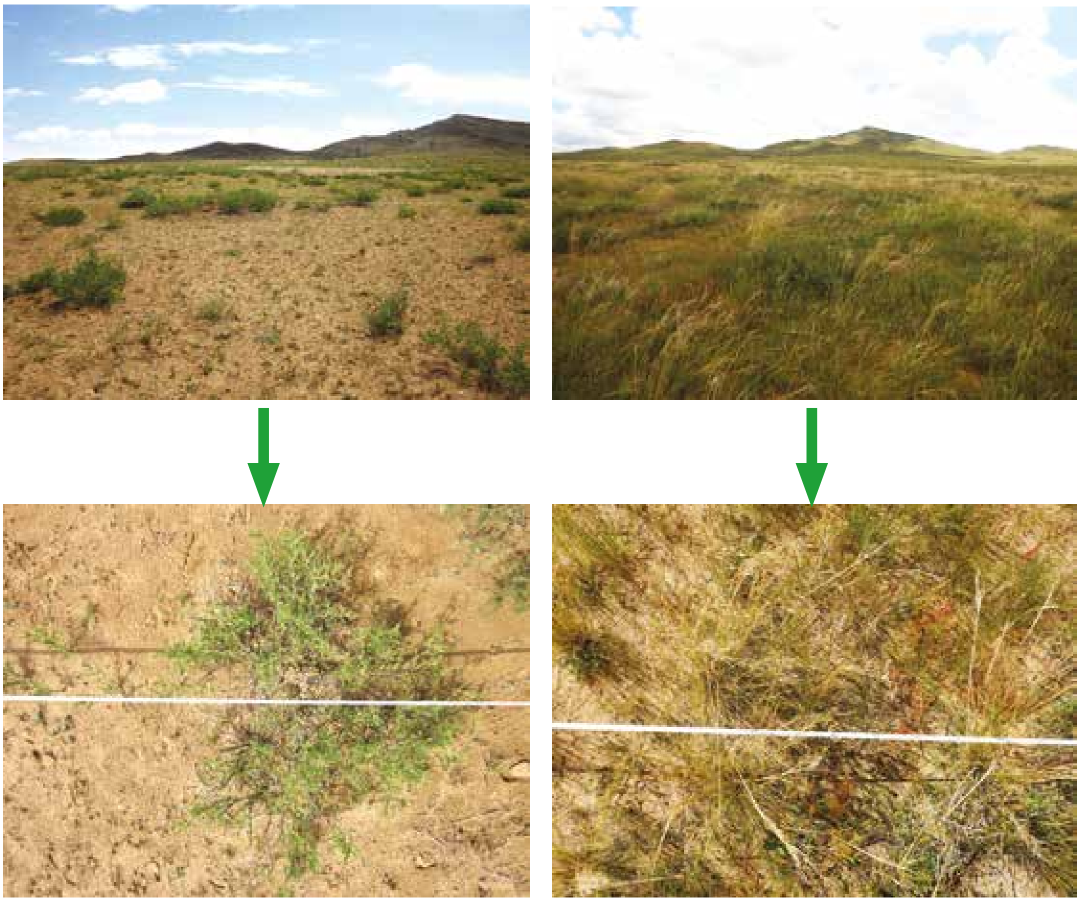

Figure 12. Comparison of Sti pa krylovii-grass with Caragana steppe rangeland states in reporting years; A. Dominant species replaced state - 2013; Б. Grass dominated reference state- 2018

ANNEX 3.

ECOLOGICAL SITE GROUPS OF DESERT STEPPE ZONE IN MONGOLIA

1. Characteristics of desert steppe zone

The desert steppe zone covers all the area being having dominated by *Stipa gobica, S.glareosa, S.brevifolia*. As A.A.Yunatov (1974) noted, except these Stipa spp. *Cleistogenes soongorica and Allium polyrhizum* are also the key indicators for this zone (Fig 1).

