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ЗАСГИЙН ГАЗАР

**MINISTRY OF FOOD
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**Swiss agency for Development
and Cooperation SDC**

NATIONAL REPORT ON THE RANGELAND HEALTH OF MONGOLIA

МОНГОЛ УЛСЫН
ЗАСГИЙН ГАЗАР

**ADMINISTRATION OF LAND
AFFAIRS, GEODESY AND
CARTOGRAPHY**

GREEN GOLD PROJECT

**"GREEN GOLD"
PROJECT, SDC**

INSTITUTE OF METEOROLOGY, HIDROLOGY AND ENVIRONMENT

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INSTITUTE OF METREOLOGY
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EXECUTIVE SUMMARY

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 85.5 million sheep units in 2014 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 and monitoring procedures and conduct a detailed, field-oriented assessment of rangeland health across Mongolia. A nationally standardized methodology for rangeland monitoring provides for 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 Descriptions (ESDs) were developed by Green Gold and the Administration of Land Affairs, Geodesy and Cartography (ALAGAC). The new procedures for monitoring and interpretation were implemented beginning in 2011 by NAMEM at its 1450 long-term monitoring sites. Based on 2014 data, sixty-five percent of these sites were judged to be altered relative to the ecological potential (reference condition) of the soils and climate zones for those sites. Only forty eight percent of the sites, however, would require more than three years for recovery to occur with altered management and seven percent of sites have experienced highly persistent degradation or desertification.

A vast majority of monitoring sites representing more than half of Mongolian rangelands suggest that changes to grazing management could result in recovery, or progress toward recovery, within ten years.

A new, comprehensive approach called resilience-based rangeland management was developed to initiate management changes. 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. This framework integrates the traditional, community-based pasture management practices of the past with more recent rangeland management concepts and new technologies. Implementing resilience-based rangeland management requires national coordination among the Ministry of Food and Agriculture, Ministry of Environment, Green Development, and Tourism, and Ministry of Urban Development and Construction as well as collaboration among herders and local government.

The application of internationally accepted procedures for calculating a resilient carrying capacity for Mongolian pastures, as well as another recent national study, indicates that carrying capacity has been greatly exceeded in many areas and suggests that overgrazing is a primary factor explaining rangeland degradation observed in Mongolia. Thus, control of livestock numbers is a fundamental pre-condition for effective rangeland management. Training and extension messages on the benefits of reducing animal numbers to increase animal quality should be expanded. Strengthening Rangeland Use Agreements and applying grazing fees could enable control of livestock numbers. Development of international markets, animal health certification, government compensation and price support for animal quality, and linkage of herder cooperatives to processing companies could also provide short- and medium-range mechanisms for controlling animal numbers.

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.

Abbreviations

MoFA- Ministry of Food and Agriculture

ALAGAC- Administration of Land Affairs, Geodesy and Cartography

NAMEM- National Agency for Meteorology and Environmental Monitoring

MSUA- Mongolian State University of Agriculture

APUG - Pasture Users Group Associations

PUG- Pasture Users Group

ESD- Ecological Site Descriptions

STM- State and Transition model

1. THE FUTURE OF LIVESTOCK PRODUCTION IN MONGOLIA

1.1. Challenges to the livestock production sector

The livestock production sector in Mongolia has reached a crossroads[15]. The absence of policy or market-based mechanisms to control livestock numbers and a lack of awareness about rangeland degradation has led to increasing herd sizes. National livestock numbers as of 2014, at 85.5 million sheep units, are unprecedented in the historical record. Increasing livestock numbers beyond the capacity of rangeland to support them can lead to acute limitations of forage and persistent rangeland degradation. Degradation ultimately reduces livestock production capacity and increases the vulnerability of herders to dzud and droughts. Catastrophic losses associated with dzud and unprecedented livestock numbers have already been observed in recent years (Fig. 1.1). Such losses and longer-term rangeland degradation can negatively affect herder livelihoods, Gross Domestic Product, and the food security of the country.

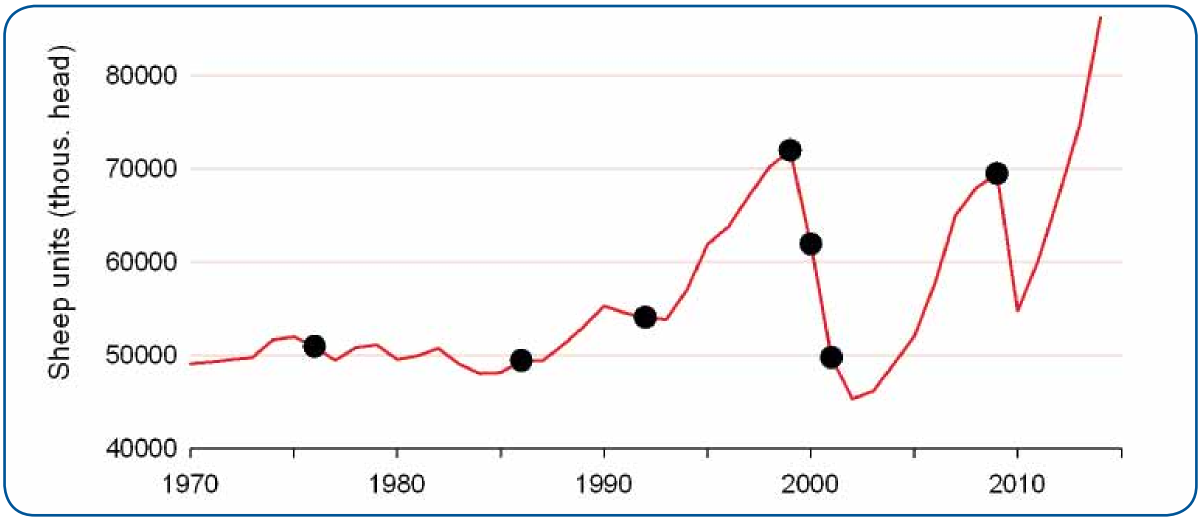


Figure 1.1 Animal numbers standardized to sheep units. Data from the National Statistical Office of Mongolia. Black dots are dzud years.

As Mongolia becomes increasingly modern, herders are facing increased pressure to make the transition from being subsistent survivors to market-oriented producer-managers. Enabling herders and local governments to make progress toward sustainable rangeland management requires meaningful technical assistance that is specific to land areas that vary in ecological potential, productive capacity and recovery needs. Sustainable management also requires a capacity to monitor rangeland health accurately and to react to changes, especially those that will be caused by climate change. Implementing sustainable management further requires government policies enabling the management of rangeland use and reduction of livestock numbers.

1.2. What is rangeland health and why does it matter?

Rangeland health is the set of environmental conditions that sustain the productivity and biodiversity of rangelands. Healthy rangelands are those that provide the maximum options for varied ecosystem services. The loss of rangeland health, known as rangeland degradation, is essentially a loss of options. In cases where thresholds are crossed involving loss of species or degradation of soils, recovery of rangeland health is long-term (Fig. 1.2a) or not possible and those options can be lost forever. Such persistent losses of rangeland productive capacity are well documented throughout the world [3, 12, 38]. In other cases, rangeland health can be preserved or restored through careful management

(Fig. 1.2b). Management to improve rangeland health has led to improved livestock production and associated environmental benefits in many parts of the world, including the United States, China, Canada, Australia, Argentina, and South Africa[6, 19, 22, 29, 37, 46].

Figure 1.2 a) A highly degraded rangeland dominated by unpalatable plant species and b) a rangeland that has been restored to perennial grass dominance via improved grazing management in sandy alluvial soils of Dry Steppe.

In Mongolia, healthy rangelands can contribute to the resilience of livestock production and the herder community in the face of drought and natural disasters. Healthy rangelands promote greater overall forage and better nutrition for animals. In addition to increasing animal production, healthy rangelands promote well-fed, healthy animals coming into winter that are better able to survive dzuds[11]. Healthy animals also provide a basis for marketing according to quality indicators in meat, hide, and the environment[22].

Healthy rangelands can also mitigate the impact of dzuds on forage resources[11, 22, 30]. For example, taller residual cover in winter can lessen the severity of white dzud by providing greater access to forage after heavy snowfall. Greater insulation provided by residual plant stubble and litter cover can protect plants from the effects of a dry, cold “black dzud”. Grassland plants with strong root systems can speed recovery following drought and hoofed dzuds. A focus on rangeland health would have long-term benefits for Mongolia, especially as climate change increases variability in weather conditions. **The key question is, which areas of Mongolia are degraded and what can be done to recover rangeland health?**

2. NEW TOOLS FOR ASSESSING RANGELAND HEALTH

2.1. Confusion about the state of rangeland health

Although the concept of rangeland health is widely accepted in the international community, it is difficult to assess because rangelands exhibit great variability and criteria for degradation are not consistently defined. For example, lands featuring different soil and long-term climate have different ecological potential. We do not expect the same forage productivity from a desert as we do from a forest meadow. Rangeland productivity also varies greatly over time in response to rainfall and temperature. We cannot expect the same rangeland productivity during a drought year that we measure in a wet year. Thus, the land areas observed and when they are observed have a great impact on evaluations of rangeland health.

Differences in sampling methodology and criteria for determining degradation can also lead to confusion and disagreements about rangeland health trends. Inaccurate rangeland health assessments can lead to flawed prescriptions that lead to misplaced management efforts, such as by reducing livestock numbers where reductions are not needed, or by allowing management that causes degradation to continue.

Environmental and methodological variability have led to vast discrepancies in assessments of rangeland degradation, ranging from 9-90% in a recent review[1]. In some areas, particularly in the Gobi Desert, there has been limited evidence of rangeland degradation because rainfall variability forces animals to move, thereby placing natural limits on grazing intensity[1, 39, 40, 45]. Nonetheless, there are widespread reports, from both herders and scientists, that rangeland degradation is occurring in other ecological zones of Mongolia[7, 10, 21, 23, 34].

The causes and persistence of rangeland degradation are not well understood. Changes in climate are often implicated as a cause of degradation[21]. Comparative and experimental studies in Mongolian steppe, however, show that heavy grazing pressure can result in reduced productivity, reductions of desirable species, and reduced root mass[14, 20, 26, 34, 43]. Studies also suggest that grazing management can lead to vegetation recovery and/or increased forage availability[22, 24, 25, 27].

Because assessments of rangeland health have not been adequate to inform management responses to combat rangeland degradation in Mongolia, Green Gold collaborated with government agencies and universities to conduct a detailed, field-oriented assessment of rangeland health across Mongolia. The goal of this effort was to i) develop a system for assessment and monitoring to measure rangeland health and degradation precisely and ii) develop technical capacity and tools for interpreting rangeland health data and to recommend management remedies for specific land areas in reports called Ecological Site Descriptions.

2.2. Assessment, monitoring, and interpretation using Ecological Site Descriptions

Vegetation and soil surface indicators are used to detect changes in rangeland health[17]. Quantitative indicators, such as the cover of important plants and bare ground, provide for precise and repeatable measurements. In addition, qualitative indicators can supplement these measurements with information about important processes, such as soil erosion, that are difficult to quantify. Both types of indicators can be used for two distinct activities: assessment and monitoring. Assessment is the evaluation of measurements at an initial point in time to make decisions about the management needs for a specific rangeland area. Monitoring is the gathering of repeated measurements in a rangeland area to evaluate change and to test the effects of a management decision made following the assessment. Monitoring information is then used to adjust management, known as adaptive management. Both activities should use the same indicators or confusion will result.

Ecological site descriptions (ESDs) are a primary tool used for interpreting assessment and monitoring data and translating the interpretations into management decisions[2, 8]. ESDs are interpretive guides for different rangeland areas that feature two important elements. First, ESDs specify the distinctive climate and soil conditions of rangeland areas, called "ecological sites", which require variations in how assessment and monitoring data are interpreted. Second, each ESD possesses a "state-and-transition model" that describes how rangeland ecosystems have changed and can change. Relatively healthy rangeland conditions that are observed within an ecological site are used as a reference for assessing rangeland health. Important variations in rangeland vegetation and soils that can occur over time in the same ecological site are called "ecosystem states". Different states call for different management recommendations. ESDs are used extensively in the United States, and similar management guides are used in Canada, Australia, and Argentina[19, 28, 36, 41].

Thus, ESDs serve as a guide for assessing the ecosystem state for a specific ecological site and then selecting an appropriate management strategy (Fig. 2.1). The description of the ecosystem state includes information that is used to define and communicate management goals. For example, if an observer is in the productive, sandy loam alluvial fan ecological site of dry steppe, the state and transition model indicates that there may be a healthy state with a high cover of perennial grasses or a degraded state featuring high cover of bare ground, signs of erosion, and a dominance of subshrubs. The healthy state provides good forage for livestock and wildlife, whereas the degraded state is less useful. If the assessment matches the healthy state, then the management of that area should continue as it is. If observations are consistent with a degraded state, then herders can consider a change in management to initiate restoration of the healthy state. If a management change is made for the degraded state, such as by providing summer periods without grazing, then monitoring data is predicted to show an increase in perennial grass cover and a decrease in bare ground over a period of five years, especially if that period includes years with good rainfall. The ESD provides these interpretations to the herders, the public, and policymakers so they can have a common understanding of rangeland health and develop management plans around them.

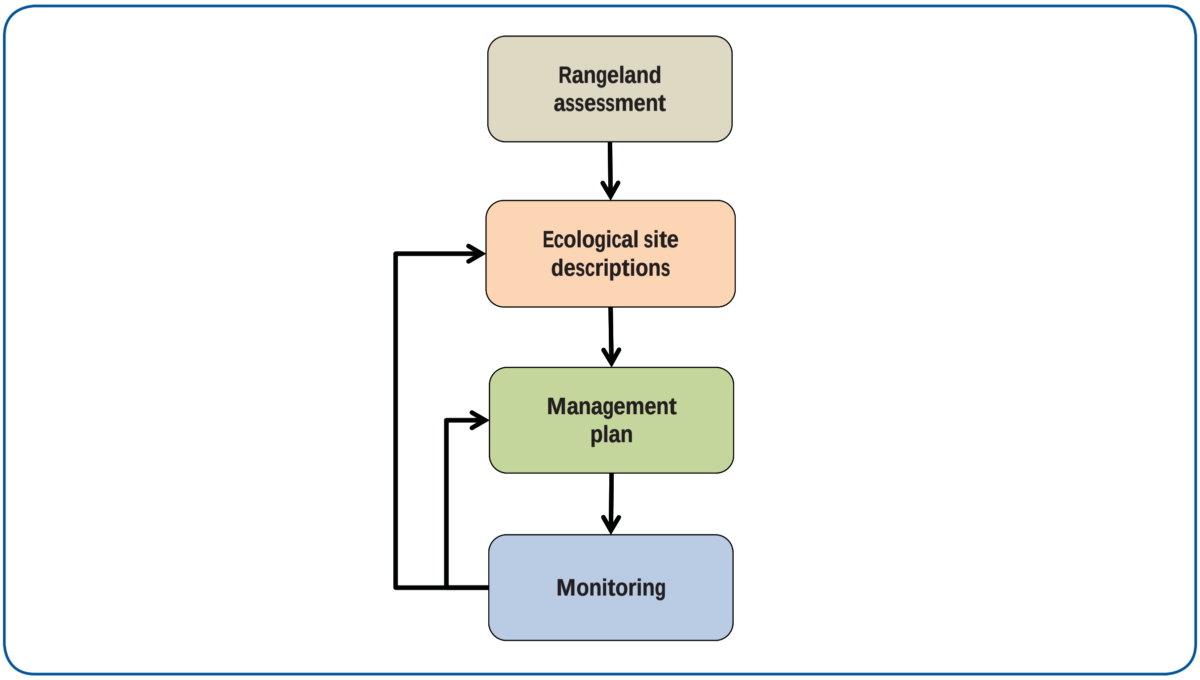


Figure 2.1 Sequence of steps in using Ecological Site Descriptions (ESDs). Monitoring data can be used both to update management strategies and to revise ESDs based on new knowledge (loop arrows).

It is important to recognize that change in rangelands is difficult to predict. This is because rangelands have many interacting parts and respond to variations in weather and historical management over long time periods. Thus, predictions in state-and-transition models are always a best guess (hypothesis) based on current information and expert knowledge. Monitoring is used not only to evaluate and adjust management, but also to learn and update information in the state-and-transition model. ESDs are a platform for long-term, collaborative learning about rangelands.

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

The National Agency for Meteorology and Environmental Monitoring (NAMEM) is the institute responsible for nationwide rangeland monitoring covering 1450 monitoring plots representing all baghs in Mongolia. Green Gold has worked with NAMEM 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 developing ESDs and interpreting monitoring data; 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, Green Development and Tourism; Ministry of Food and Agriculture; NAMEM; and the Administration of Land Affairs, Geodesy and Cartography [ALAGAC]) **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, core species composition, 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 ESDs that match existing herder concepts (see below) were also agreed upon. The newly standardized methodology is repeatable, precise, and simple enough for easy use. Training materials developed by Green Gold have been widely applied. 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 (Annex 1).

Meteorology technicians in 320 soums collect the primary data yearly at 1450 plots using the new standardized methodology since 2011. Aimag engineers ensure quality control and enter the monitoring data into the National Rangeland Monitoring Database (Fig. 2.2). The National Database is modified and adapted to Mongolia from the Database for Inventory, Monitoring and Assessment developed by the U.S. Department of Agriculture (USDA). 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

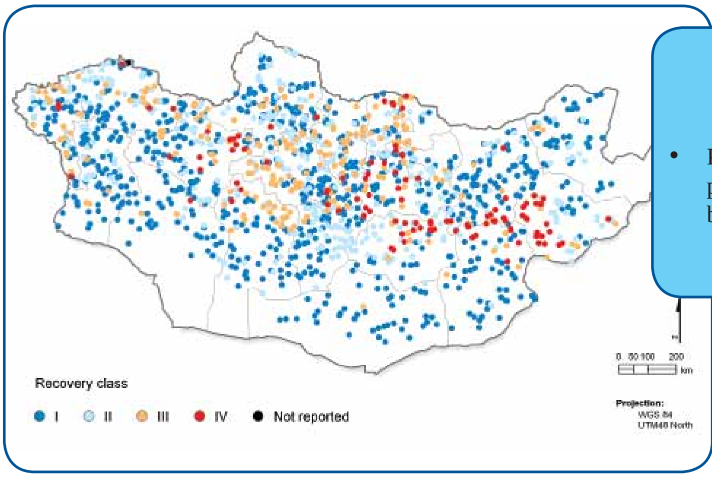
- Soum technicians collect the primary data yearly
- Aimag engineers ensure quality control and enter the monitoring data into the National Rangeland Monitoring Database

Input

National database for rangeland monitoring

- Customized reports for interpretation of assessment and monitoring data can be produced.

Output



Rangeland state outlook

- Processed dot maps for interpretation of assessment can be produced.

Figure 2.2 NAMEM monitoring data collection workflow.

2.4. New tools for interpreting assessment and monitoring data

Interpretation of assessment and monitoring data requires a comparison to standards or references, much in the same way that blood pressure and body weight are used as indicators of human health. ESDs provide standards for interpretation that are specific to different land areas and that link interpretations to management actions. ESD development was initiated in 2009 with the training of an ESD development team, including Green Gold, ALAGAC, and NAMEM staff, by USDA scientists. The procedure for developing ESDs follows steps that are being used by land management agencies in the United States[42]. While the term "ecological site description" is specific to the US, similar land classifications are used for assessment by land managers throughout the world[19, 32, 41].

Development of ESDs requires:

1) Inventory to measure the existing variability of rangeland vegetation;

2) Classifying ecological sites based on climate, landform, and soils;

3) Establishing reference and alternative ecosystem states for each ecological site;

4) Providing information about the causes of transitions among ecosystem states; and,

5) Describing how transitions can be controlled by management.

Inventory data collection using the same methods employed for assessment and monitoring (2.3 above) were conducted from 2009-2014 at over 600 sites across Mongolia. Using the inventory data to describe variations measured in the field, workshops were conducted in 2012 in each ecological zone of Mongolia to gather local knowledge about land classification and reference conditions, the presumed causes of vegetation change, and to identify informative sites for additional inventory. Field visits and interviews with US and Mongolian rangeland management specialists were used to propose management recommendations, especially the timing of grazing, grazing deferment, and grazing rest periods, based on local and international studies. The inventory data were then initially analyzed to classify ecological site types based on soil properties (WebAnnex 1). Ecological sites (Annex 2) were grouped to 22 "ecological site groups" according to similarities in vegetation and landscape position, season of grazing, and land classification concepts already used by herders and scientists. A state-and-transition model was developed for each ecological site group (Annex 3) and complete ESD documents are being finalized (Annex 4).