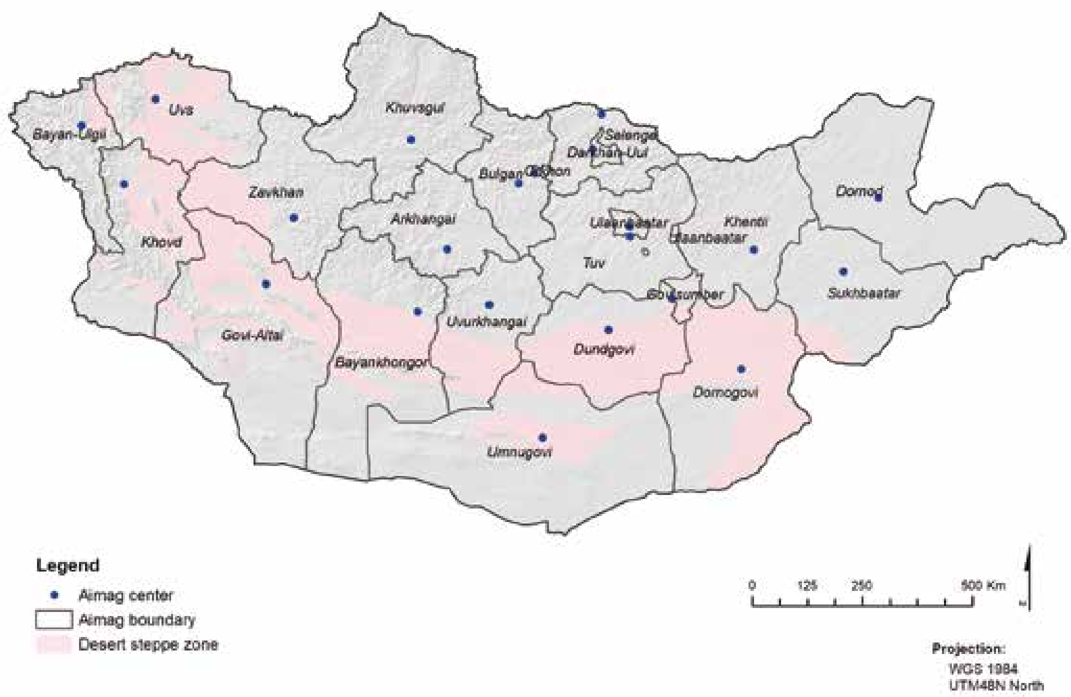

Figure 1. Map of showing location of desert steppe zone.

Desert steppe is dominated by perennial grasses (*Stipa gobica, S.glareosa, S.brevifolia, Cleistogenes soongarica*, onion (*Allium polyrhizum*), shrubs (*Caragana pygmaea, C.leucophloea, C.bungei, C.korshinskyi, Krascheninnikovia ceratoides*) and semishrubs (*Artemisia rutifolia, A.xanthochloa, A.santolinifolia, A.pychnoriza*). Sub dominants are a semishrubs such as *Artemisia frigida, A.caespitosa, A.xerophytica, Anabasis brevifolia, Salsola passerina, Convolvulus gortschakovii, Ajania achilloides, A.trifida, Reaumuria soongorica, Asterthamnus heteropappoides*. Other sub shrubs such as *Oxytropis aciphylla, Ptilotrichum canescens, Kochia prostrata, forbs Allium mongolicum, Gypsophilla desertorum, Convolvulus ammanii, Lagochilus ilicifolius, Scorzonera divaricata, Aster hispidus, Asparagus gobicus* and annuals (*Salsola pestifera, S.collina, Artemisia scoparia, Neopalassia pectinata) are present* (Tuvshintogtokh, 2014).

1.1. Climatic features

Based on long term data source from the meteorology station of Tsogt-Ovoo soum, Umnugobi aimag annual mean temperatures range between 3.1°C-8.1°C and the total annual precipitation is about 110.7 mm in desert steppe zone (Table 1 & Figure 2).

Some climatic parameters

	Minimum	Maximum
Annual precipitation (mm):	60.1	205
Annual air temperature (°C)	3.83	8.16

Table 1. Annual precipitation (mm) and annual air temperature (°C) in Tsogt ovoo soum of Umnugobi aimag (2010-2018).

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Annual precipitation (mm)	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7	98.7
Annual air temperature,°C	4.16	3.83	4.08	5.52	6.67	3.89	4.67	5.88	8.16

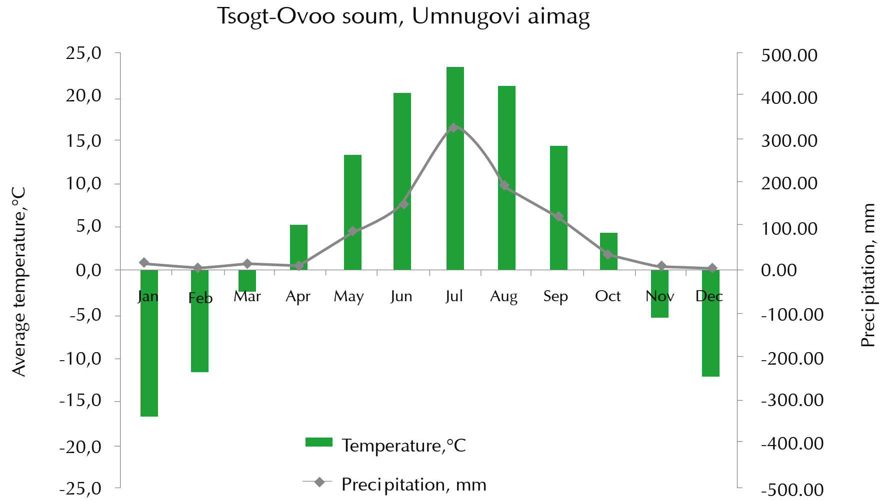

Figure 2. Climadiagram of desert steppe zone (Tsogt-Ovoo soum, Umnugovi; 2010-2018)

2 Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland in Sandy plain ESG, Desert steppe

2.1 Physiographic features

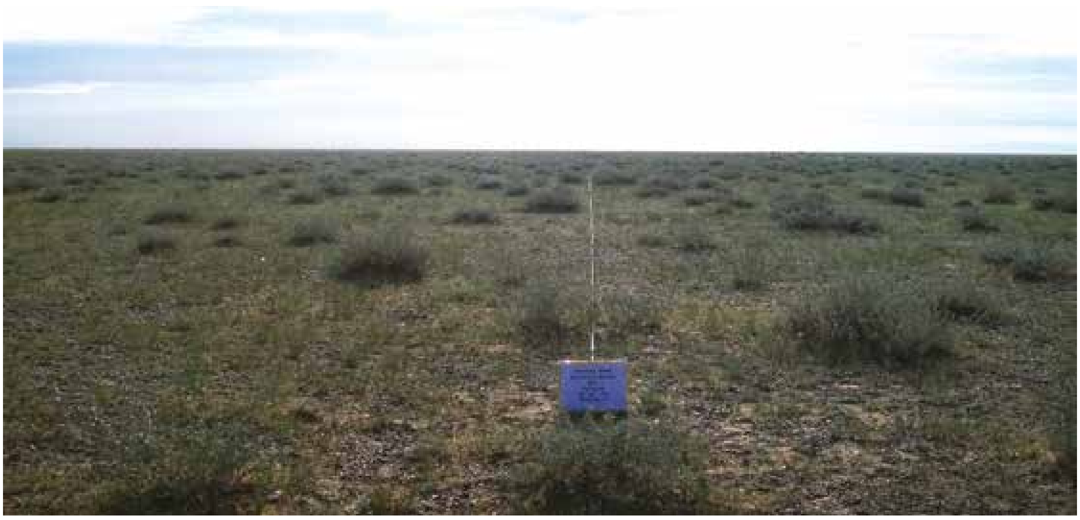

Figure 3. Example of the landscape position in sandy plain Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland (Site name: Den, Bulgan soum, Umnugobi aimag)

2.2 Representative soil features

Surface textures (< 2 mm) usually range from sandy loam to loamy sand, and clay content is less than 10% and sand is higher than 50%. Soil may contain gravel and/or cobbles, but they will not exceed an average of 35% by volume in all layers (Figure 4).