A National Ecological Site Core Group was established in 2011 composed of experienced plant community ecologists representing different ecological zones across Mongolia as well as decision makers of key institutes in order to develop shared interpretations of inventory data. The National Core group i) provides information on reference conditions and causes of state change in ESDs; ii) organizes ESD development activities with herders, and iii) performs outreach to encourage adoption of materials by local government and herders.

In order to create a national assessment of rangeland health that incorporates variations in ecological potential across Mongolia, standardized "recovery classes" were developed (Fig. 2.3). Recovery classes are based on information and assumptions about the reference condition or ecological potential of a pasture area (the plant communities expected to exist at a site in healthy condition) and the process of recovery with a change in management. The recovery classes are analogous to degradation classes already used in Mongolia, but are based on ESDs and provide information about recovery rates based on quantitative measurements. Assigning a recovery class to a site requires measurements of plant cover and soil surface conditions that are compared with the information in the appropriate ESD. A state-and-transition model developed for an ecological site group, such as Caragana-grass rangeland in deep sandy alluvial plain, dry steppe (Fig. 2.3), can be used to assign recovery classes based on the following criteria and interpretation:

Class I: Reference state dominated by *Stipa krylovii* at 35% foliar cover, full complement of species present

Class II: Stipa cover has declined to 6-10 %. *Artemisia frigida* (1-3%) and *Carex duriuscula* (<1%) cover is low. Recovery could occur in a few growing seasons.

Class III: Stipa cover low (< 6%), but *Carex duriuscula* is dominant (>15%) . May take several years to recover high Stipa cover.

Class IV: Caragana, with coppices formed by soil erosion, is dominant and other perennial plants are sparse. Annuals dominate in wet seasons.

Class V: Deep gully with extensive soil loss, production of area is permanently reduced.

Figure 2.3 Examples of recovery classes from states of the Caragana-grass rangeland in deep sandy alluvial plain, dry steppe, Undurshireet soum.

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 (see 4.4 below) 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).

2.5. The national rangeland health monitoring system

As a result of the efforts and tools described above, the rangeland monitoring system managed by NAMEM can provide:

1) Yearly reports of a variety of rangeland indicators at bagh, soum, aimag, regional and national levels.

2) Trends in rangeland indicators over time, starting with a complete dataset in 2011.

3) Maps and summaries of ecological states and recovery classes for each year (see below).

4) Interactive maps describing ecological site information and state-and-transition models for each monitoring point.

This monitoring system is fully integrated and funded within NAMEM programs.

3. THE CURRENT STATE OF RANGELAND HEALTH IN MONGOLIA

3.1. Recovery classes of monitoring sites

Monitoring records collected by NAMEM at 1450 sites were evaluated relative to the STMs matched to the sites (Annex 3). Based on this comparison, 65% of sites evaluated in 2014 were found to be altered with respect to the plant species composition of the reference communities for the matched ecological site groups (Fig. 3.1). Sites were then assigned to recovery classes based on the ESDs. Based on this analysis, 48% of the sites would require more than 3 years of management for recovery to occur.

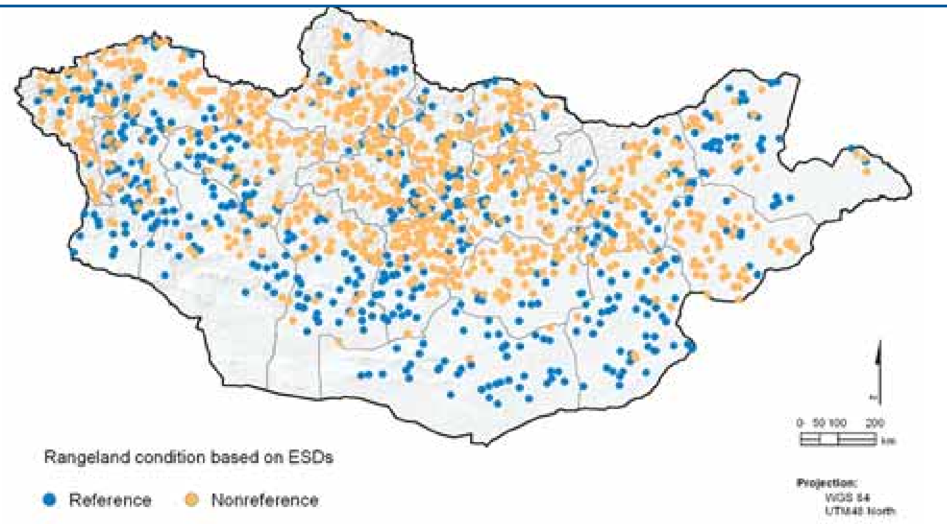


Figure 3.1 NAMEM monitoring sites classified to reference or non-reference rangeland conditions in 2014 based on the ESDs.

According to this analysis, 52 % of the points were in Class I; 25% in Class II; 15% in Class III; and 7% in Class IV (Fig. 3.2). Sites with very different recovery classes were intermingled, indicating that great variability in rangeland condition exists within soums. No NAMEM monitoring sites were located in areas with Class V, but while uncommon, such areas do exist and have been recorded in inventory by Green Gold. The ecological site group and STM associated with each monitoring site can be explored using web-based maps (WebAnnex 2).

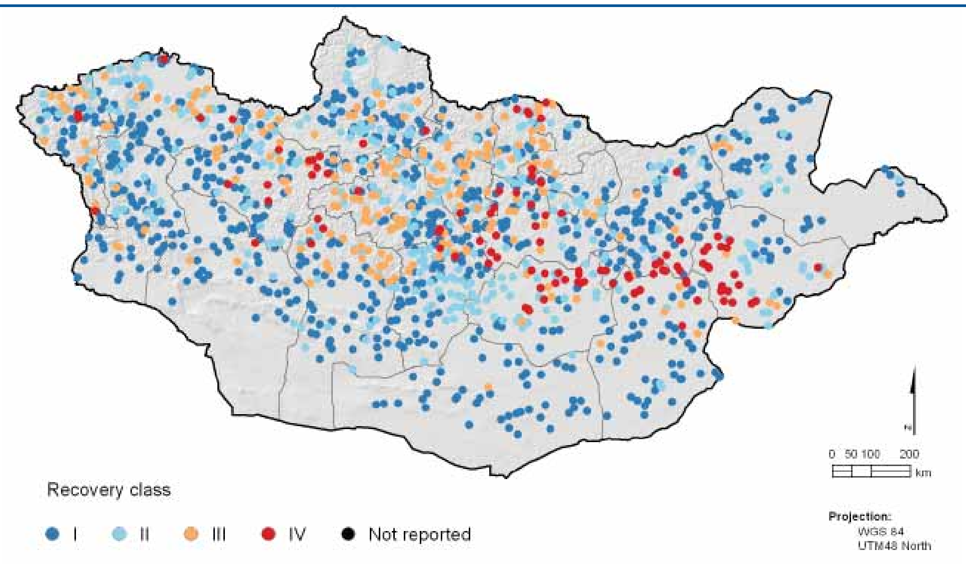


Figure 3.2 NAMEM monitoring sites classified to Recovery Classes based on the ESDs.

Most monitoring sites in Desert Steppe and Desert ecological zones are in reference condition or only slightly altered (Class I). A higher percentage of sites requiring more than 3 years of management for recovery (Classes II-IV) were observed in forest steppe, steppe and semi-desert zones (Fig. 3.3). Sites in aimags such as Arkhangai, Bulgan, Tuv, Selenge, and Dundgobi have experienced the greatest degree of rangeland degradation, reflected in the lowest percentages of sites in Class I and II (Fig. 3.4).

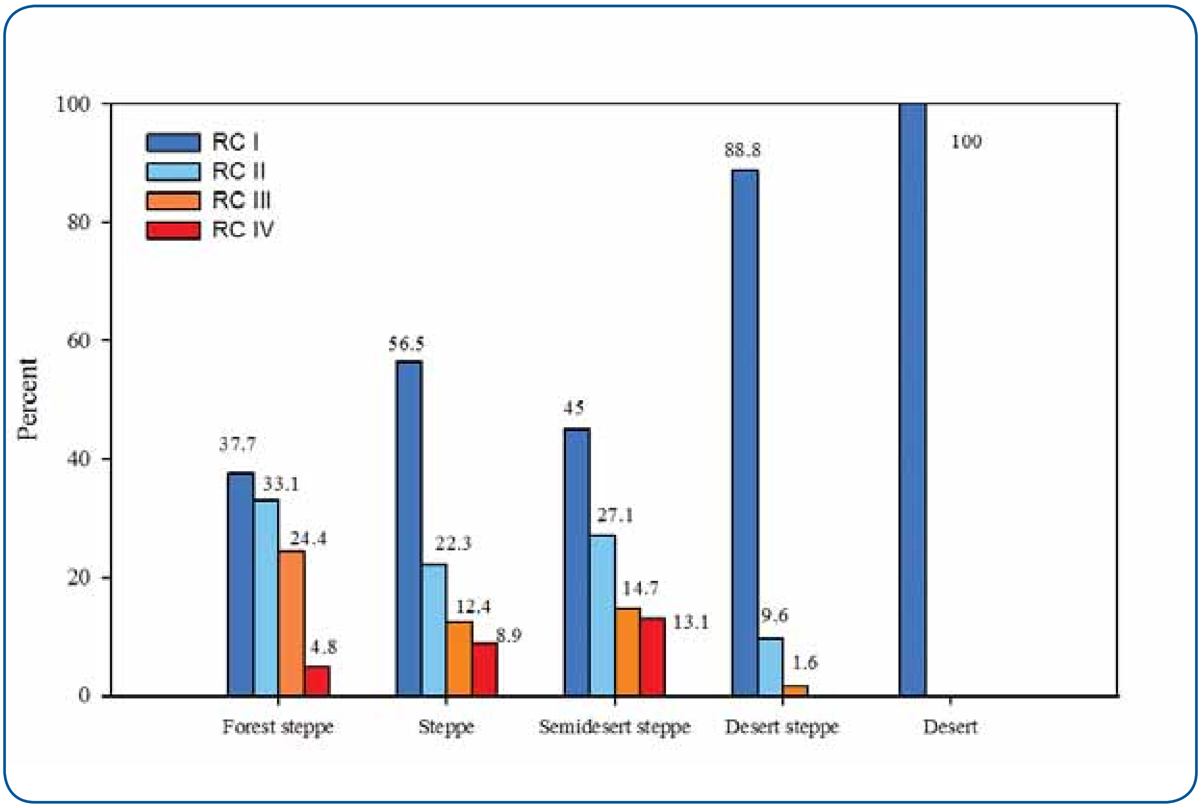


Figure 3.3 The percentages of NAMEM monitoring sites classified to different Recovery Classes for each ecological zone

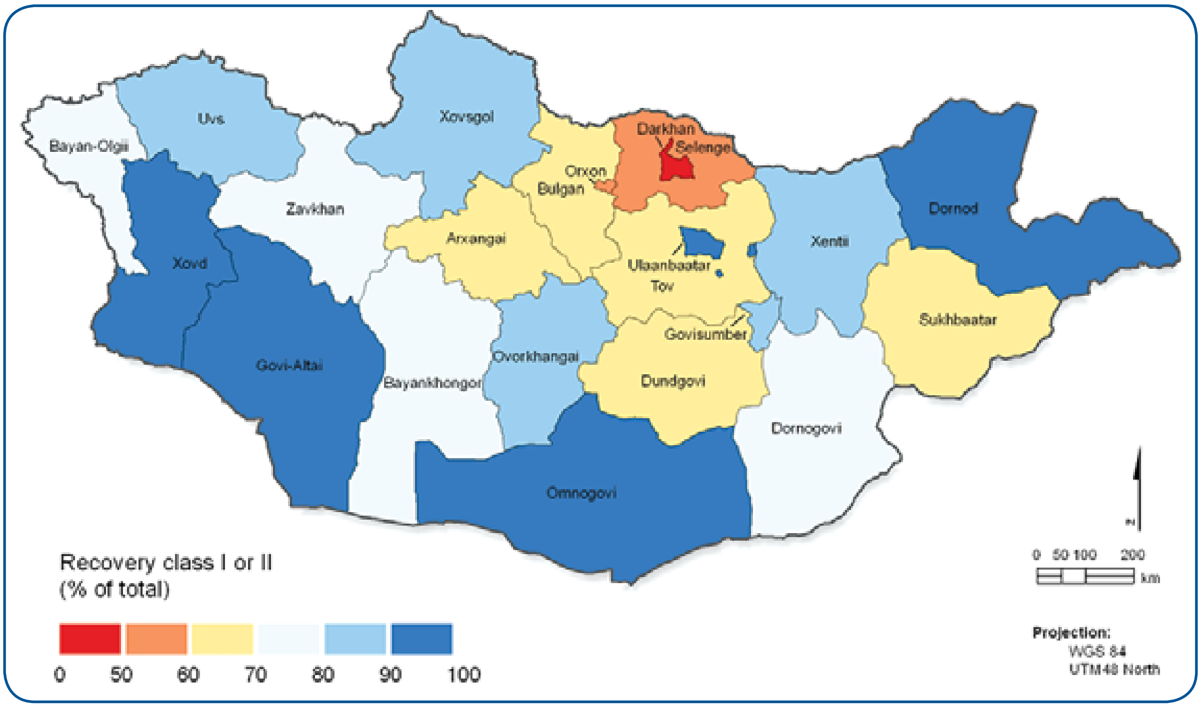


Figure 3.4 The percent of total NAMEM monitoring sites within each aimag that were classified to Recovery Class I or II. Redder colors indicate a higher percentage of more highly degraded sites requiring extended recovery time.

A significant trend of declining precipitation (Fig. 3.5a) and increasing animal numbers (Fig. 3.6) has occurred in many of these same areas. In addition, most of Mongolia has experienced a significant warming trend (Fig. 3.5b). Combined, these trends indicate an increasing risk of further rangeland degradation, especially in central and northern parts of Mongolia. The notion that irreversible degradation is spreading from southern Mongolia is not supported by the analysis.

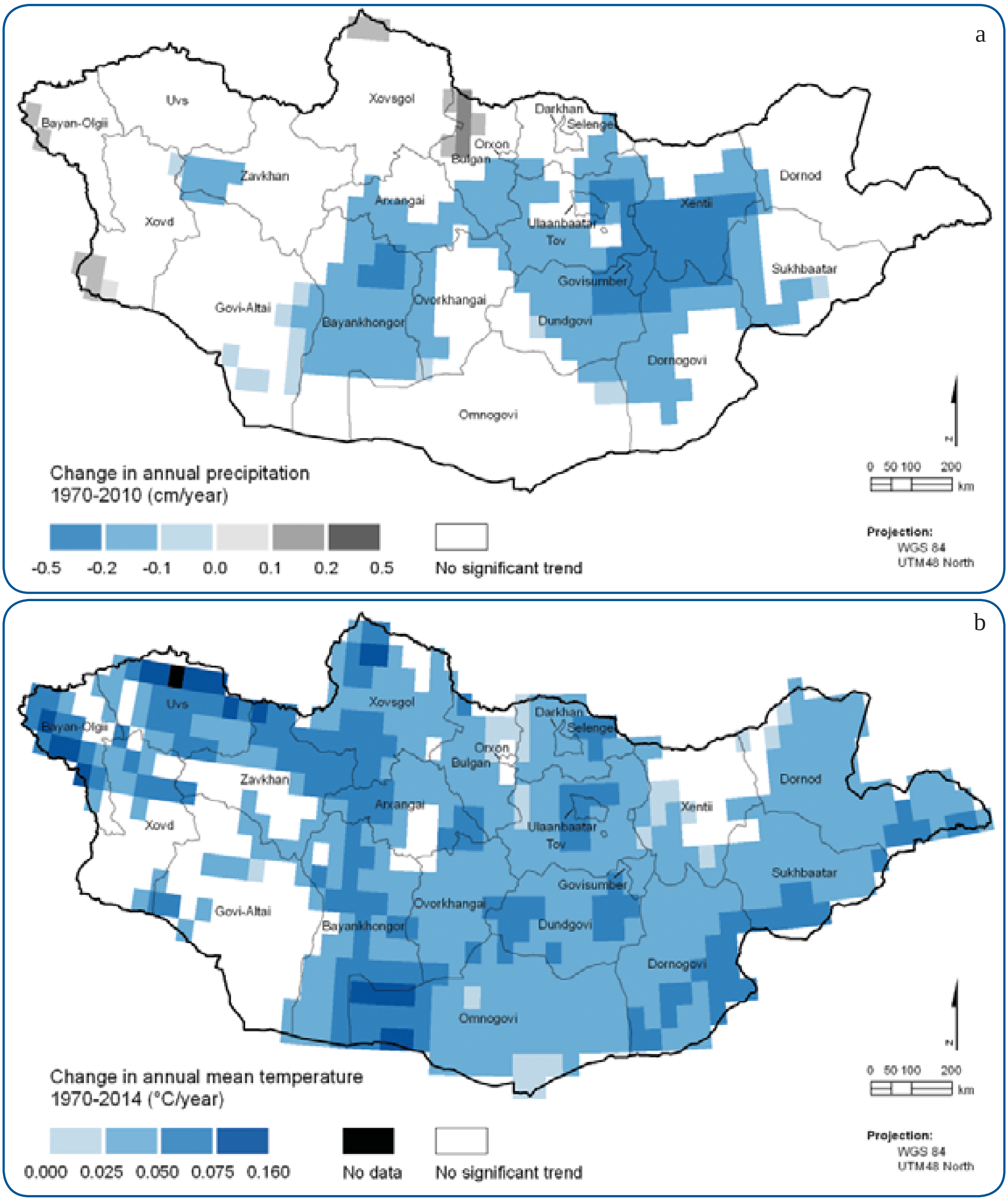


Figure 3.5 A. Trends in annual precipitation from 1970-2010, based on the University of Delaware global gridded monthly precipitation dataset. B. Trends in annual mean temperature from 1970-2014, based on the Global Historical Climatology Network version 3 global gridded monthly temperature dataset. Both datasets have a spatial resolution of 0.5 degree latitude x 0.5 degree longitude and were acquired from the NOAA Earth System Research Laboratory, Physical Sciences Division (http://www.esrl.noaa.gov/psd/). Trend significance was measured on a per-pixel basis using the Mann-Kendall trend test, and trend slope was measured on a per-pixel basis using the Theil-Sen estimator.

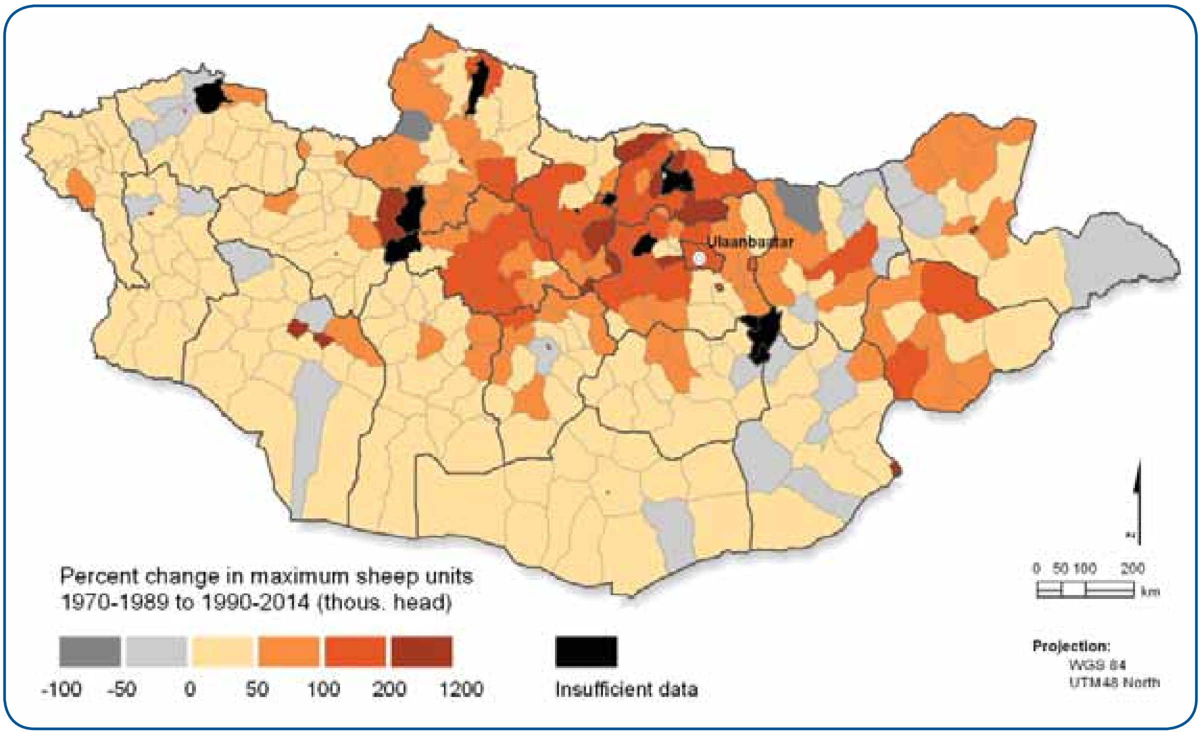


Figure 3.6 The percentage change in the maximum number of sheep of units observed in years 1970-1989 to the 1990-2014 period, based on data from the Mongolian Statistical Office.

The Undurshireet soum case indicates that the degree of degradation differs among seasonal pastures and ecological site groups. Pastures occurring on deep sandy soils in summer pastures near to the Tuul River are at high risk due to out-of-season grazing and erodible soils (Fig. 3.7, Fig. 3.8). These types of patterns may vary among soums due to the availability of water and area of the seasonal pastures.

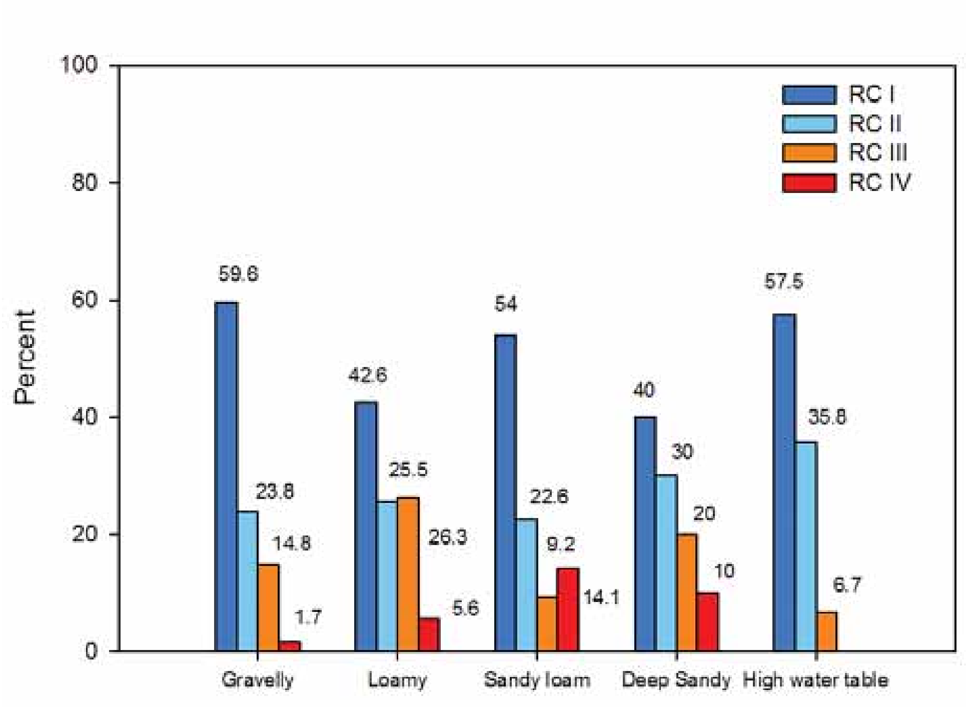


Figure 3.7 Percent of NAMEM monitoring and Green Gold (GG) inventory sites classified to each Recovery Class in different ecological site groups of Undurshireet soum.

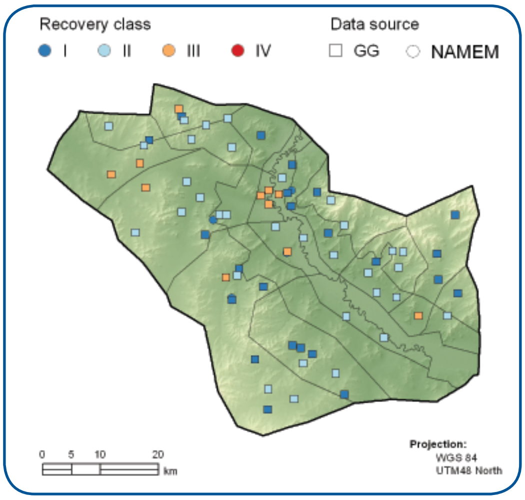


Figure 3.8 Map of NAMEM and Green Gold (GG) inventory sites classified to Recovery Classes in Undurshireet soum, with pasture boundaries delineated.

3.2. Rangeland degradation and general management responses

Based on the results presented above, a relatively low proportion of samples have experienced highly persistent degradation or desertification, represented by Recovery Class IV and V. A vast majority of samples suggest that changes to grazing could result in recovery, or progress toward recovery, within 10 years. A review of the ESDs associated with samples can be simplified into a general set of management responses.

Grazing management to sustain existing states (Recovery Class I). Within these areas, stocking rates should be adjusted to match a resilient, long-term carrying capacity (see 4.4 below) to maintain or improve vegetation condition, along side any needed adjustments to seasonal use patterns.

Grazing management to support perennial grass recovery and reduce dominance of degradation indicator plants (Recovery Class II and III). Reduced stocking rates and deferment periods (temporary non-use) in late spring and summer for portions of pastures and strict adherence to seasonal pasture use rules can lead to increases in perennial grasses from remnant populations. An initial period of intensive targeted grazing of current dominant plants, especially *Carex duriuscula* and *Artemisia frigida* in the fall or winter, followed by deferment or rest (year-long non-use) might be useful to open up areas for colonization by grasses, but this approach needs to be tested.

Grazing management to promote perennial plant establishment and control soil erosion (Recovery Class IV and V). Areas that have markedly reduced perennial plant cover are dominated by annual plants during rainy years and bare ground in dry years, sometimes associated with patches of grazing-resistant plants such as Caragana shrubs, *Ephedra sinica*, and *Achnatherum splendens*. The primary goal in these cases is to promote the gradual recovery of perennial plants to stabilize soils and the eventual recovery of perennial grasses. This can be accomplished using multi-year rest and then a reduced stocking rate after recovery of perennial plants. Other measures, such as the addition of manure, sustaining snow cover into Spring using a sweeper harrow to harden snow, and structures to accumulate snow deposits may help promote recovery. In heavily eroded areas with large bare patches and crusting, initial disturbance to the soil surface may improve infiltration. Seeding/planting of species appropriate to the ecological site group can be performed. In gullied areas, stabilization at the head of gullies and flattening gullies can be attempted.

Implementing sustainable management and restoration, as described above, requires a new management approach that can allow these types of prescriptions to be applied where they are needed in Mongolia. We propose that a “resilience-based rangeland management” approach be adopted.

4. A NEW APPROACH TO RANGELAND MANAGEMENT IN MONGOLIA

4.1. Resilience based rangeland management

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. 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 variability. 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 resilience-based rangeland management frame work integrates the traditional, community-based pasture management practices of the past with more recent rangeland management concepts and new technologies.

4.2. Integrating resilience-based rangeland management with current planning procedures

The current rangeland management framework used by ALAGAC is described in the Soum Annual Land Management Planning (SALMP) manual[51]. The SALMP process, while involving PUGs, has not been adequate because herder's participation in developing plans is limited and there is little information about the specific areas that are degraded and the types of management needed for restoration. Thus, plans do not specify management goals for pasture areas that vary in ecological sites and current states, recommendations do not accord with herder perceptions, and recommendations are often not feasible to implement. Furthermore, rangeland quality assessment reports upon which plans should be based may not be delivered in a timely fashion. Thus, reports are often not used in making land management decisions.

Resilience-based rangeland management promoted by Green Gold and ALAGAC seeks to improve the SALMP process by:

1) Providing clear criteria for identifying healthy and degraded areas.

2) Using ESDs and maps of rangeland conditions to specify where grazing can usefully be deferred or pastures rested, select appropriate timing of grazing, and recommend adjustments to stocking rates.

3) Adjusting management to specific areas based on differences among ecological site groups and rangeland health.

4) Focusing management on rangeland health as well as animal herds.

5) Linking monitoring to expectations about pasture use and the maintenance or improvement of rangeland health, based on specific indicators.

6) Encouraging participation of all stakeholders, including herders and local government officials, in selecting preferred management options and updating plans.

Seven specific steps are used in resilience-based rangeland management that rely on interactions between ALAGAC and NAMEM at the national level and PUGs and soum government at the local level

(Fig. 4.1, Annex 5). The process begins with soum land management planning activities with PUGs (step 1). Every five years, a rangeland quality assessment is conducted by professional companies contracted by ALAGAC. The soum land manager, rangeland specialist, and PUG representatives use the ESDs to evaluate pasture areas within each PUG (step 2). Longer-term monitoring trends provided by NAMEM and ALAGAC national offices are also considered in this step. Based on the assessment, the land manager prepares a map of ecosystem states and recovery classes that provide a spatially-explicit representation of management needs (step 3). 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 4). Plans are implemented by herders and local government (step 5). Management impact monitoring based on a photopoint method (Web Annex 3) and observations of pasture use by the land manager is used to adjust or enforce the management (step 6). Long-term monitoring data collected by NAMEM and ALAGAC at their respective monitoring sites are delivered to aimag and national offices and trends are reported to soum government and the national public. New information about rangeland change can be used by ALAGAC to periodically update ESD documents in the future.

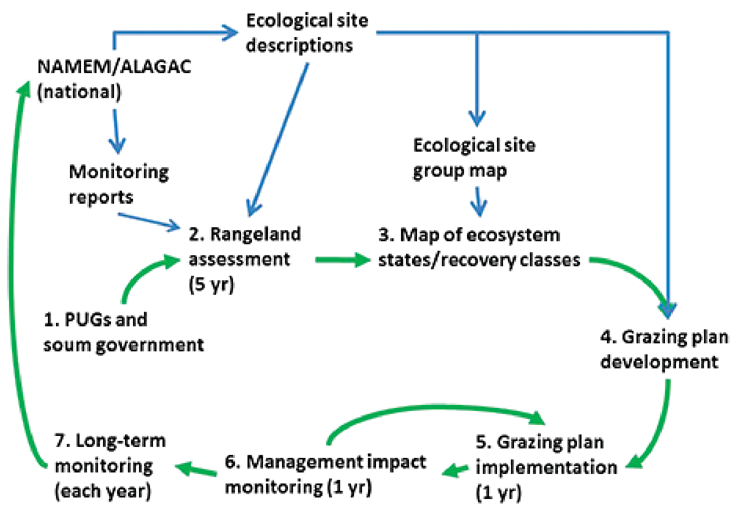


Figure 4.1 Steps in the resilience-based management approach. Green arrows indicate activities occurring at the local (soum and PUG) level and blue arrows indicate support from the national government, such as providing ecological site descriptions, ecological site group maps, and monitoring data.

The Green Gold project has worked with ALAGAC to test the use of ESDs within the resilience-based management framework in 5 different soums including Undurshireet soum of Tuv aimag, Chandman soum of Khovd aimag, Undurkhangai soum of Uvs aimag, Ider soum of Zavkhan aimag and Bulgan soum of Dornod aimag representing different ecological zones of Mongolia. While it is too early to detect changes in rangeland health and high livestock numbers limit management options (see 4.4 below), plans are being implemented and early experiences are detailed in Annex 5.

Based on this progress, 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 ALAGAC (Web Annex4). These technical documents can be used as a roadmap not only for grazing management, but also for wildlife conservation and environmental restoration programs.

Based on the lessons learned from pilot studies of the resilience-based rangeland management approach, ALAGAC will:

1) Include resilience-based rangeland management procedures as an annex to the Soum Annual Land Management Planning manual.

2) Collaborate with the Mongolian University of Life Sciences on a capacity development program for their personnel at national, regional and local levels.

3) Collaborate with Green Gold in further application of the resilience-based rangeland management approach in 15 soums representing different ecological zones as well as at the aimag level in Arkhangai.

The total investment for developing ESDs and procedures for mapping and use of ESDs in resilience-based rangeland management was approximately 910,0 million MNT. Upscaling these tools to additional soums beyond the 32 already completed or in progress will require approximately 10.5 million MNT per soum on average. Sixty to eighty soums could be completed per year by existing ALAGAC staff and all soums completed by 2020. This cost could easily be accommodated within the existing budget lines of ALAGAC.

4.3. The importance of carrying capacity concepts for resilience based rangeland management.

The most significant limitation for implementing resilience-based rangeland is the control of animal numbers and, therefore, the timing and amount of grazing in a pasture area[6]. Rangeland management in Mongolia has focused only on forage availability but not on the management of rangeland health that sustains forage quality over the long term. The maintenance and recovery of rangeland health requires that sufficient plant biomass and cover remains to promote plant growth and reproduction, maintain soil fertility, and sustain biodiversity. Current procedures for calculating carrying capacity and stocking rates in Mongolia make no allowance for plant vigor, periodic plant reproduction, and the retention of stubble to maintain soil quality, control erosion, and protect plant crowns from trampling and weather extremes. Modern rangeland management focuses on managing plants and soils, in addition to livestock.

4.4. A new procedure for estimating resilient carrying capacity

A resilient carrying capacity will maintain or improve rangeland health and animal quality and provide a sustainable level of meat and fiber production. Calculation of a long-term resilient carrying capacity and location- and time-specific stocking rates account for i) forage utilization levels that leave sufficient biomass to maintain rangeland health; ii) adjustments to utilization levels and the timing of grazing or rest needed to promote the recovery of key plant species; and iii) realistic estimates of actual utilization that account for forage loss to trampling, decomposition, and other herbivores. Harvest efficiency, the percentage of total plant production that is ingested by the animal, is one of the core criteria that define the carrying capacity. There have been many studies of grazing harvest efficiency[4, 5, 9, 16, 31, 35]. Harvest efficiency can be controlled, within limits, through animal density and amount of utilization. Studies indicate that above 35 to 45% harvest efficiency, forage intake in ruminant animals decreases sharply and plant production also decreases. When harvest efficiency exceeds 45 to 50%, forage production drops by 80% and no residue exists on the plants or soil surface[33].

A 30% harvest efficiency is proposed as a general rule for Mongolia in order to attain 50-60% percent utilization (Fig. 4.2). The 30% value accounts for improved efficiency of forage consumption associated with herding management that is typical of Mongolia, compared to values used in North America (25%) where herding is seldom practiced. A 50% utilization level is broadly recommended to maintain rangeland health and is similar to or greater than that recommended for steppes in Inner Mongolia in recent studies[26, 44]. Recovery of rangeland health in degraded pastures, however, often requires reduced utilization.

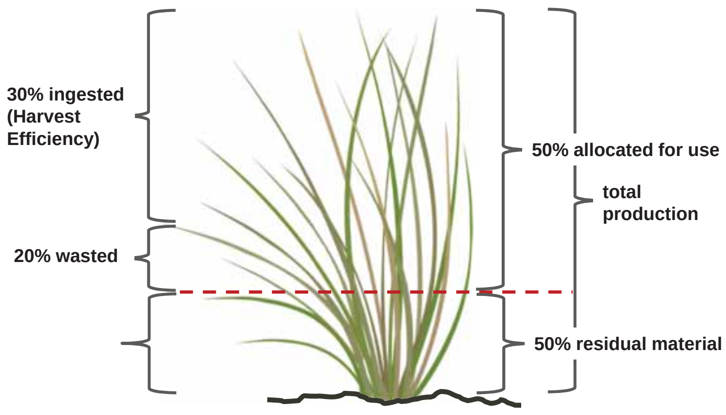


Figure 4.2 Schematic of the use of 30% harvest efficiency to attain 50% utilization for attaining a resilient carrying capacity.

Resilient carrying capacity calculations are recommended based on the following assumptions and guidelines:

1. Animal intake varies between 2.5 and 3.0 percent of body weight. Values of 3.0 percent or 1.4 kg/day/ Mongolian Sheep Units (MSU) will be used.

2. A harvest efficiency estimate of 30%.

3. Forage production is estimated as the total vegetation collected by clipping established plots in each soum. For simplicity, adjustments for vegetation functional group, topography or distance to water are ignored.

Therefore, a standard approach for computing the resilient carrying capacity is:

Forage production (kg/ha) = F;
Intake demand (kg/MSU/yr) = 511 kg;
Harvest efficiency = 0.30;
(F/511)*0.30 =MSU/ha/yr;
or 1/((F/511)*0.30) = ha/MSU/yr.

Based on these calculations, several soums in which Green Gold has detailed data on forage production livestock number in 2014 exceed a resilient carrying capacity from 2-4 times (Table 4.1; Table 4.2).

Table 4.1 Resilient carrying capacity (CC) estimates for intensively studied soums compared with current stocking rates (SR).

Soums	Ecological zones	Resilient CC, MSU/100 ha	Existing SR, MSU/100 ha
Undurkhangai, Uvs	High mountain	20	49
Ider, Zavkhan	Forest steppe	36	47
Ikhtamir, Arkhangai	Forest steppe	38	113
Undurshireet, Tuv	Dry steppe	48	113
Bulgan, Dornod	Typical steppe	116	27
Chandmani, Khovd	Desert steppe	26	54
Erdene, Gobi Altai	Desert	11	46

Table 4.2. Resilient carrying capacity (CC) estimates compared with current stocking rates (SR) in seasonal pastures of PUGs within Undurshireet soum. Bold values are for total PUG area.

PUGs	Seasonal pastures	Resilient CC, MSU/100 ha	Existing SR, MSU/100 ha	SR/RCC
Uuliin khan		**36**	**112**	**3.11**
	Winter	130	279	2.17
	Spring/fall	90	327	3.77
	Summer	100	437	4.32
Bayanbulag		**49**	**155**	**3.14**
	Winter	150	306	2.04
	Spring/fall	120	315	2.65
	Summer *	100	923	9.12
Ikh am		**40**	**411**	**10.38**
	Winter	140	691	4.83
	Spring/fall	60	1014	15.67
	Summer *	-	-	
Tesegt		**47**	**386**	**8.14**
	Winter	170	709	4.17
	Spring/fall	80	848	10.69
	Summer *	-	-	-
Sant		**46**	**107**	**2.33**
	Winter	80	240	3.08
	Spring/fall	120	264	2.20
	Summer	140	706	5.13
Berkh		**73**	**38**	**0.52**
	Winter	110	48	0.42
	Spring/fall	250	398	1.60
	Summer	190	378	2.03
Muurs		**57**	**74**	**1.29**
	Winter	70	146	2.12
	Spring/fall	180	285	2.39
	Summer	70	946	14.51
Zuulun		**53**	**216**	**4.09**
	Winter/spg/fall	50	187	3.86
	Summer	53	358	6.75

**: Three PUGs (Bayanbulag, Ikh am and Tesegt) share the same summer pasture.*

Livestock numbers in one soum, Bulgan in Dornod aimag, are significantly below carrying capacity. A similar calculation (based on 50% utilization) using national-level data and remote sensing-based forage models indicates that from 30 to 55% of all ecological zones in Mongolia, except for desert, experienced overgrazing in 2014 and chronic overgrazing (for more than 10 years) is observed in 11% of Mongolia (Fig. 4.3)[13]. **Thus, it is likely that overgrazing is a primary factor explaining rangeland degradation observed in many areas in Mongolia, and with current livestock numbers, rangeland degradation will likely intensify.**

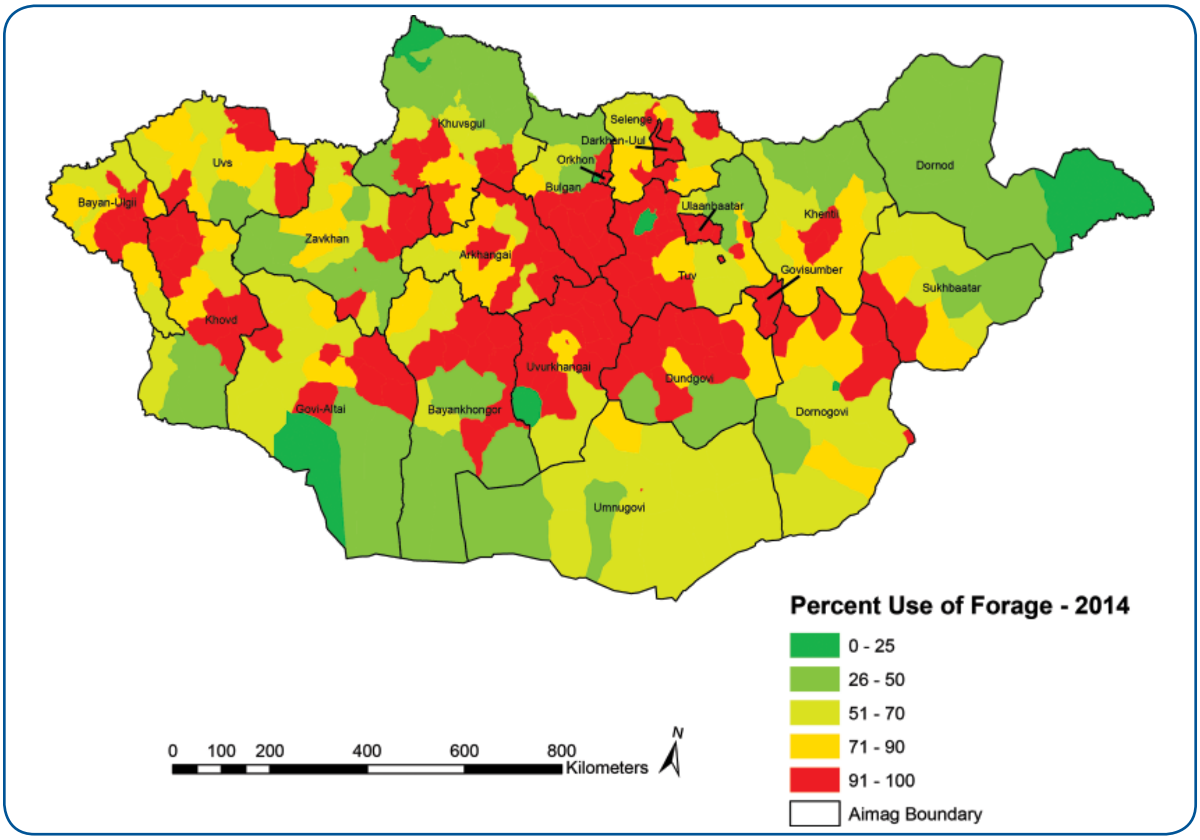


Figure 4.3 Estimated percent use of available forage by livestock in 2014 from Gao et al., 2015[13].