Figure 4. Example of soil profile and samples from different horizon in the shovel, shows the color of the soil. (Bayandelger soum, Sukhbaatar aimag).

Table 2. Soil features of sandy ecological group

Soil Depth	>50 cm
Surface texture	FSL - SL - L - SiL - SCL (18 -35% clay, or if <18% clay then < 45% sand)
Sub-surface texture (but within 50 cm)	FSL – SL – L – SiL - SCL (18-35% clay)
Pedoderm (0-3 cm) % volume rock fragments	<35%
Surface horizons % volume rock Fragments	<15%
Sub-surface horizons % volume rock fragments	<35%
Surface effervescence (0-30 cm)	Non – slightly
Subsurface effervescence (30-50 cm)	Non – strongly
Permeability Class (mm/hour)	Moderately slow 50 - 150

2.3. Plant community characteristics

Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland in Sandy plain is the most common ESG in desert steppe out of 5 different ESGs.

This type of rangeland is distributed in majority of soums in Dornogobi, Dundgobi, Umnugobi, Khovd, Uvs, Gobi Altai aimags; southers soums of Uvurkhangai, Bayankhongor, and Zavkhan aimags and northern soums of Bayan Ulgii aimag (Fig 5).

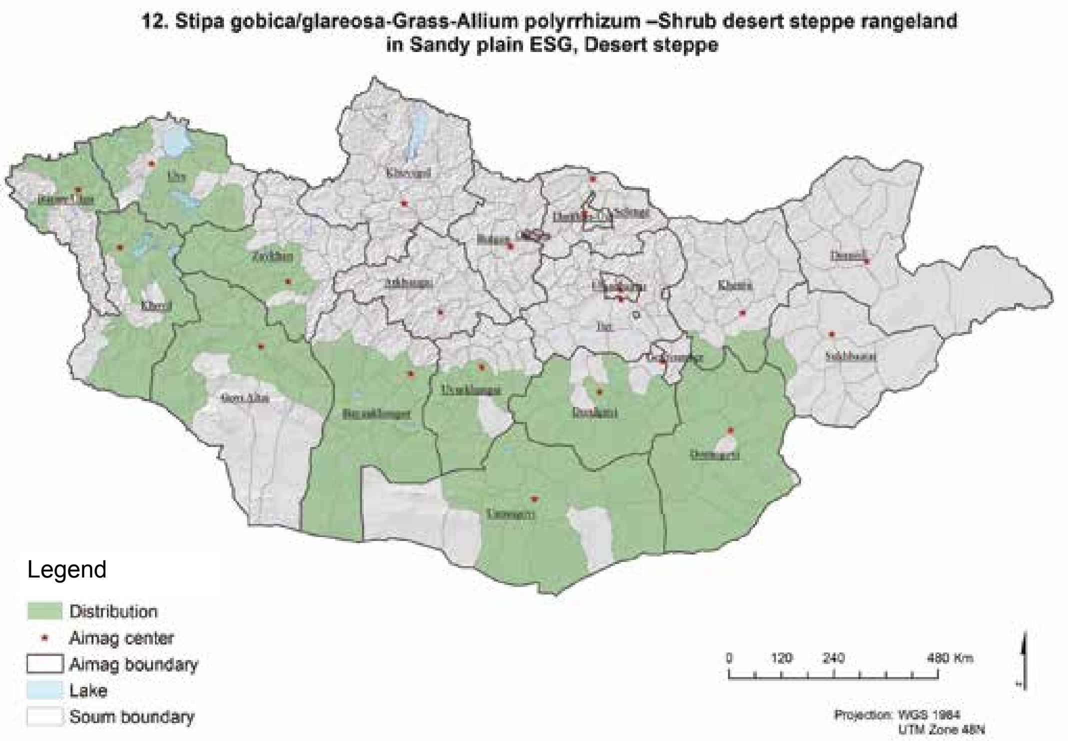

Figure 5. Distribution of the **Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland** (Source: "State and Transition models of Mongolian rangeland"

Based on literature reviews and field data the shifts of community phases and states of **Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland** with triggers and restoration recommendations are modelled (Fig.6). *Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub* desert steppe rangeland has 4 alternative states.