The adoption of a resilient carrying capacity concept is crucial for sustainable rangeland management in Mongolia because:

1) Scientifically sound procedures for estimating actual forage intake are critical for developing useful carrying capacity and utilization estimates, and;

2) A general utilization rate of 50-60%, at most, is needed to allow for the maintenance and recovery of rangeland health and the benefits it provides. In addition, a conservative utilization rate can act as insurance for droughts and dzuds that are likely to intensify with climate change.

In addition, the proposed 30% harvest efficiency has a precedent in existing ALAGAC methodology, in which harvest efficiency values vary from 27 to 34% depending on ecological zones. Thus, there is an opportunity to promote this existing approach as a means to standardize a resilient carrying capacity calculation methodology at a national level.

Restoration of degraded pastures can be promoted by, and may require, stocking rates below the resilient carrying capacity. Thus, stocking rates can be reduced by 5% in Recovery Class II, 10% in class III, and 15% in class IV and V.

4.5. Strengthening institutions to implement resilience-based rangeland management

Sustainable land management planning in Mongolia has been challenged by i) the lack of participation by herders in the planning process; ii) a lack of spatially-explicit information about rangeland management needs and timing; iii) a lack of effective monitoring; iv) poor coordination among ministries and their activities at national and local levels; v) the absence of a regulatory framework for enforcement of management plans; and vi) the lack of mechanisms to encourage reduction in livestock numbers.

The involvement of herders in the development of rangeland management plans can be encouraged by government programs to promote formation of herder's customary organizations and training. With Green Gold support, herder's representatives of PUGs and Pasture Users Group Associations (APUGs) have received training on sustainable rangeland and herd management approaches as well as user's roles in local-level decision making and budgets. Expansion of this training could be supported by government to ensure that herders play a catalyzing role in a bottom-up approach to rangeland management.

The development of spatially-explicit information about rangeland management needs requires training of land managers and rangeland specialists in the use of ESDs and derived maps for planning and monitoring. Maps based on ESDs will be provided by ALAGAC staff at the national level. Monitoring will include both management impact (i.e. evidence that recommendations are being implemented) and long-term responses of rangeland health to management. ALAGAC land managers are responsible for management impact monitoring and adaptive management. Measurements gathered by ALAGAC and NAMEM can be used over the long-term to assess changes in rangeland health.

National coordination among the Ministries and agencies including the Ministry of Environment, Green Development and Tourism, NAMEM, Ministry of Food and Agriculture, ALAGAC, Universities, and the Standing Committee on Petition has been promoted by the Green Gold project via the development of technical standards, policy documents, coordination workshops, and Memoranda of Understanding to define the resilience-based rangeland management approach.

At the local level, the specific roles and interactions of Ministry and agency representatives, including meteorologists (rangeland monitoring), environmental officers (conservation), land managers (management planning and enforcing), animal health and breeding unit specialists (herd management), and PUGs (herders) are more clearly defined under the new management framework (Fig. 4.4). Methodologies that detail the specific roles of stakeholders are being developed currently by ALAGAC with Green Gold support.

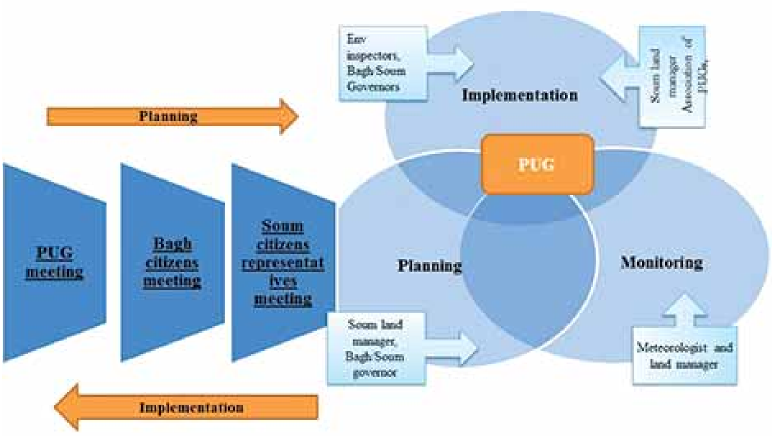


Figure 4.4 Local level coordination and roles for implementing resilience-based rangeland management.

Green Gold and its partners have created an infrastructure for resilience-based rangeland management over the last decade. This includes i) new procedures, technical manuals, and a database for assessment, monitoring, interpretation, and reporting on rangeland health; ii) a method for calculating resilient carrying capacity that is based on internationally-used procedures; iii) Ecological Site Description documents and simple training materials that describe the carrying capacities and management options for different ecological states; and iv) a method and training materials for implementing resilience-based rangeland management based on ESDs.

However, without a strong regulatory environment that addresses stocking rates, rangeland health standards cannot be enforced and rangeland management will be difficult or impossible to implement.

5. POLICY CONSIDERATIONS FOR RANGELAND HEALTH

5.1. The need to manage animal numbers

In all but the most arid rangelands, it is well established that persistent high stocking rates and overgrazing result not only in forage limitations for vulnerable herders but also long-term declines in rangeland health, especially forage productivity[6, 50]. Increases in animal numbers also result in falling market prices for fiber and reductions in income. As incomes decline, herders are motivated to increase animal numbers to make up for lost income. This feedback contributes to skyrocketing animal numbers, and has been referred to as the "circle of devil"[47, 49].

Policies to establish moderate stocking rates, on the other hand, can lead to a virtuous cycle of improved forage productivity, livestock productivity, and financial returns[18, 22]. The question is, **how can moderate stocking rates based on a resilient carrying capacity be encouraged?**

5.2. Actions to promote resilience-based rangeland management

Several measures could be implemented to promote sustainable management of rangelands.

1) **Adopt the resilient carrying capacity concept.** An interagency working group at the Ministry of Food and Agriculture is considering the adoption of this concept. The benefits of reduced stocking rates are also being quantified. For example,the Center for Policy Research of Mongolia has shown that stocking rate reduction of 8% can result in a 10% increase of herder's income[48], similar to results observed in Inner Mongolia[22].

2) **Strengthen Rangeland Use Agreements.** Current land use agreements on rangelands should be extended to encompass all seasonal pastures and should clearly specify herders' responsibility to keep stocking rates within a resilient carrying capacity. The benefits of strong land use agreements have been demonstrated by several donor-sponsored projects[52]. These experiences show that land use agreements should ensure that the rangeland under agreement is used exclusively by those who sign it, with the exception of reciprocal access rights in emergencies. If the exclusivity condition fails then there is no way to assign the responsibility for rangeland degradation to those who sign the agreement. These projects also demonstrate that grazing fees designed to discourage overgrazing and encourage sustainable use are feasible and supported by herders.

3) **Promote quality versus quantity.** Existing subsidy schemes could be used to promote the quality of animal products, rather than quantity maximization, which might promote reductions in animal numbers. For example, the recent decision to top up the price of first-grade baby camel wool could be extended to other products with subsidized prices.

4) **Improve market accessibility for livestock products.** Market opportunities with international trading partners should be sought to increase animal off-take, increase herder's income, and promote a longer-term focus on animal quality. Outreach on the benefits of converting animals to cash and the benefits of a focus on animal quality should be expanded. The establishment of rural cooperatives, the linkage of cooperatives to processing companies, and animal health certification should be supported.

6. KEY MESSAGES

- Science and experiences throughout the world indicate that a focus on rangeland health is necessary to sustain pastoral livelihoods and other environmental services, particularly in the face of increasing resource use pressures and climate change.

- Data collected by NAMEM, as well as those in other recent reports[10], suggest that rangeland degradation is widespread but few areas are irreversibly degraded.

- Rangeland health of most areas can be maintained and improved with reduced stocking rates and changes in grazing management. These changes should be initiated now before rangeland degradation intensifies, pasture productivity is lost, and recovery of rangeland health becomes increasingly difficult.

- Resilience-based rangeland management approaches, based on Ecological Site Descriptions, and implemented in soum land management plans developed by ALAGAC, could result in measurable improvements in rangeland health over several years' time.

- Without a strong regulatory environment that addresses stocking rates, rangeland health standards cannot be enforced and rangeland management will be difficult or impossible to implement.

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ANNEXES

Annex I. Letter of approval of monitoring methodology.

Annex II. Key to ecological site concepts.

Annex III. State-and-transition models for each ecological site groups.

Annex IV. Example Ecological Site Description with detailed narratives.

Annex V. Resilience-based rangeland management case study in Undurshireet soum.

Web annexes

http://imh.mn

http://gazar.gov.mn

http://jornada.nmsu.edu/esd/international/mongolia

Web Annex 1. Statistical analyses supporting ecological site description development.

Web Annex 2. Web map-based information about conditions of NAMEM monitoring plots.

Web Annex 3. Manual for the photopoint methodology.

Web Annex 4. Photo catalogues of state-and-transition models for herders and managers.

Annex 1

Letter of approval of monitoring methodology.

МОНГОЛ УЛСЫН
БАЙГАЛЬ ОРЧИН, АЯЛАЛ ЖУУЛЧЛАЛЫН
САЙДЫН ТУШААЛ

2011 оны 04 сарын 22 өдөр Дугаар А-114

Заавар батлах тухай

"Цөлжилттэй тэмцэх үндэсний хөтөлбөр"-ийн 3 дугаар зүйлийн 3.14.1.2 да заалтыг хэрэгжүүлэх зорилгоор Байгаль орчин, аялал жуулчлалын яамны Шинжл ухаан, технологийн зөвлөлийн 2011 оны 01 дүгээр хурлын тэмдэглэлийг үндэсл ТУШААХ НЬ:

1. Монгол орны хэмжээнд цөлжилтийн төлөв байдлын үнэлгээнд ашигл бэлчээрийн ургамал, хөрсний чанарын анхан шатны үзүүлэлтүүдийг тодорхойлох "Цөлжилтийн хяналт шинжилгээний заавар"-ыг хавсралтаар баталсугай.

2. Цөлжилт, газрын доройтол, газрын хянан баталгааны чиглэлээр улсы хэмжээнд хийж буй бэлчээрийн ургамал, хөрсний чанарын анхан шатны хяна шинжилгээнд энэхүү зааврыг 2011 оны 7 дугаар сарын 1-ээс эхлэн мөрдө ажиллахыг энэ чиглэлээр үйл ажиллагаа явуулдаг төрийн болон төрийн б байгууллагууд, гадаад, дотоодын төсөл хөтөлбөрүүдэд зөвлөсүгэй.

3. Бэлчээрийн ургамал, хөрсний чанарын хяналт шинжилгээний ажлы ...ыг хэвлүүлэх, төв, орон нутгийн мэргэжлийн байгууллагуудын инжене ...икийн ажилтнуудад зааж сургах, ус цаг уур, орчны хяналт шинжилгээний улсы сүлжээний өртөө, харуул, лабораторийн шинжилгээний ажлын хөтөлбөрт нэмж 201 2012 онд багтаан улсын хэмжээнд хэрэгжүүлэх арга хэмжээ авахыг Цаг уур, орчн шинжилгээний газрын дарга С.Энхтүвшинд даалгасугай.

4. Ус цаг уур, орчны хяналт шинжилгээний улсын сүлжээнд бэлчээри ургамал, хөрсний чанарын хяналт шинжилгээний ажлыг хийхтэй холбогдуулан аймагт Байгаль орчны шинжилгээний лаборатори байгуулах зардлыг 2012 оны төсө тусгах арга хэмжээ авахыг Цаг уур, орчны шинжилгээний газрын дарга С.Энхтүвши Тогтвортой хөгжил, стратегийн төлөвлөлтийн газрын дарга Ц.Банзрагч нарт үүр болгосугай.

5. Энэхүү тушаалын биелэлтэд хяналт тавьж ажиллахыг Хүрээлэн буй орчи ...лийн нөөцийн газрын дарга Д.Энхбат, Цөлжилтийн үндэсний хорооны нари ...ийн дарга Д.Баярбат нарт даалгасугай

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Annex II

Key to ecological site concepts.

General soil	Ecological site concept	Soil characteristics*	Drainage class	Flooding	Flooding	Slope	Soil Depth	Surface	Sub-surface	Pedoderm (0-	Surface	Sub-surface	Surface	Subsurface	Presence of Bk	Presence	Presence of	Presence of well-
Sandy	Sandy†	LS-SL-FSL surface[B] and subsurface[C] (to 10-18%	Excessively	none	Extremely	≤10%	>50 cm	LS-SL-FSL	LS-SL-FSL (10-	<35%	<15%	<35%	NE-SL	NE-SL	optional	not within	optional	no
Sandy	Calcareous sandy†	LS-SL-FSL surface and subsurface (to 10-18%	Excessively	none	Extremely	≤10%	>50 cm	LS-SL-FSL	LS-SL-FSL (10-	<35%	<15%	<35% rock	NE-VE	ST-VE	within 50 cm or	not within	optional	no
Sandy	Deep sand	LS or S with < 10% clay and little change in	Excessively	none	Extremely	<10%	>100 cm	LS-S (<10%	LS-S (<10%	<35%	<15%	<35%	NE-SL	NE-SL	not within 50	not within	not within 50	not within 100
Sandy	Sandy loam†	LS-SL-FSL surface, argillic horizon evident with	Moderately	none	Extremely	≤10%	>50 cm	LS-SL-FSL	FSL-SL-L-SCL	<35%	<15%	<35%	NE-SL	NE-SL	optional	not within	optional	yes within 50 cm
Sandy	Sandy terrace	LS-SL-FSL surface, argillic horizon may or may	Moderately	occasional	Very brief-	<5%	>50 cm	LS-SL-FSL	LS-FSL-SL-L-	<35%	<15%	<35%	NE-SL	NE-VE	optional	not within	optional	optional
Sandy	Calcareous sandy loam†	LS-SL-FSL surface, argillic horizon evident with	Moderately	none	Extremely	≤10%	>50 cm	LS-SL-FSL	FSL-SL-L-SCL	<35%	<15%	<35% rock	NE-VE	ST-VE	within 50 cm or	not within	optional	yes within 50 cm
Sandy	Saline sandy	> 800 µS within 50 cm and LS-SL-FSL surface	Excessively	occasional	Extremely	≤10%	>50 cm	LS-SL-FSL	LS-SL-FSL (10-	<35%	<15%	<35%	NE-VE	NE-VE	optional	not within	optional	no
Loamy	Clay loam†	Loamy surface (usually 18-35% clay but possibly	Moderately	none	Extremely	≤10%	>50 cm	FSL-SL-L-SiL-	SiCL-CL-SiC-SC-	<35%	<15%	<35%	NE-SL	NE-SL	optional	not within	optional	yes within 50 cm
Loamy	Loamy†	18-35% clay throughout, may see clay increase	Moderately	none	Extremely	≤10%	>50 cm	FSL-SL-L-SiL-	FSL-SL-L-SiL-	<35%	<15%	<35%	NE-SL	NE-SL	optional	not within	optional	no
Loamy	Loamy terrace	SL-FSL-L surface with strong argillic	Moderately	occasional	Very brief-	<10%	>50 cm	FSL-SL-L-SiL-	FSL-L-SiL-CL-	<35%	<15%	<35%	NE-VS	NE-SL	optional	not within	optional	yes within 50 cm
Loamy	Calcareous loamy†	SL-FSL-L surface with strong argillic	Moderately	none	Extremely	≤10%	>50 cm	FSL-SL-L-SiL-	FSL-L-SiL-CL-	<35%	<15%	<35%	NE-VE	SL-VE	within 50 cm or	not within	optional	yes within 50 cm
Loamy	Loamy overflow	SL-FSL-L surface with loamy subsurface, in	Moderately	frequent	Very brief-	<5%	>50 cm	FSL-SL-L-SiL-	FSL-L-SiL-CL-	<35%	<15%	<35%	NE-VE	NE-VE	optional	not within	optional	yes within 50 cm
Loamy	Saline loamy	> 800 µS within 50 cm, and 18-35% clay	Moderately	occasional	Extremely	<5%	>50 cm	FSL-SL-L-SiL-	FSL-L-SiL-CL-	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	optional
Clayey	Clayey†	Surface and subsurface soils are clayey	Moderately	none	Extremely	≤10%	>50 cm	SiCL-CL-SiC-	SiCL-CL-SiC-SC-	<35%	<15%	<35%	NE	NE-VE	optional	no	optional	within 50 cm or
Clayey	Saline clayey	> 800 µS within 50 cm; surface and subsurface	Moderately	occasional	Extremely	≤10%	>50 cm	SiCL-CL-SiC-	SiCL-CL-SiC-SC-	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	within 50 cm or
High water table	Meadow	Poorly drained, no evidence of salinity,	Poorly drained	frequent	Long-Very	<5%	>50 cm	any	any	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	optional
High water table	Saline meadow	> 800 µS within 50 cm; poorly drained, salt	Poorly drained	frequent	Long-Very	<5%	>50 cm	any	any	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	optional
High water table	Mountain meadow	Poorly drained, thick mollic epipodon (mountain	Poorly drained	frequent	Long-Very	<5%	>50 cm	any	any	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	optional
High water table	Wetland	Poorly drained, no evidence of salinity, adjacent	Very poorly	frequent	Very long	<5%	>50 cm	any	any	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	optional
High water table	Saline overflow	> 800 µS within 50 cm; poorly drained, salt	Moderately	frequent	Very brief-	<5%	>50 cm	any	any	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	optional
High water table	Subirrigated	Somewhat poorly drained, usually loamy	Somewhat	frequent	Brief-Very	<5%	>50 cm	FSL-SL-L	FSL-SL-L-SCL-	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	optional
High water table	Calcareous subirrigated	Somewhat poorly drained, usually loamy	Somewhat	frequent	Brief-Very	<5%	>50 cm	FSL-SL-L	FSL-SL-L-SCL-	<35%	<15%	<35%	NE-VE	NE-VE	optional	no	optional	optional
High water table	Floodplain	Stratified deposits within ephemeral steam	Variable	frequent	Brief-Very	<5%	>50 cm	S-LS-SL-FSL-	S-LS-SL-FSL-	any	any	any	NE	NE	none	no	none	none
Gravelly**	Gravelly sand†	>35% fragments within 50cm of surface, LS, SL,	Excessively	none	Extremely	≤10%	>50 cm	LS-SL-FSL	LS-SL-FSL	>15%	15-60%	>35%	NE-SL	NE-SL	optional	not within	optional	no
Gravelly	Gravelly loam†	>35% fragments within 50cm of surface, L, SCL,	Moderately	none	Extremely	≤10%	>50 cm	LS-FSL-SL-L-	FSL-L-SiL-SCL-	>15%	15-60%	>35%	NE-SL	NE-VE	optional	not within	optional	within 50 cm or
Gravelly	Calcareous gravelly sand†	>35% fragments within 50cm of surface,	Excessively	none	Extremely	≤10%	>50cm	LS-FSL-SL-L	SL-FSL-L-SiL-	>15%	15-60%	>35%	VS-VE	ST-VE	within 50 cm or	optional	optional	no
Gravelly	Calcareous gravelly loam†	>35% fragments within 50cm of surface,	Moderately	none	Extremely	≤10%	>50 cm	LS-FSL-SL-L-	FSL-L-SiL-SCL-	>15%	15-60%	>35%	VS-VE	ST-VE	within 50 cm or	optional	optional	within 50 cm or
Gravelly	Extremely gravelly	>60% fragments within 30cm of surface; gravels,	Excessively	none	Extremely	≤10%	>50 cm	any	any	>15%	15-60%	>60%	NE-VE	NE-VE	optional	not within	optional	no
Hills/mountains	Shallow igneous***	complex but usually > 10% slope, shallow to	Moderately	none	Extremely	any	<50cm	SL-FSL-L	FSL-SL-L-SCL-	>15%	>15%	>35%	NE-VE	NE-VE	optional	if present,	optional	optional
Hills/mountains	Stony slopes	> 10% slope, deep, >15% fragments, including	Moderately	none	Extremely	>10%	>50cm	SL-FSL-L	FSL-SL-L-SCL-	>15%	>15%	>35%	NE-VE	NE-VE	optional	not within	optional	optional
Hills/mountains	Mountain shallow ridge	> 10% slope on ridge, typically exposed bedrock	Moderately	none	Extremely	>10%	<50 cm	SL-FSL-L	FSL-SL-L-SCL-	> 15%	0-60%	>35%	NE-VE	NE-VE	optional	if present,	optional	optional
Hills/mountains	Mountain ridge	> 10% slope on ridge, typically exposed bedrock	Moderately	none	Extremely	>10%	>50cm	SL-FSL-L	FSL-SL-L-SCL-	> 15%	0-60%	>35%	NE-VE	NE-VE	optional	not within	optional	optional

A. These groups are based only on soil texture types. Ecological Site Groups were defined separately within each Natural Ecological Zone and be based on similarities in plant community types and landforms recognized by herders

B. The surface includes the first 30 cm of the soil that contains the vast majority of root biomass for most herbaceous species worldwide (Schenk and Jackson 2002) and on Mongolian Plateau (Ao et al., 2009).

C. Subsurface generally refers to the 30-50+ cm depth. We regard properties that occur exclusively below 50 cm as unimportant in this key.

† If < 10% slope then "upland" modifier used; if > 10% slope then "slopes". Note that point based slope estimates may not adequately reflect the where slope complexity is undulating or rolling, in which case modifier assignment may be based on slope at a broader extent or landform. All abbreviations and classes follow Schoeneberger et al. (2002).

* other concepts types might be pedogenic soil shallow to C material including sand and gravel (e.g., shallow gravel) or to natric claypans or other pan types, or to bedock without a slope > 15%

** could also recognize skeletal soils, perhaps adding a very gravelly site type

*** other parent materials possible, such as limestone, siltstone, sandstone

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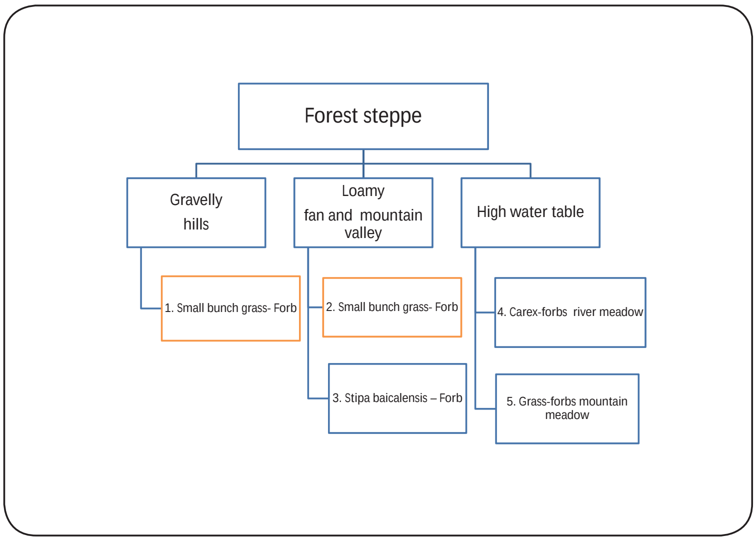
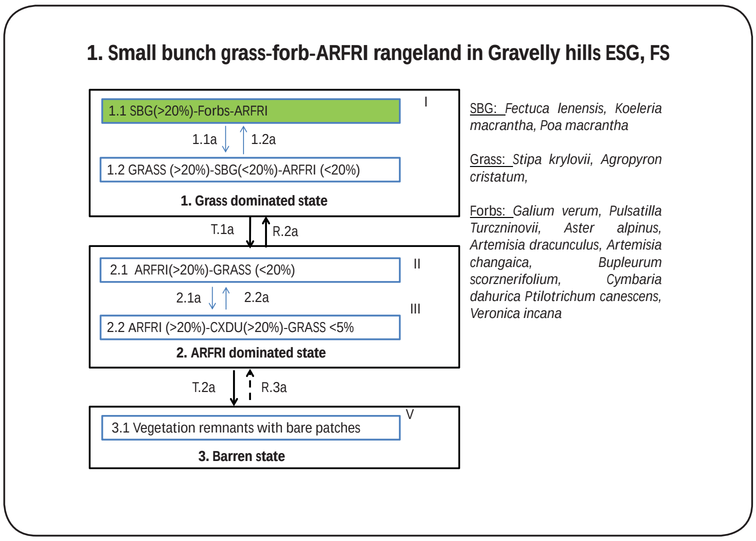
Annex III

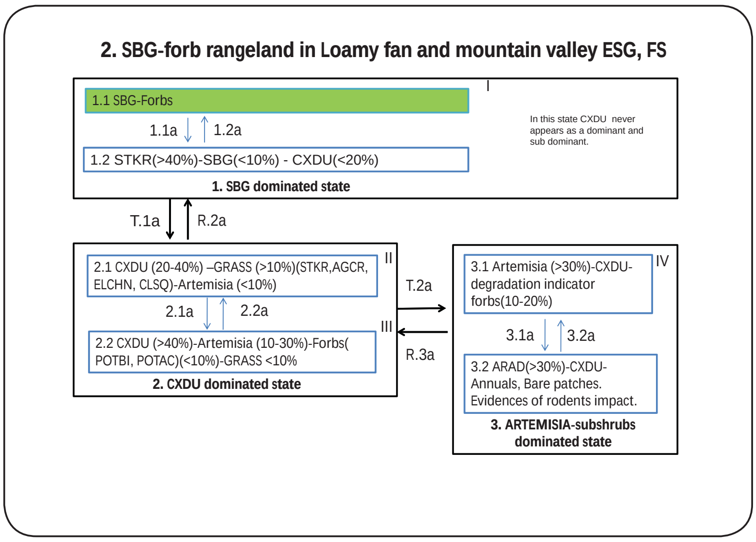
State-and-transition models for each ecological site groups



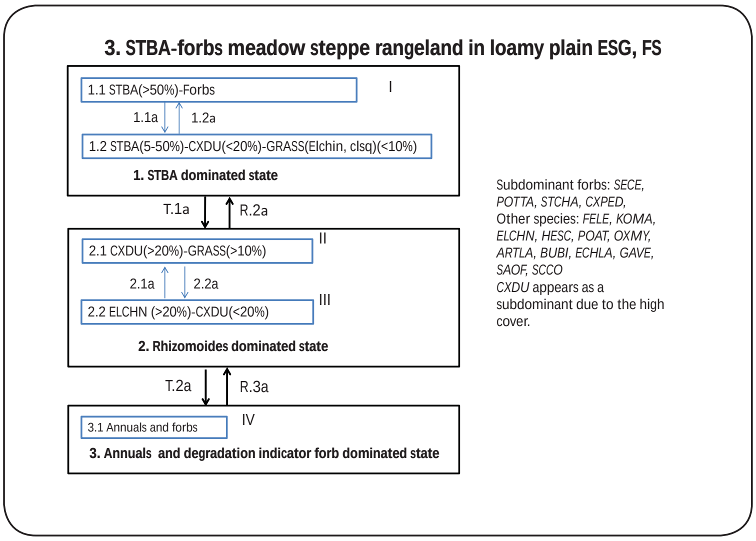
Forest steppe
Gravelly hills
Loamy fan and mountain valley
High water table
1. Small bunch grass- Forb
2. Small bunch grass- Forb
3. Stipa baicalensis – Forb
4. Carex-forbs river meadow
5. Grass-forbs mountain meadow



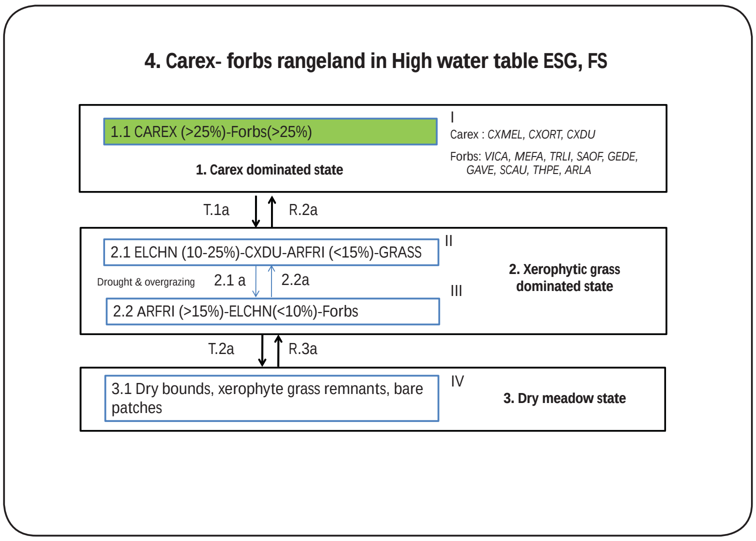
1. Small bunch grass-forb-ARFRI rangeland in Gravelly hills ESG, FS
1.1 SBG(>20%)-Forbs-ARFRI
I
1.1a
1.2a
1.2 GRASS (>20%)-SBG(<20%)-ARFRI (<20%)
1. Grass dominated state
T.1a
R.2a
2.1 ARFRI(>20%)-GRASS (<20%)
II
2.1a
2.2a
III
2.2 ARFRI (>20%)-CXDU(>20%)-GRASS <5%
2. ARFRI dominated state
T.2a
R.3a
3.1 Vegetation remnants with bare patches
V
3. Barren state
SBG: Fectuca lenensis, Koeleria macrantha, Poa macrantha
Grass: Stipa krylovii, Agropyron cristatum,
Forbs: Galium verum, Pulsatilla Turczninovii, Aster alpinus, Artemisia dracunculus, Artemisia changaica, Bupleurum scorznerifolium, Cymbaria dahurica Ptilotrichum canescens, Veronica incana



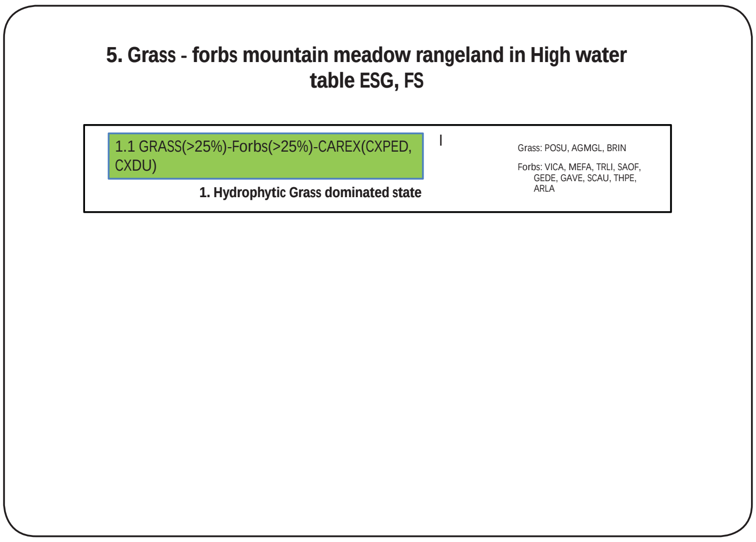
2. SBG-forb rangeland in Loamy fan and mountain valley ESG, FS
1.1 SBG-Forbs
I
1.1a
1.2a
1.2 STKR(>40%)-SBG(<10%) - CXDU(<20%)
In this state CXDU never appears as a dominant and sub dominant.
1. SBG dominated state
T.1a
R.2a
2.1 CXDU (20-40%) –GRASS (>10%)(STKR,AGCR, ELCHN, CLSQ)-Artemisia (<10%)
II
2.1a
2.2a
III
2.2 CXDU (>40%)-Artemisia (10-30%)-Forbs(POTBI, POTAC)(<10%)-GRASS <10%
2. CXDU dominated state
T.2a
R.3a
3.1 Artemisia (>30%)-CXDU-degradation indicator forbs(10-20%)
IV
3.1a
3.2a
3.2 ARAD(>30%)-CXDU-Annuals, Bare patches. Evidences of rodents impact.
3. ARTEMISIA-subshrubs dominated state



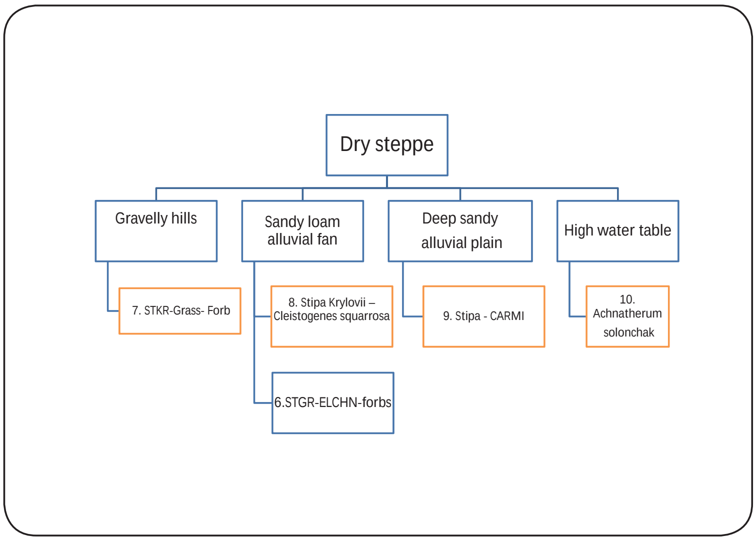
3. STBA-forbs meadow steppe rangeland in loamy plain ESG, FS
1.1 STBA(>50%)-Forbs
I
1.1a
1.2a
1.2 STBA(5-50%)-CXDU(<20%)-GRASS(Elchin, clsq)(<10%)
1. STBA dominated state
T.1a
R.2a
2.1 CXDU(>20%)-GRASS(>10%)
II
2.1a
2.2a
2.2 ELCHN (>20%)-CXDU(<20%)
III
2. Rhizomoides dominated state
T.2a
R.3a
3.1 Annuals and forbs
IV
3. Annuals and degradation indicator forb dominated state
Subdominant forbs: SECE, POTTA, STCHA, CXPED,
Other species: FELE, KOMA, ELCHN, HESC, POAT, OXMY, ARTLA, BUBI, ECHLA, GAVE, SAOF, SCCO
CXDU appears as a subdominant due to the high cover.

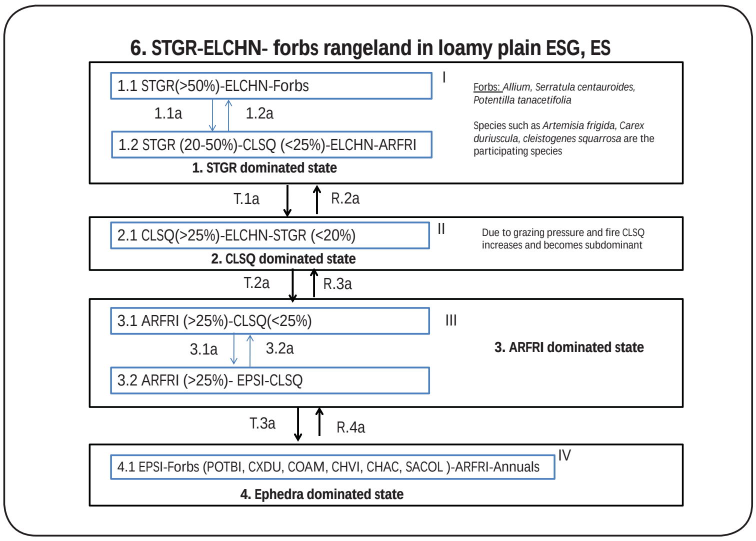


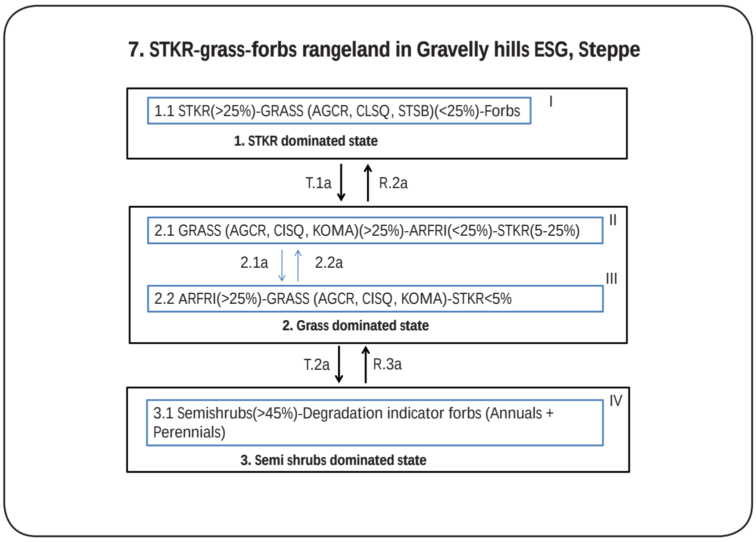
4. Carex- forbs rangeland in High water table ESG, FS
1.1 CAREX (>25%)-Forbs(>25%)
I
Carex : CXMEL, CXORT, CXDU
Forbs: VICA, MEFA, TRLI, SAOF, GEDE, GAVE, SCAU, THPE, ARLA
1. Carex dominated state
T.1a
R.2a
2.1 ELCHN (10-25%)-CXDU-ARFRI (<15%)-GRASS
II
Drought & overgrazing
2.1 a
2.2a
III
2.2 ARFRI (>15%)-ELCHN(<10%)-Forbs
2. Xerophytic grass dominated state
T.2a
R.3a
3.1 Dry bounds, xerophyte grass remnants, bare patches
IV
3. Dry meadow state



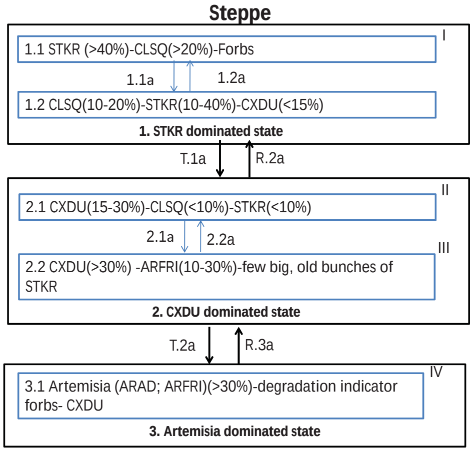
5. Grass - forbs mountain meadow rangeland in High water table ESG, FS
1.1 GRASS(>25%)-Forbs(>25%)-CAREX(CXPED, CXDU)
I
1. Hydrophytic Grass dominated state
Grass: POSU, AGMGL, BRIN
Forbs: VICA, MEFA, TRLI, SAOF, GEDE, GAVE, SCAU, THPE, ARLA


Dry steppe
Gravelly hills
Sandy loam alluvial fan
Deep sandy alluvial plain
High water table
7. STKR-Grass- Forb
8. Stipa Krylovii – Cleistogenes squarrosa
9. Stipa - CARMI
10. Achnatherum solonchak
6.STGR-ELCHN-forbs