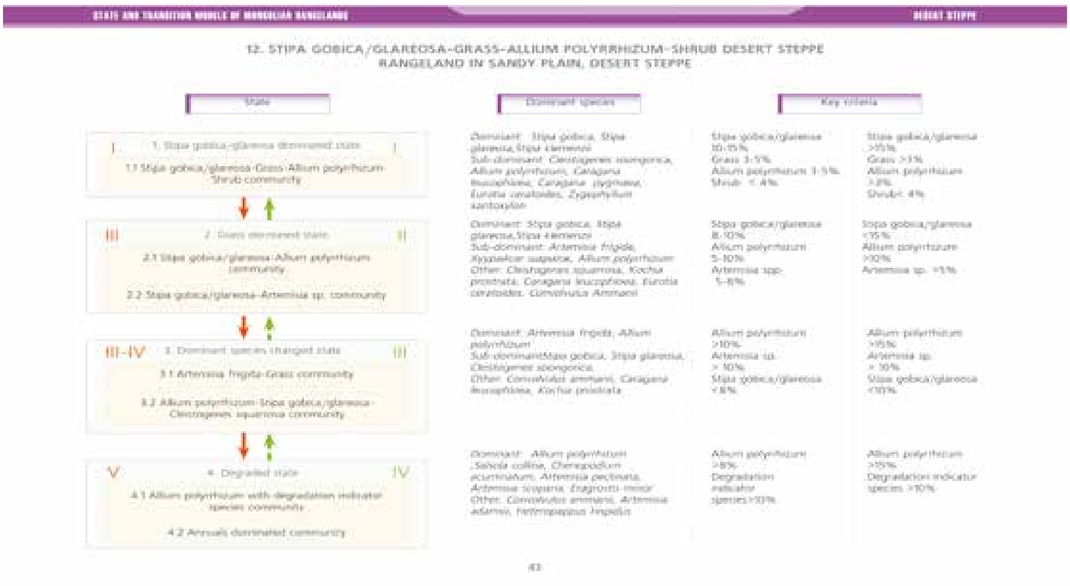

Figure 6. State and transition model of the Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland, a small orange boxes represent an alternative phases of community. Red numbers (I-V): degradation level; Green numbers (I-V): recovery classes; Green lines: restoration paths; Dotted green lines: when the restoration measures are not certain; Red lines: triggers

States of *Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert* steppe rangeland

1. *Stipa gobica/glareosa dominated reference state of Stipa gobica/glareosa-Grass-Allium polyrrhizum* –Shrub desert steppe rangeland

Total cover of dominant grass species: *Stipa gobica, S.glareosa, S.klemenzii* > 15%
Sub dominant species: Cleistogenes squarrosa>3%, Allium polyrhizum >3%
Other species: *Caragana bungei, C.pygmaea, Krascheninnikovia ceratoides <4%* (Fig. 7).