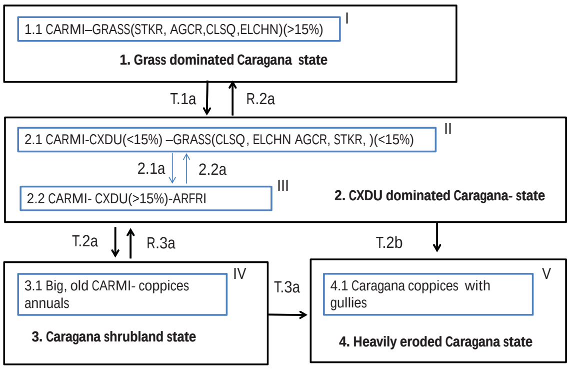

6. STGR-ELCHN- forbs rangeland in loamy plain ESG, ES
1.1 STGR(>50%)-ELCHN-Forbs
I
1.1a
1.2a
1.2 STGR (20-50%)-CLSQ (<25%)-ELCHN-ARFRI
1. STGR dominated state
Forbs: Allium, Serratula centauroides, Potentilla tanacetifolia
Species such as Artemisia frigida, Carex duriuscula, cleistogenes squarrosa are the participating species
T.1a
R.2a
2.1 CLSQ(>25%)-ELCHN-STGR (<20%)
II
2. CLSQ dominated state
Due to grazing pressure and fire CLSQ increases and becomes subdominant
T.2a
R.3a
3.1 ARFRI (>25%)-CLSQ(<25%)
III
3.1a
3.2a
3.2 ARFRI (>25%)- EPSI-CLSQ
3. ARFRI dominated state
T.3a
R.4a
4.1 EPSI-Forbs (POTBI, CXDU, COAM, CHVI, CHAC, SACOL)-ARFRI-Annuals
IV
4. Ephedra dominated state


7. STKR-grass-forbs rangeland in Gravelly hills ESG, Steppe
1.1 STKR(>25%)-GRASS (AGCR, CLSQ, STSB)(<25%)-Forbs
I
1. STKR dominated state
T.1a
R.2a
2.1 GRASS (AGCR, CISQ, KOMA)(>25%)-ARFRI(<25%)-STKR(5-25%)
II
2.1a
2.2a
III
2.2 ARFRI(>25%)-GRASS (AGCR, CISQ, KOMA)-STKR<5%
2. Grass dominated state
T.2a
R.3a
3.1 Semishrubs(>45%)-Degradation indicator forbs (Annuals + Perennials)
IV
3. Semi shrubs dominated state

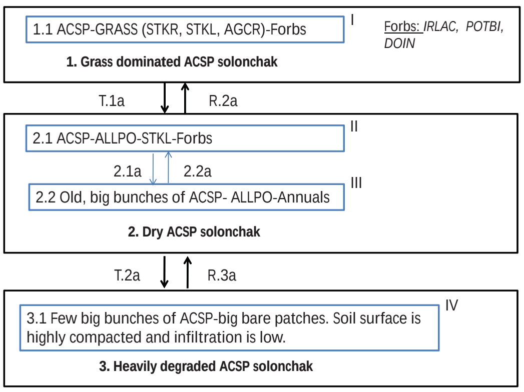
8. STKR- CLSQ- forbs rangeland in Sandy loam alluvial fan ESG, Steppe

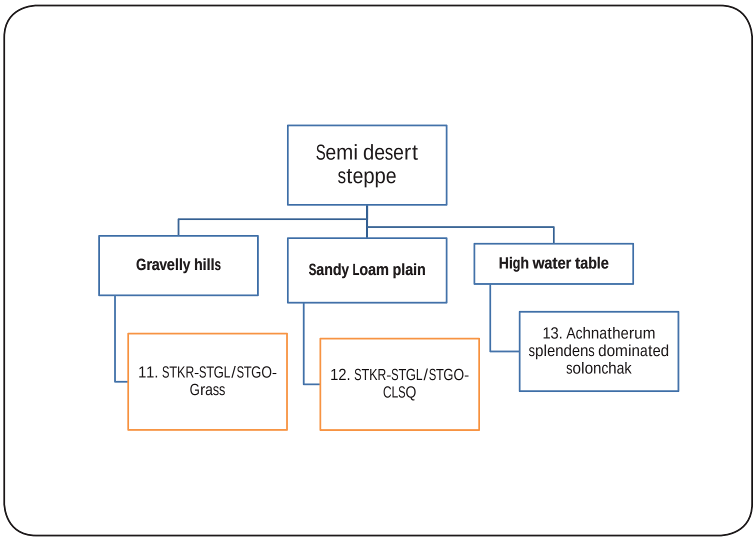


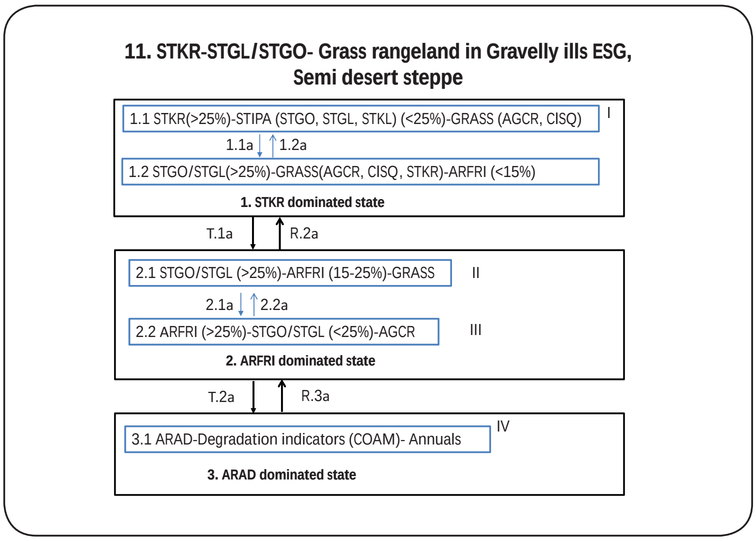
9. Caragana-grass rangeland in Deep sandy alluvial plain ESG, Steppe

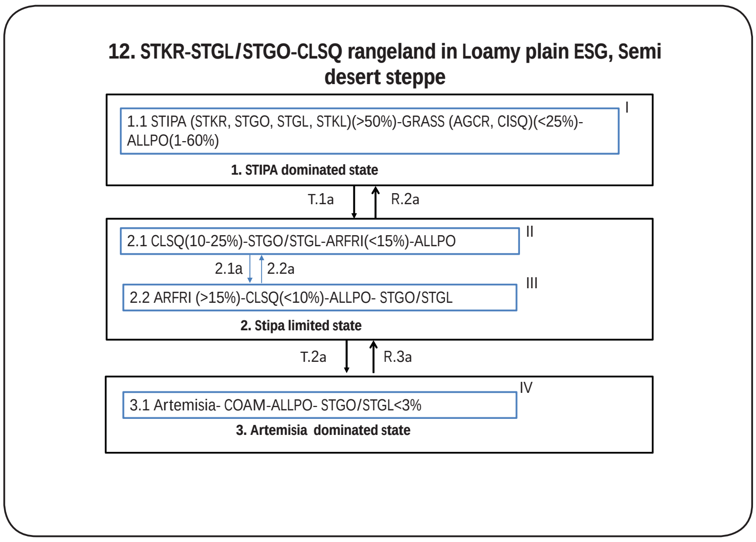


10. ACSP dominated solonchak in HWT ESG, Steppe

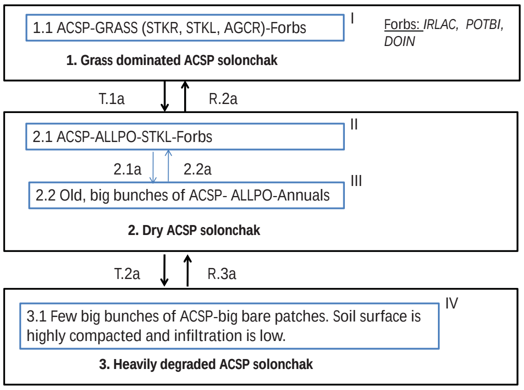


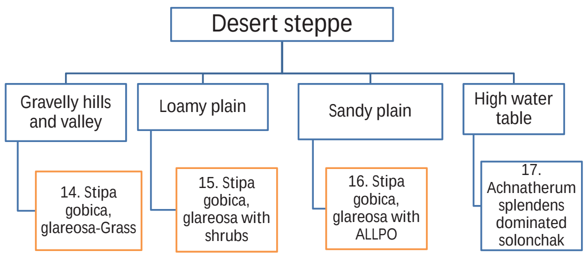

Semi desert steppe
Gravelly hills
Sandy Loam plain
High water table
11. STKR-STGL/STGO-Grass
12. STKR-STGL/STGO-CLSQ
13. Achnatherum splendens dominated solonchak


11. STKR-STGL/STGO- Grass rangeland in Gravelly ills ESG, Semi desert steppe
1.1 STKR(>25%)-STIPA (STGO, STGL, STKL) (<25%)-GRASS (AGCR, CISQ)
I
1.1a
1.2a
1.2 STGO/STGL(>25%)-GRASS(AGCR, CISQ, STKR)-ARFRI (<15%)
1. STKR dominated state
T.1a
R.2a
2.1 STGO/STGL (>25%)-ARFRI (15-25%)-GRASS
II
2.1a
2.2a
2.2 ARFRI (>25%)-STGO/STGL (<25%)-AGCR
III
2. ARFRI dominated state
T.2a
R.3a
3.1 ARAD-Degradation indicators (COAM)- Annuals
IV
3. ARAD dominated state

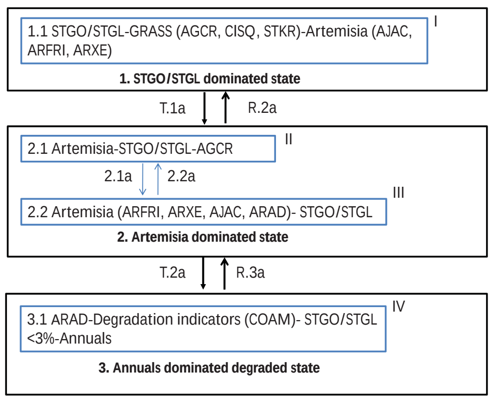

12. STKR-STGL/STGO-CLSQ rangeland in Loamy plain ESG, Semi desert steppe
1.1 STIPA (STKR, STGO, STGL, STKL)(>50%)-GRASS (AGCR, CISQ)(<25%)-ALLPO(1-60%)
I
1. STIPA dominated state
T.1a
R.2a
2.1 CLSQ(10-25%)-STGO/STGL-ARFRI(<15%)-ALLPO
II
2.1a
2.2a
2.2 ARFRI (>15%)-CLSQ(<10%)-ALLPO- STGO/STGL
III
2. Stipa limited state
T.2a
R.3a
3.1 Artemisia- COAM-ALLPO- STGO/STGL<3%
IV
3. Artemisia dominated state

13. ACSP dominated solonchak in HWT ESG, Steppe

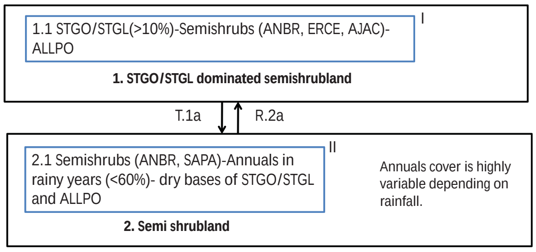




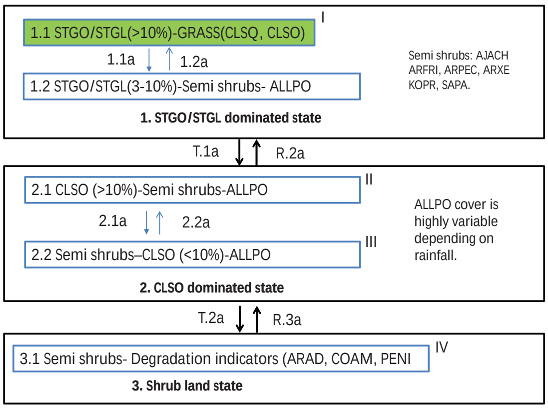
14. Stipa gobica/ Stpa glareosa –grass rangeland in Gravelly ills ESG, Desert steppe



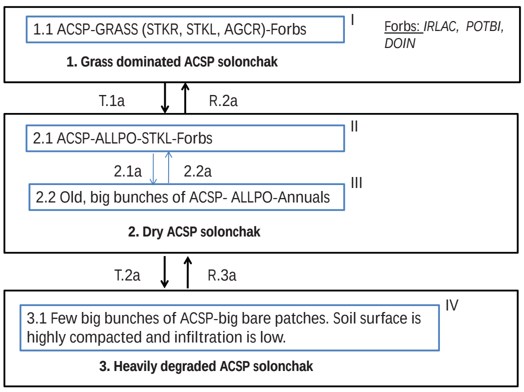
15. STGL/STGO-semi shrubs rangeland in Sandy plain ESG, desert steppe

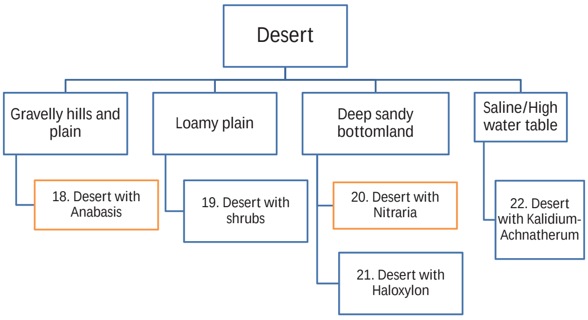


16. STGL/STGO-ALLPO rangeland in Loamy plain ESG , Desert steppe

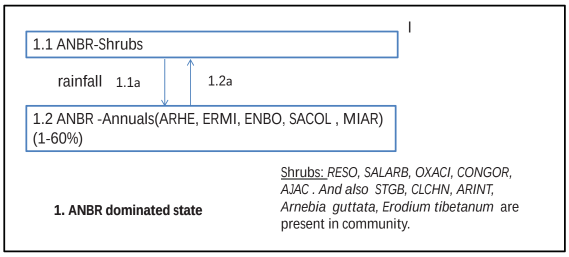


17. ACSP dominated solonchak in HWT ESG, Steppe

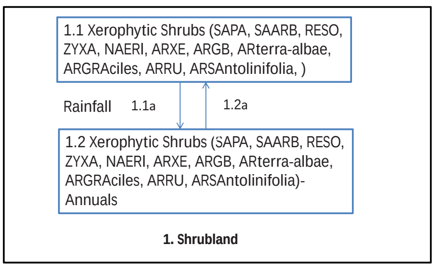




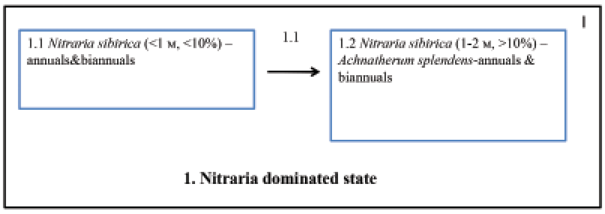
18. Desert rangeland with Anabasis in Gravelly ESG, Desert



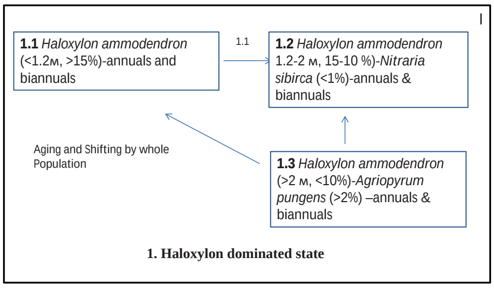
19. Desert rangeland with shrubs in Gravelly ESG, Desert



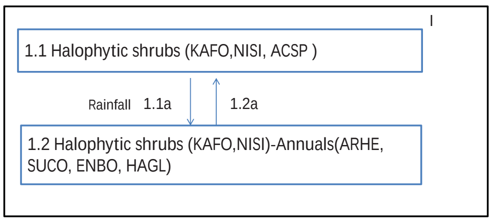
20. Desert rangeland with Nitraria in Deep sandy ESG, Desert



21. Desert rangeland with Haloxylon in Deep sandy ESG, Desert



22. Desert rangeland with halophyte shrubs in Saline solonchak ESG, Desert



Annex IV

Example Ecological Site Description with detailed narratives

ECOLOGICAL SITE GROUPS OF FOREST STEPPE ZONE IN MONGOLIA

1. About 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 north and center of Mongolia (figure 1).

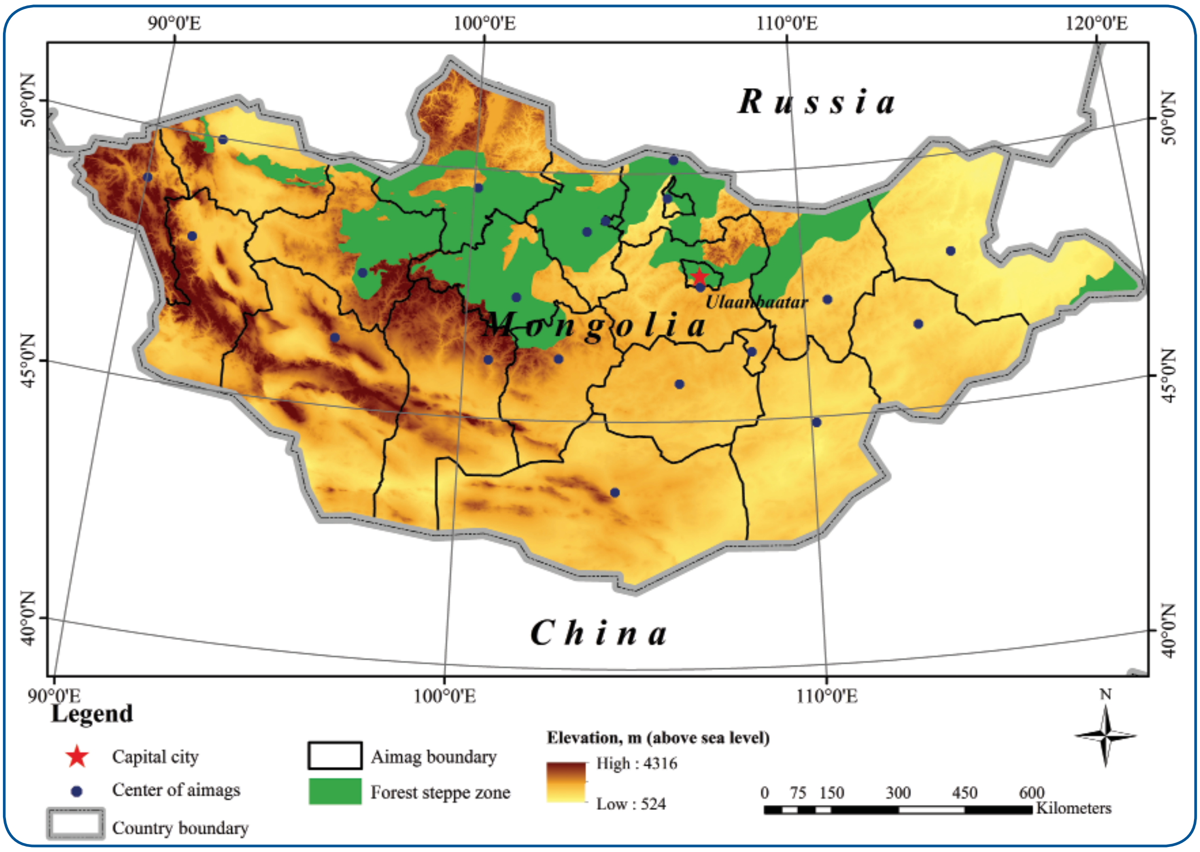


Figure 1. Map of showing location of forest steppe natural ecological zone.

The forest steppe is dominated by perennial grasses and forbs *(Stipa Krylovii Roshev., Agropyron cristatum (L.) P. B., Cleistogenes squarrosa (Trin.) Keng, Koeleria macrantha (Ldb.) Schult.*, and *Festuca lenensis Drob.),* forbs and subshrubs *(Bupleurum bicaule Helm. Thermopsis dahurica Czefr, Artemisia frigida Willd.).* Wet meadows are located along the rivers. Forest steppe zone is suitable for intensive animal husbandry (Jigjidsuren & Johnson 2003).

2. 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). Annual mean temperatures range from 1.3°C to –7.2°C. Generally a very cold winter, spring is windy and dry.

	Minimum	Maximum
Frost free days:	65	100
Annual effective precipitation (mm):	250	400
Annual air temperature (°C)	-7.2	1.3

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

Based on data source from Bayasgalan & Dagvadorj (1996)

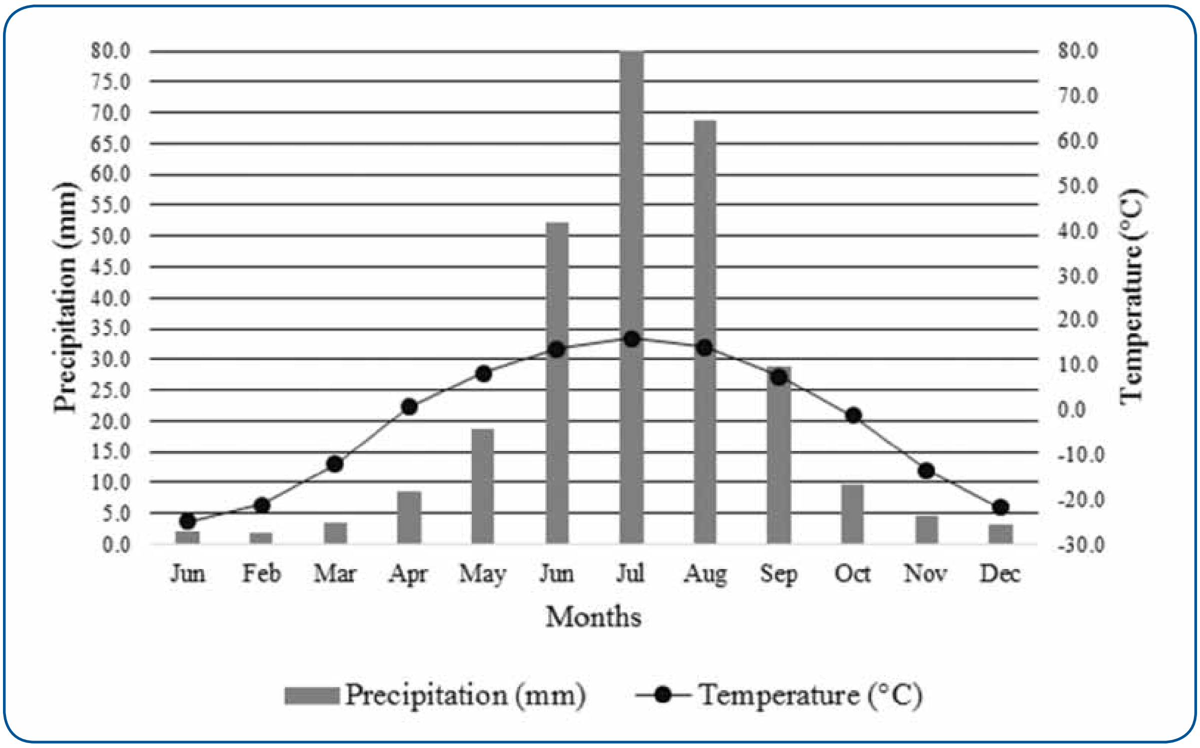


Figure 2. Precipitation is extremely variable from month to month. Mean annual precipitations about 284 mm falls majority June, July and August. Coldest month is January -24.8°C, hottest month is July 15.8°C. Annual mean air temperatures -2.9.

3. Ecological site groups characteristics Loamy fan and mountain valley

3.1 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 slightly sloping alluvial fans, mountain valleys.

Figure 3. Example of landscape position in loamy ecological group (Zavkan aimag, Ider soum 24 July 2014).

Predominant Landforms: (1) Alluvial fan
(2) Alluvial plain
(3) Mountain valley

Table 2. *Physiographic features of loamy ecological group*

	Minimum	Maximum
Elevation (m)	1,000	2,000
Slope (percent)	0%	15%
Water Table Depth (cm)	>100cm	
Flooding:		
Frequency:	None	None
Duration:	None	Extremely brief
Ponding:		
Depth (cm):	None	None
Frequency:	None	None
Duration:	None	None

3.2 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 field management. 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. (Zavkan aimag, Ider soum, Latitude 48.25311° Longitude 97.61906°, 24 July 2014)

<u>Predominant Parent Materials:</u>

Kind: alluvium

Typical Surface Texture (< 2 mm):

(1) Loam
(2) Silt loam
(3) Clay loam

Typical Textural Family: Loamy

Table 3. *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

3.3 Plant community characteristics

3.3.1. Narratives of the Stipa baicalensis-forbs meadow rangelands in loamy fan ESG

Stipa baicalensis-forbs meadow rangelands share most of the mountain meadow in Khangai, Khentii and Mongol dauric subregions of forest steppe zone and along the Khyangan mountains and Numrug river (Fig.5; Fig.6).

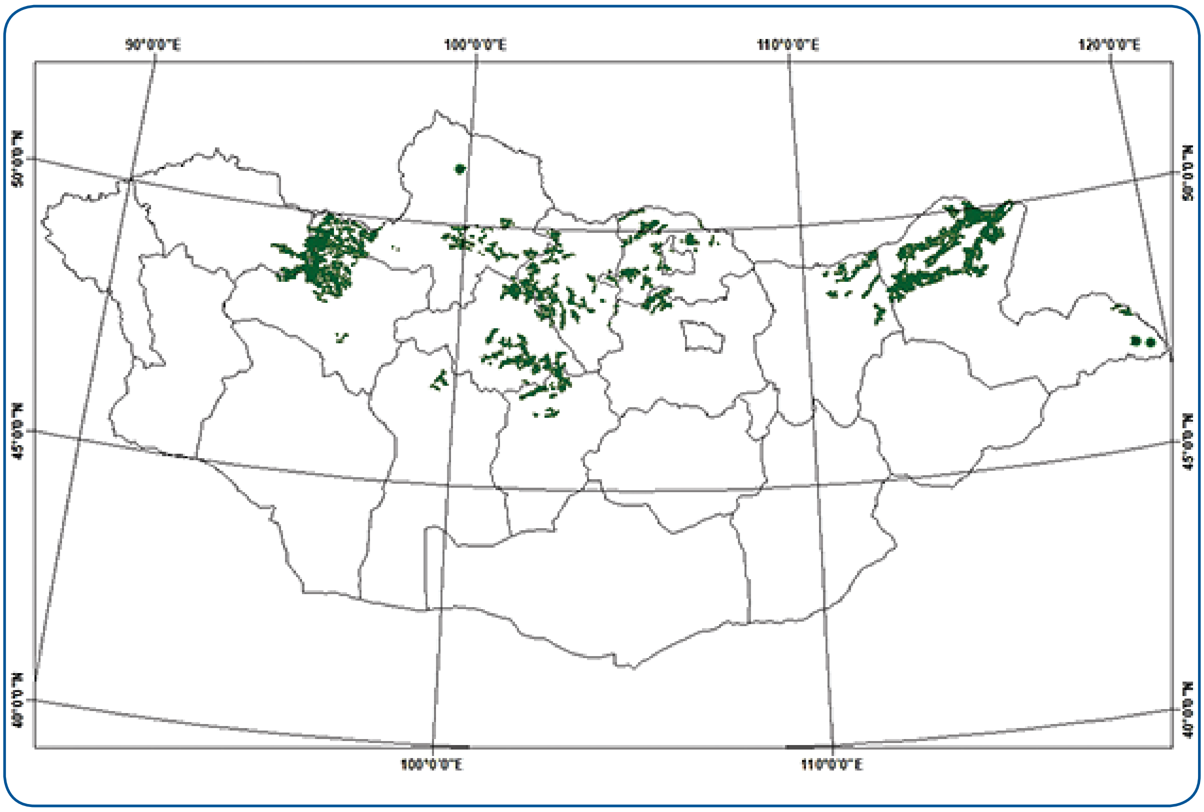


Figure 5. Distribution map of the Stipa baicalensis-forbs meadow rangelands (I.Tuvshintogtokh, 2014.)

Figure 6. Stipa baicalensis-forbs meadow rangeland (Plot name: Hunug-Nuudii, Battsengel soum, Arkhangai aimag, 2014)

Based on literature reviews and field data the shifts of community phases and states of the Stipa baicalensis-forbs meadow rangelands with triggers and restoration recommendations are modelled (Fig.7).

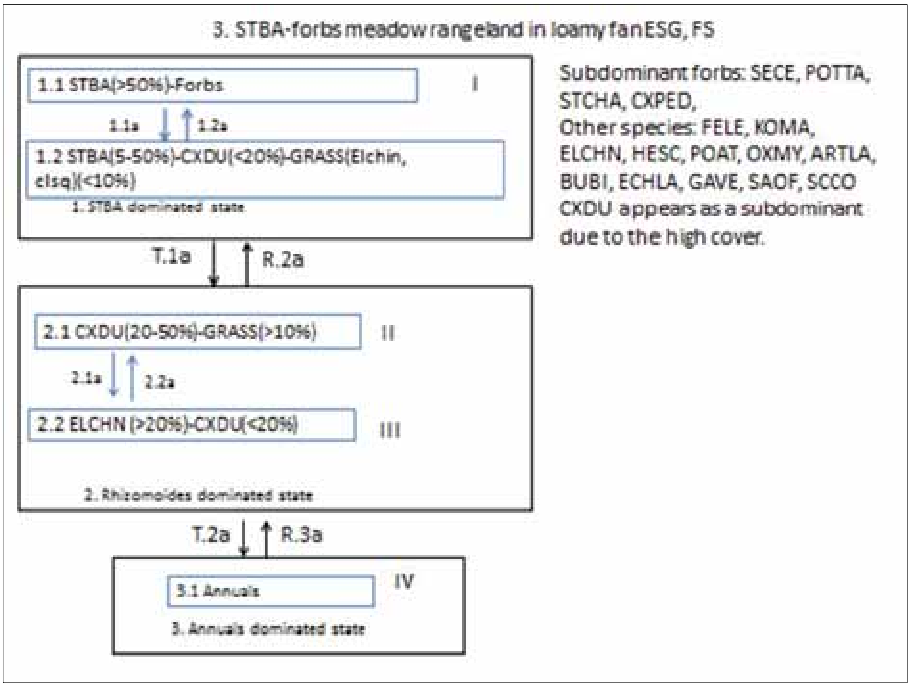


Figure 7. State and transition model of the Stipa baicalensis-forbs meadow rangeland. Black boxes represent a different states of the rangelands, a small blue boxes represent an alternative phases of community (1.1, 1.2) and a lines represent the triggers and res

1.1à, 2,1à	Overgrazing, droughts
1.2à, 2.2à	Short term deferment and stocking rate adjustment into carrying capacity
Ò1à, Ò2à	overgrazing
R.2à	recovery may take 10 years through seasonal rotations and resting
R.3à	Stocking rate will be set 15% below Resilient Carry Capacity and the areas will receive three (3) consecutive years of growing season deferment.

1. Stipa baicalensis dominated state

Dominant species: *Stipa baicalensis, Stipa grandis, Carex pediformis*

Sub dominant species: *Polygonum divaricatum, Heteropappus hispidus, Gentiana decumbens, Sanguisorba officinalis, Thalictrum petaloideum, Galium verum, Filifolium sibiricum, Scutellaria baicalensis*

This state has 2 community phases:

1.1 Stipa baicalensis-forbs community phase: Dominant species such as *Stipa baicalensis and Stipa grandis has higher than* 50% foliar cover, subdominants such as *Filifolium sibiricum, Scutellaria baicalensis* has higher than 30% cover. Species such as *Carex duriuscula, Artemisia frigida, Bupleurum bicaule, Galium verum, Sanguisorba officinalis, Allium senescens* have less than 10% cover (Fig. 8).

Figure 8. Stipa baicalensis-forbs community phase. (Plot name: Biluut, Bayandun soum, Dornod aimag)

1.2 Stipa baicalensis-Carex duriuscula-grass community phase: *Stipa baicalensis* is still dominating and participation of grass species such as *Cleistogenes squarrosa*, *Elymus chinensis*, *Agropyron cristatum* increases and proportion of forbs decreases (Fig. 9). Total cover remains same as of phase 1.1.

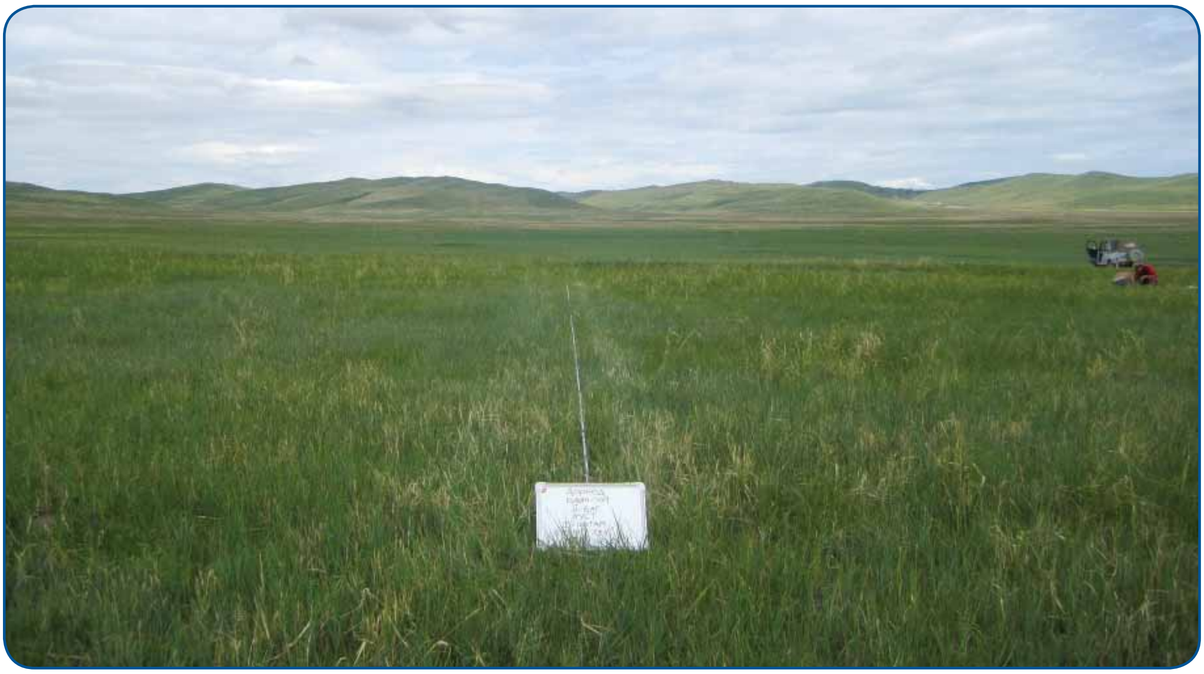


Figure 9. Stipa baicalensis-Carex duriuscula-grass community phase (Plot name: Yargai, Bayandun soum, Dornod aimag)

2. Rhizomoides dominated state

Dominant species: *Elymus chinensis*, *Carex duriuscula*

Subdominants: *Cleistogenes squarrosa*, *Stipa baicalensis*

Proportion of hydrophytic forbs is in decline and proportion xerophytic species such as *Artemisia frigida*, *Heteropappus hispidus*, *Leontopodium ochroleucum* in increase. This state has following 2 community phases:

2.1 Carex duriuscula-grass community phase: *Carex duriuscula and Artemisia frigida have* 20-50% cover. Xerophytic forbs such as *Arenaria capillaris*, *Heteropappus hispidus*, *Artemisia glauca* have less than 10 % cover (Fig. 10).

Figure 10. Carex duriuscula-grass community (Plot name: Buyant, Shariin gol soum, Darkhan Uul aimag)

2.2 Leymus-carex duriuscula community phase:

Dominant species: *Elymus chinensis*, *Carex duriuscula* (Fig.11)

Figure 11. Leymus-carex duriuscula community (Plot name: Narangiin enger, Murun soum, Khuvsgul aimag)

3. Annuals and indicator plants of degradation dominated state

3.1 Annuals community phase: Due to grazing and other anthropogenic impacts the Stipa baicalensis- forbs community replaced by annuals community.

Dominants species: *Chenopodium album*, *Chenopodium viride*, *Salsola collina*, *Artemisia scoparia*

Restoration recommendations:

At the state 2: With the aim to support the perennial grass recovery i) implementation of simplified rotational grazing via splitting the pasture into 5-7 divisions and important to maintain the herding system. Through this herding we could decrease the grazing pressure by 10-25 percent. ii) Short term deferment in the beginning of growing season; iii) season long resting if possible

At the state 3: Important to support the increase in perennial species cover to maintain the soil stability and erosion control. Improvement may take more than 10 years because of palatable key species are lost. Masures to take:

À. The first three (3) years of deferment will be followed by two (2) years of growing season grazing at the 15% of Resilient Carrying Capacity numbers, followed by three (3) years of growing season deferment, followed by two (2) years of growing season grazing. This pattern will continue for at least ten (10) years and until State 1 conditions are achieved. When State 1 conditions are achieved, stocking rates may be increased to match the Resilient Carrying Capacity and timing of grazing can be adjusted to fit overall management plan.

B. Technical restoration through harrowing and seeding followed by deferment for 1-2 year

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3.3.2 Reference community information of the Stipa baicalensis-forbs rangelands

Table 4. Species composition of the reference community

Latin code	Latin name	Mongolian name	Foliar cover,%	Basal cover, %
STBA	Stipa baicalensis Roshev.	Áàéãàëü õÿëãàí à	34.625	1.35
STSB	Stipa sibirica (L.) Lam.	Ñèáèðü õÿëãàí à	23	4
AGRE	Agropyron repens (L.) P. B.	Ì ºëõºº õèàã	14	1.64
ELCHN	Elymus chinensis (Trin.) Keng.	Í àí ãèàä öàãààí ñóëü	11.75	0
CLSQ	Cleistogenes squarrosa (Trin.) Keng.	Äýðâýýí õàçààð ºâñ	8.1	0.63
AGPE	Agropyron pectinatum (M. B.) P. B.	Ñàì àí õèàã	7.5	0.75
POAT	Poa attenuate Trin.	Ñóí àãàð áèåëýã ºâñ	3.625	0
AGCR	Agropyron cristatum (L.) P. B.	Ñàì àí åðõºã	3.41	0.14
BRIN	Bromus inermis Leyss.	Ñî ðã¿é ñî ãî î âî ð	2.25	0
KOMA	Koeleria macrantha (Ldb.) Schult.	Òî ì öýöýãò äààãàí ñ¿¿ë	1.5	0
CXPED	Carex pediformis C.A. Mey.	Çî ãäî ð óëàëæ	21.6	0.05
CXKO	Carex Korshinskyi Kom.	Êî ðæèí ñêèéí óëàëæ	10	0
CXDU	Carex duriuscula C.A.Mey.	Ø èðýã óëàëæ	9.83	0.44
ANIN	Androsace incana Lam.	Áóóðàë äàëàí òî â÷	8	0.33
GEDE	Gentiana decumbens L.f.	Õýâòýý äýãä	7.625	0.25
SCCO	Scabiosa comosa Fisch.	Öî ì öî ãò áýð öýöýã	6.875	0
BUBI	Bupleurum bicaule Helm.	Õî ¸ð èø ò áýðèø	5.875	0.08
HEHI	Heteropappus hispidus (Thunbg.) Less.	Àðçãàð ñî ãñî î ëæ	5.27	0
SAOF	Sanguisorba officinalis L.	Ýì èéí ñºä ºâñ	5	0
LEOC	Leontopodium ochroleucum Beauvd.	Öàéâàð øàðãàë öàãààí ò¿ð¿¿	4.64	0
PLDI	Polygonum divaricatum L.	Äýðâýýí òàðí à	4.25	0
SADI	Saposhnikovia divaricata (Turcz.)	Äýðâýãýð æèðãýð¿¿	28.5	0.0
GERPR	Geranium pratense L.	Í óãûí øèì òýãëýé	4	0
ALLSE	Allium senescens L.	Õèæýýë ñî í ãèí î	7	0
STCHA	Stellera chamaejasme L.	Î äî é äàëàí ò¿ð¿¿	5	0
THMI	Thalictrum minus L.	Áàãà áóðæãàð	3.5	0
GAVE	Galium verum L.	Æèí õýí ýºðºì ò¿¿ë	3.33	0
ASALP	Aster alpinus L.	Òàãèéí ãî ë ãýñýð	3.17	0.67
SICH	Silene chamarensis Turz.	Õàì àð äàâààí û øýýðýí ãý	2.625	0
POTTA	Potentilla tanacetifolia Willd. ex Schlecht.	Ì àðàë íàâ÷èò ãè÷ãýí ý	2.5	0
SECE	Serratula centauroides L.	Õî í ãî ðçóëèã Õî í ãî ðçàëàà	2.5	0
THIS	Thalictrum simplex L.	Ýí ãèéí áóðæãàð	4.0	0
VEDE	Veronica densiflora Ldb.	Áºº í öýöýãò ãàí äáààäðàà	2.5	0
PEHY	Peucedanum hystrix Bge.	Ø èâ¿¿ðò æààâ	1.75	0.25
PLVI	Polygonum viviparum L.	Òº ëë¿¿ð òàðí à	1.67	0
LEUN	Leuzea uniflora (L.) Holub.	ª í÷èí õî í ãî ðöî í î	1.64	0
FISB	Filifolium sibiricum (L.) Kitam.	Ñèáèðü ç¿ð ºâñ	1	0
DOIN	Dontostemon integrifolius (L.) C.A.Mey.	Á¿õýë íàâ÷èò áàãäàé	1.25	0
ARFRI	Artemisia frigida Willd.	Àãü	9.82	0.86
ARCO	Artemisia commutata Bess.	Õóðãàí øàðèëæ	2.92	0.25
ARAD	Artemisia Adamsii Bess.	Àäàì ñûí øàðèëæ	0.375	0

Table 5. Maximum and Minimum cover of reference community

	Minimum	Maximum
Total cover, %	54.5	100
Basal cover, %	0	16.5
Species richness	13	28
Bare ground, %	0	15
Litter amount,%	1.8	98.5

Table 6. Production of reference community in kg/ha by functional groups

Functional groups in Stipa baicalensis-Forb community	Plant production, kg/ha	
	Minimum	Maximum
Stipa	40	57.56
Others	32.54	20
Shrub, semi-shrub	51.2	25.98
Artemisia frigida	45.2	52.02
Other artemisia	10.5	5.5
Forb	15.6	6.86
Annuals and biannuals	94.98	2.08
Carex	2.72	23.76

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Plant community characteristics

Annex V

Resilience-based rangeland management
case study in Undurshireet soum

Background

Undurshireet soum in Tuv aimag represents the steppe zone of Mongolia which occupies 33 percent of the total rangeland area of Mongolia. Undurshireet soum is 280000 ha and animal numbers were 290,540 Mongolian Sheep Units in 2014. Grazing management is based on the traditional four season movement pattern. The lower areas near to the Tuul River are grazed in summer and autumn while winter and spring pastures are located in the mountainous areas away from the river. Mean temperature in January is -21.5 °C compared to 19.5 °C in July. Mean annual precipitation is 225 mm. As in many other soums of the region, livestock numbers have doubled in last decade and there is evidence of vegetation cover change and soil erosion (Fig. 1).