Figure 7. Stipa gobica/glareosa dominated reference state of Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
STGB	*Stipa gobica Roshev.*	Goviin hyalgana	2016	29.5	0.0
COAM	*Convolvulus Ammanii Desr.*	Ammanii sedergene	2016	10.0	0.0
CARLE	*Caragana leucophloea Pojark.*	Altan hargana	2016	3.5	0.0
KOPR	*Kochia prostrata (L.) Schrad.*	Delhee togtorgono	2016	3.5	0.0
ELCHN	*Elymus chinensis (Trin.) Keng.*	Nangiad tsagaan suli	2016	1.5	0.0
ARFRI	*Artemisia frigida Willd.*	Agi	2016	1.0	0.0
ALLMGL	*Allium mongolicum Rgl.*	Mongol songino, Homol	2016	0.5	0.0

2. Grass thinned state of *Stipa gobica/glareosa-Grass-Allium polyrrhizum* –Shrub desert steppe rangeland

Grass thinned state has a following 2 community phases:

2.1. Stipa gobica/glareosa-Allium polyrrhizum community.

Species composition and proportion of key dominants are same as in Reference state in general. Only the proportion of the ***Allium polyrrhizum*** is in increase.

2.2. Stipa gobica/glareosa-Artemisia sp. community.

Total cover of dominant grasses (*Stipa gobica, S.glareosa, S.klemenzii)* is lower than 15%. Cover of sub dominants (*Cleistogenes squarrosa*), (*Allium polyrhizum*) is in reduction and proportion of *Artemisia frigida, A.xeropytica)* is increases up to 5-8%. Cover of shrubs (*Caragana bungei, C.pygmaea, Krascheninnikovia ceratoides*) remains without changes (Fig. 8).

Figure 8. Grass thinned state **of Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland** (Site name: Shivnee, Khatanbulag, Dornogobi aimag)

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
ALLPO	*Allium polyrrhizum Turcz. ex RgL.*	Taana	2016	16.5	6.5
STGL	*Stipa glareosa P. Smirn.*	Sairiin hyalgana	2016	9.0	2.0
COMGL	*Corispermum mongolicum Iljin*	Mongol hamhuul	2016	1.0	0.0
ASGO	*Asparagus gobicus Ivanova. ex grub.*	Goviin hereen nud	2016	0.5	0.0

3. Dominant species replaced state of *Stipa gobica/glareosa-Grass-Allium polyrrhizum* –Shrub desert steppe rangeland

This state has a following 2 community phases:

3.1. Artemisia frigida-Grass community.

Dominant species: *Artemisia frigida* >10%
Subdominant species: *Stipa gobica, S.glareosa, S.klemenzii, Cleistogenes squrrosa* <8%
Shrubs are in slight thinning.

3.2. Allium polyrrhizum-Stipa gobica/glareosa-Cleistogenes squarrosa community.

Dominant species*: Allium polyrrhizum* >15%
Subdominant species: *Stipa gobica, S.glareosa, S.klemenzii, Cleistogenes squrrosa* <8%
Shrubs are in slight thinning.
Abundance of *Kochia prostrata, Convolvulus ammanii, Caragana pygmaea* is in increase *(Fig. 9).*