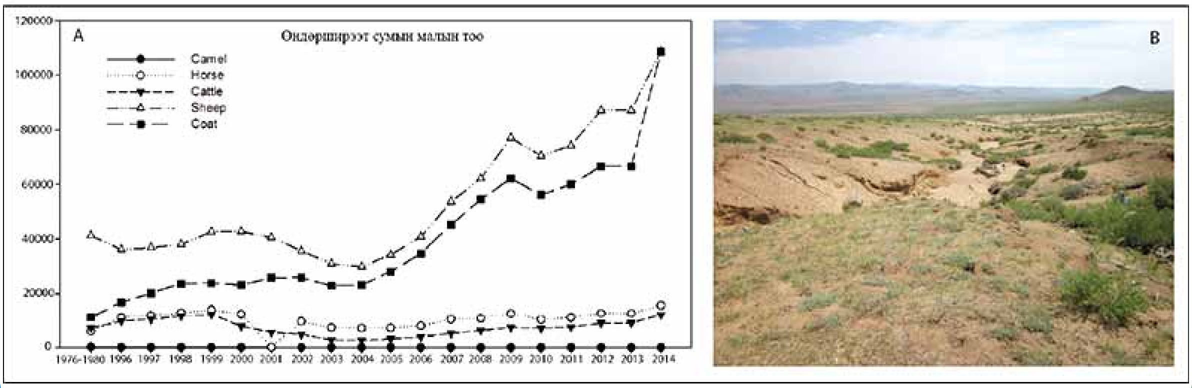

Fig 1. A. Livestock numbers in Undurshireet soum over time. B. Example of land degradation in the Undurshireet soum area.

Field assessment and stakeholder's meetings

Green Gold initiated a detailed field study for 2 years in this soum from 2013-2014 and concluded that:

- Animal numbers at the soum level exceeded a resilient carrying capacity by 2.4 times.
- 67% of rangeland area is altered and 38% will likely require more than 10 years for recovery to reference conditions.
- Most summer pasture areas with sandy soil along the river are vulnerable to erosion.Existing eroded and gullied areas cannot be recovered naturally and require intensive restoration. Ongoing increases in livestock numbers are likely to intensify and expand this severe form of degradation.

Following this assessment in 2014, Green Gold organized stakeholder's meetings at the soum level in which the results from field studies were presented. The goal of the meeting was to develop a consensus among herders and local government officials on the implications of the assessment and to raise awareness on the causes of and solutions to rangeland degradation. As a result, herders became more aware of sensitive Ecological Site Groups, the indicators of rangeland productivity and quality decline, and restoration needs.

Based on these meetings, participants agreed that; i) healthy rangeland states, the basis for herder livelihoods and local economy, are at risk; ii) livestock numbers in excess of a resilient carrying capacity are the primary cause of degradation; iii) there is still time for management changes to produce recovery; and iv) collaboration in implementation of a resilience-based rangeland management approach is needed.

Design of resilience-based management plans

Steps in resilience-based rangeland management applied in Undurshireet soum included:

1. Development of an Ecological Site Group (ESG) map. Rangelands in Undurshireet soum were divided into the following four different ESGs; i) Gravelly hills with *Stipa krylovii*-grass-forbs rangeland; ii) Sandy loam alluvial fans with *Stipa krylovii*- *Cleistogenious squarrosa*- forbs rangeland; iii) Deep sandy alluvial plains with Caragana-grass rangeland; and iv) High water table areas with *Achnatherum splendens*-dominated solonchak (Fig.2.).

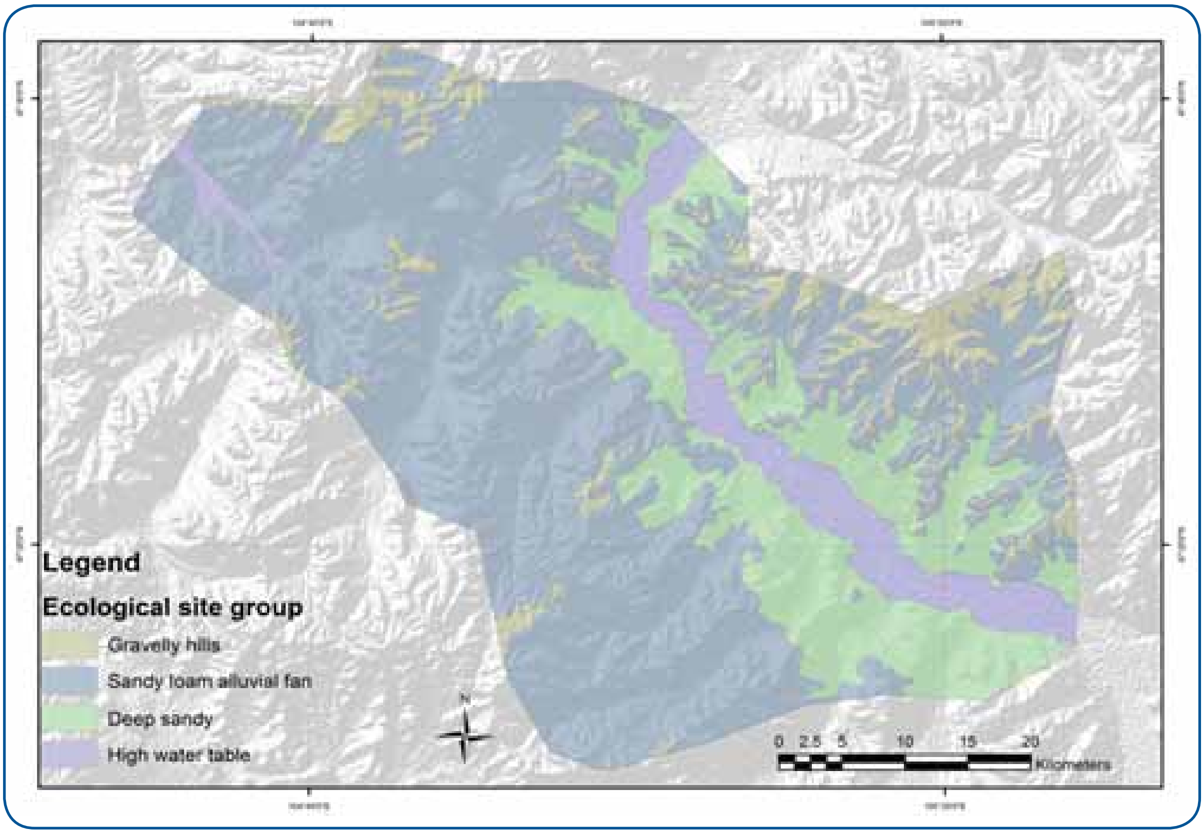

Figure 2. Ecological site group map for Undurshireet soum, Tuv aimag

2. Development of state and transition models (STMs) for each ESG with triggers and drivers causing the community changes and specific management and restoration recommendations for each state (Fig. 3.).

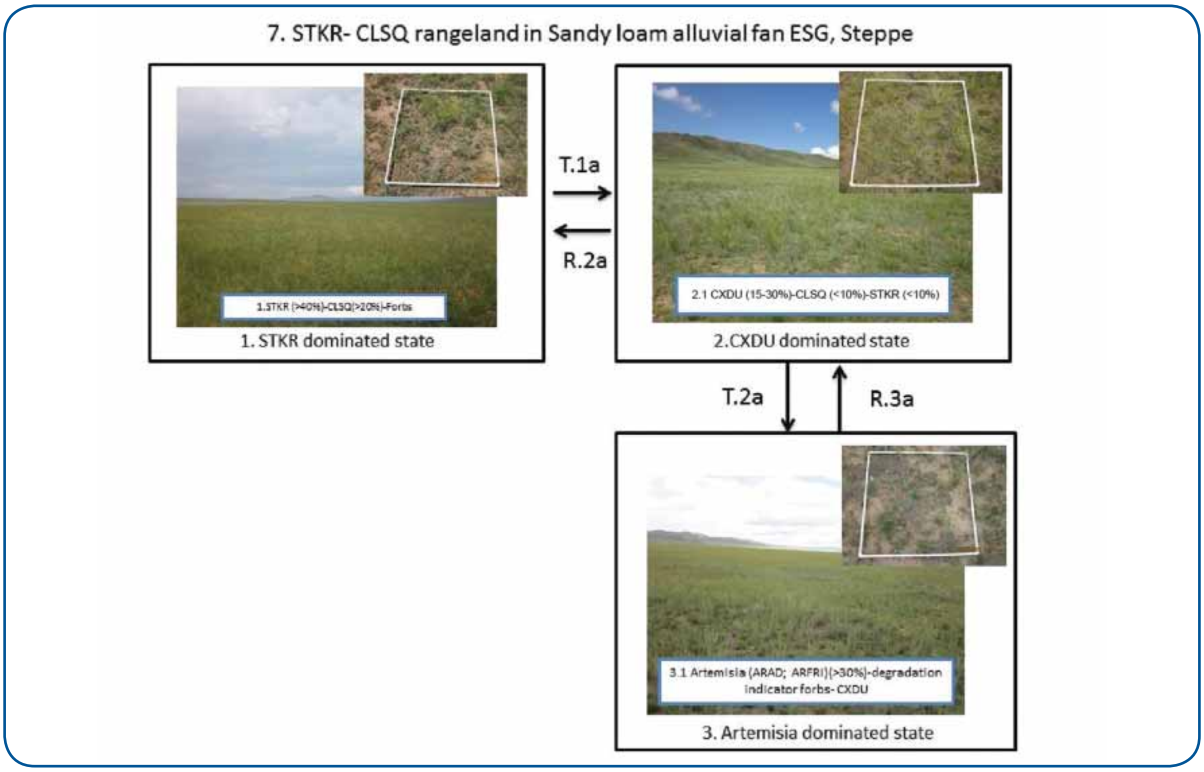

Figure 3. State and transition model for the Sandy loam as a management roadmap

3. Development of the soum annual rangeland management plan based on the ESG map and related STMs in a participatory fashion. Advantages of this participatory planning were i) the production of detailed, consistent information on the ecological potential, degradation risks, and recovery goals for specific land areas within the soum and ii) the active participation of herders and inclusion of their detailed knowledge of rangeland processes and animal management in the plan (Fig. 4.).

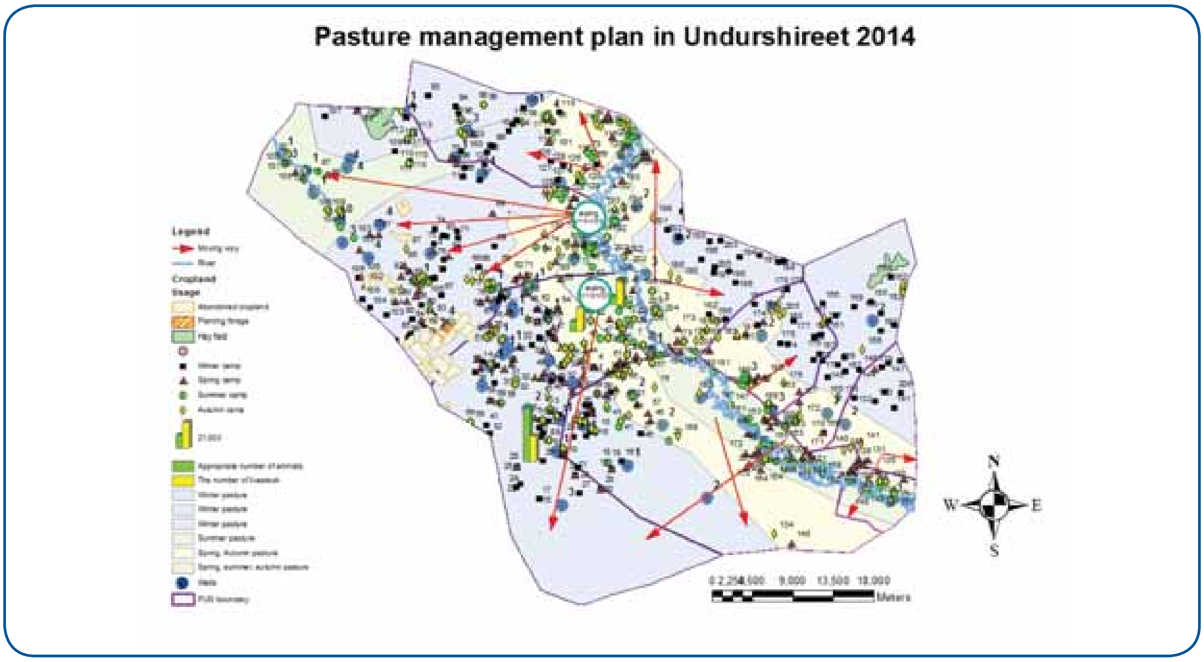

Figure 4. ESD based soum rangeland management plan developed with the participation of local government officials and users

4. Approval and implementation of the resilience-based rangeland management plan with needed funding sources.

5. Monitoring and assessment of rangeland management impact (Fig. 5.), including:

   - Training for the soum land manager and APUG leader on the use of simplified photo monitoring methodology able to detect variations in management impacts, rangeland productivity, and forage quality.

   - Selection of monitoring plots with participation of herders.

   - An initial round of monitoring and the creation of baseline data and a database.

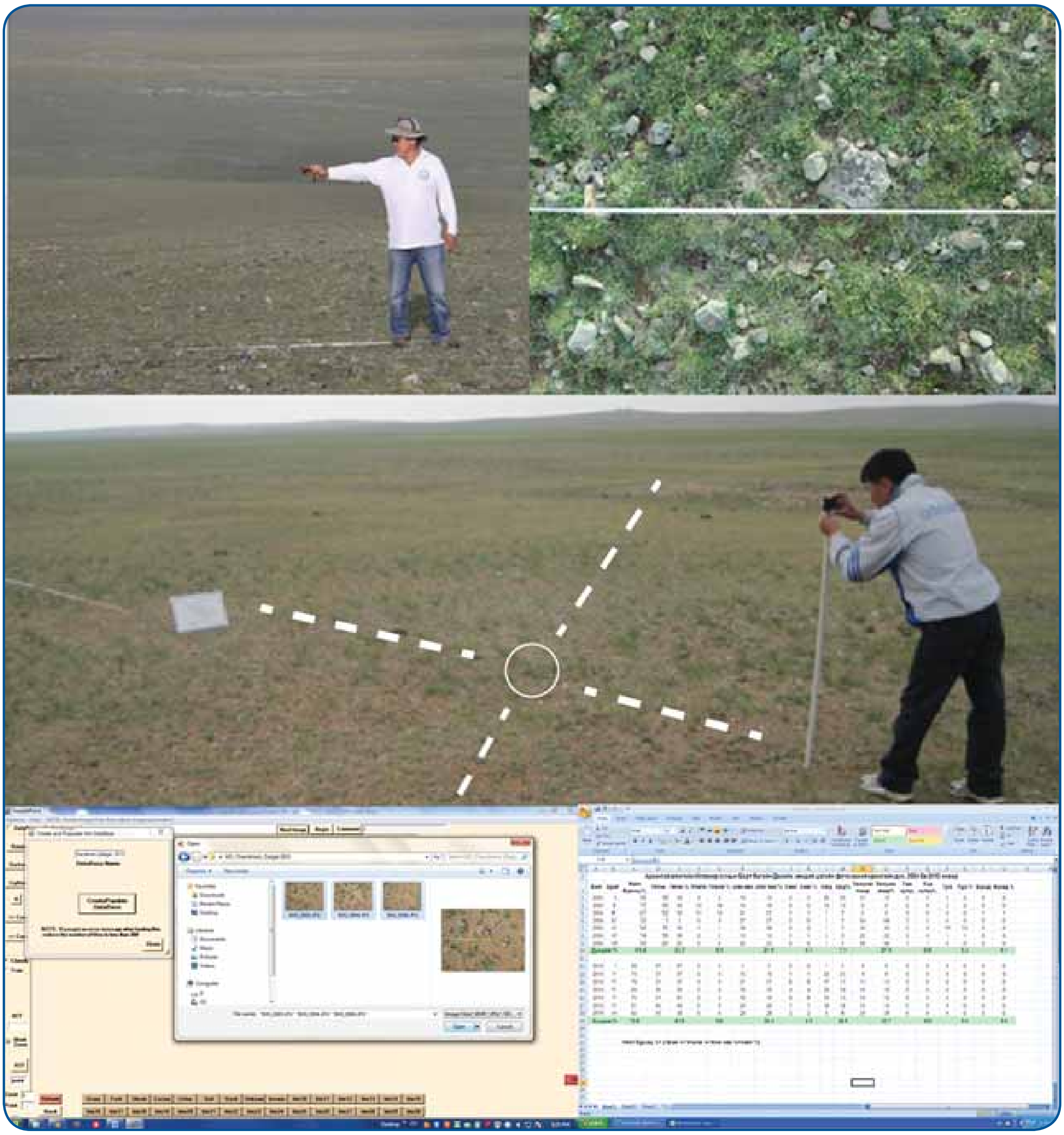

Figure 5. Photo monitoring program for grazing management impact monitoring

Lessons learned and future opportunities

Based on these initial experiences with plan development and implementation, we learned that:

1. Participants were motivated to address rangeland management issues by having clear information on:

   - The state of their pastures
   - Opportunities to sustain rangeland health and their livelihoods as well as risks associated with loss of rangeland health
   - Context-specific roadmaps on how to manage their rangeland
   - Evidence that rangeland conditions can improve following management changes

2. Managers became more confident because of training on:

   - Concepts and language to describe alternative rangeland states
   - Selection of appropriate management recommendations
   - Rangeland management activities via local coordination
   - Targeting funding sources for rangeland management activities.

3. Due to the limited information on the effects of reduced animal numbers, herders are reluctantto reduce herd sizesand await government policies on the matter.

4. Herder's and manager's sense of responsibility for managing rangeland condition can be increased through the participatory monitoring and through a policy of using rangeland health to assess Land Use Agreements.

5. Resilience-based rangeland management can be a platform for other cooperative activities including:

   - A "Community based hunting tourism" project funded by Hunting Society of Mongolia built on PUG structure and in which PUG leaders are paid as rangers charged with maintaining of ecosystem health.
   - A veterinary service project with a private veterinary company. Under this project the "Amin nutag" company provides a full package of veterinary services and certifies animal health for wholesale to the center "Tenger". With this certificate more than 10 herder family were able to sell beef and mutton at premium prices (2500 and 1300 MNT per kg).
   - Small grant projects of the Global Environment Fund on rehabilitation of Salix forest along the TuulRiver and erosion control that is being implemented in 50% of PUGs.