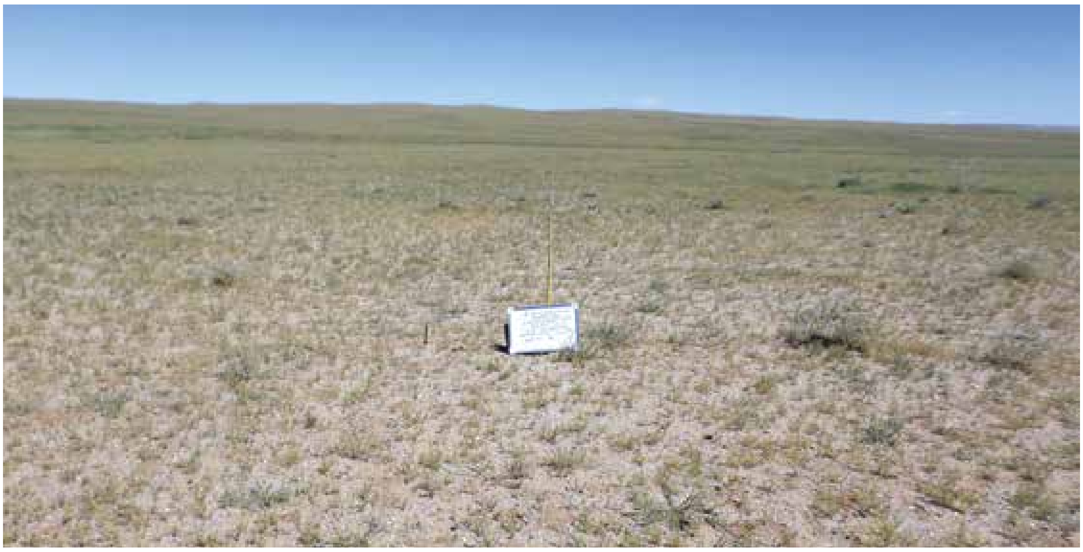

Figure 9. Dominant species changed state of Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland (Site name: Mergen, Urgun soum, Dornogobi aimag)

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
CLSQ	*Cleistogenes squarrosa (Trin.) Keng.*	Derveen hazaar uvs	2016	3.5	1.0
ALLPO	*Allium polyrrhizum Turcz. ex RgL.*	Taana	2016	3.0	1.0
MIAR	*Micropeplis arachnoidea (Moq.) Bge.*	Aalznii hush uvs	2016	2.5	0.0
BADA	*Bassia dasyphylla (Ficsh. et Mey.) Ktze.*	Uslig manan hamhag	2016	2.0	0.0
SACOL	*Salsola collina Pall.*	Tolgodiin budar-gana	2016	1.5	0.0
CXDU	*Carex duriuscula C.A.Mey.*	Shireg ulalj	2016	0.5	0.0

4. Degraded state of *Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub* desert steppe rangeland

Degraded state has 2 following community phases:
Dominant species: *Carex duriuscula, Artemisia frigida, Artemisia adamsii*
Proportion of Artemisia frigida and Artemisia Adamsii inereases up to 20% and even 40 %
The presence of degradation indicators such as *Salsola collina, Convolvulus ammanii,* Chenopodium *album, Potentilla bifurca, Heteropappus hispidus* increases (Fig. 10).

Figure 10. Degraded state of the **Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland** (Site name: Khaya-2, Saintsagaan soum, Dundgobi aimag)

Species composition

Species	Scientific	Common	Year	Foliar Cover %	Basal Cover %
ALLPO	*Allium polyrrhizum Turcz. ex RgL.*	Taana	2016	32.0	5.5
CXDU	*Carex duriuscula C.A.Mey.*	Shireg ulalj	2016	9.5	0.0
COAM	*Convolvulus Ammanii Desr.*	Ammanii sedergene	2016	7.0	1.0
ARPC	*Artemisia pectinata Pall.*	Shulhii sharilj	2016	2.0	0.0
CHAL	*Chenopodium album L.*	Tsagaan luuli	2016	2.0	0.0
ARMAC	*Artemisia macrocephala Jacquem.*	Eerem sharilj	2016	1.5	0.0
ERMI	*Eragrostis minor Host*	Baga hurgalj	2016	1.0	0.0
ALLMGL	*Allium mongolicum Rgl.*	Mongol songino, Homol	2016	0.5	0.0
CARLE	*Caragana leucophloea Pojark.*	Altan hargana	2016	0.5	0.0
CARST	*Caragana stenophylla Pojark.*	Nariin navchit hargana	2016	0.5	0.0
STKR	*Stipa Krylovii Roshev.*	Kryloviin hyalgana	2016	0.5	0.0

4.1 Allium polyrrhizum with degradation indicator species community.

Allium polyrrhizum is becoming a dominant with cover higher than 15% and degradation indicators such as *Convolvulus ammanii, Heteropappus hispidus and Artemisia Adamsii* replace the sub dominants.

4.2 Annuals dominated community.

In parallel with *Allium polyrrhizum,* other degradation indicators such as *Salsola collina,* Ch*enopodium album, Artemisia pectinata, Artemisia scoparia Eragrostis* minor are in high cover

2.4 Reference for the stipa gobica/glareosa-grass-allium polyrrhizum –shrub desert steppe rangeland

Table 3. Species composition of the reference community

Func-tional groups	Species code	Scientific name	Mongolian name	Foliar cover, %	Basal cover, %
	STGB	*Stipa gobica Roshev.*	Говийн хялгана	29.5	0.0
Grass	CLSO	*Cleistogenes songorica (Roshev.) Ohwi.*	Зүүнгарын хазаар өвс	0.0	0.0
	ELCHN	*Elymus chinensis (Trin.) Keng.*	Нангиад цагаан суль	1.5	0.0
	COAM	*Convolvulus Ammanii Desr.*	Амманий сэдэргэнэ	10.0	0.0
	CARLE	*Caragana leucophloea Pojark.*	Алтан харгана	3.5	0.0
	KOPR	*Kochia prostrata (L.) Schrad.*	Дэлхээ тогторгоно	3.5	0.0
Forbs	ARFRI	*Artemisia frigida Willd.*	Агь	1.0	0.0
	ALLMGL	*Allium mongolicum Rgl.*	Монгол сонгино	0.5	0.0
	ALLPO	*Allium polyrrhizum Turcz. ex RgL.*	Таана	0.0	0.0
	ASGO	*Asparagus gobicus Ivanova. ex grub.*	Говийн хэрээн нуд	0.0	0.0

Table 4. Maximum and Minimum cover of reference community

	Minimum	Maximum
Total cover, %	13	60
Basal cover, %	0	8
Species richness	10	15
Bare soil cover, %	40	80
Litter cover,%	5.6	60.5

3. Rangeland recovery in Desert steppe zone

According to long term monitoring data of rangeland health, Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland in Sandy plain in Delgerekh soum of Dornogobi aimag has been recovered from *Allium polyrrhizum* and degradation indicator species community to (State 4) to *Stipa gobica/glareosa-Allium polyrrhizum* community (State 2) in 3 years (Fig.11, 12).

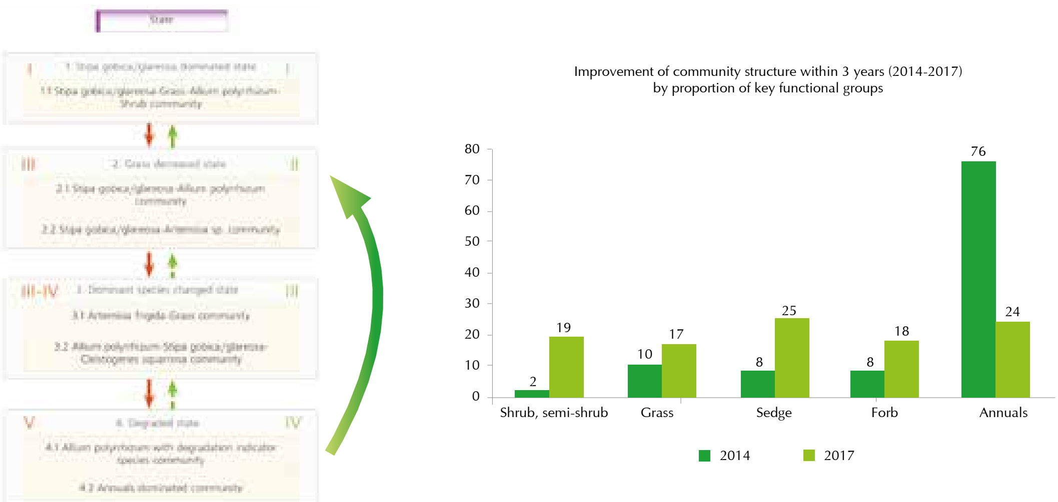

Figure 11. Recovery of degraded states of Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland

Figure 12. Comparison of Stipa gobica/glareosa-Grass-Allium polyrrhizum –Shrub desert steppe rangeland. A. Dominant species replaced state - 2014; B. Stipa gobica/glareosa-Allium polyrrhizum community- 2017

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