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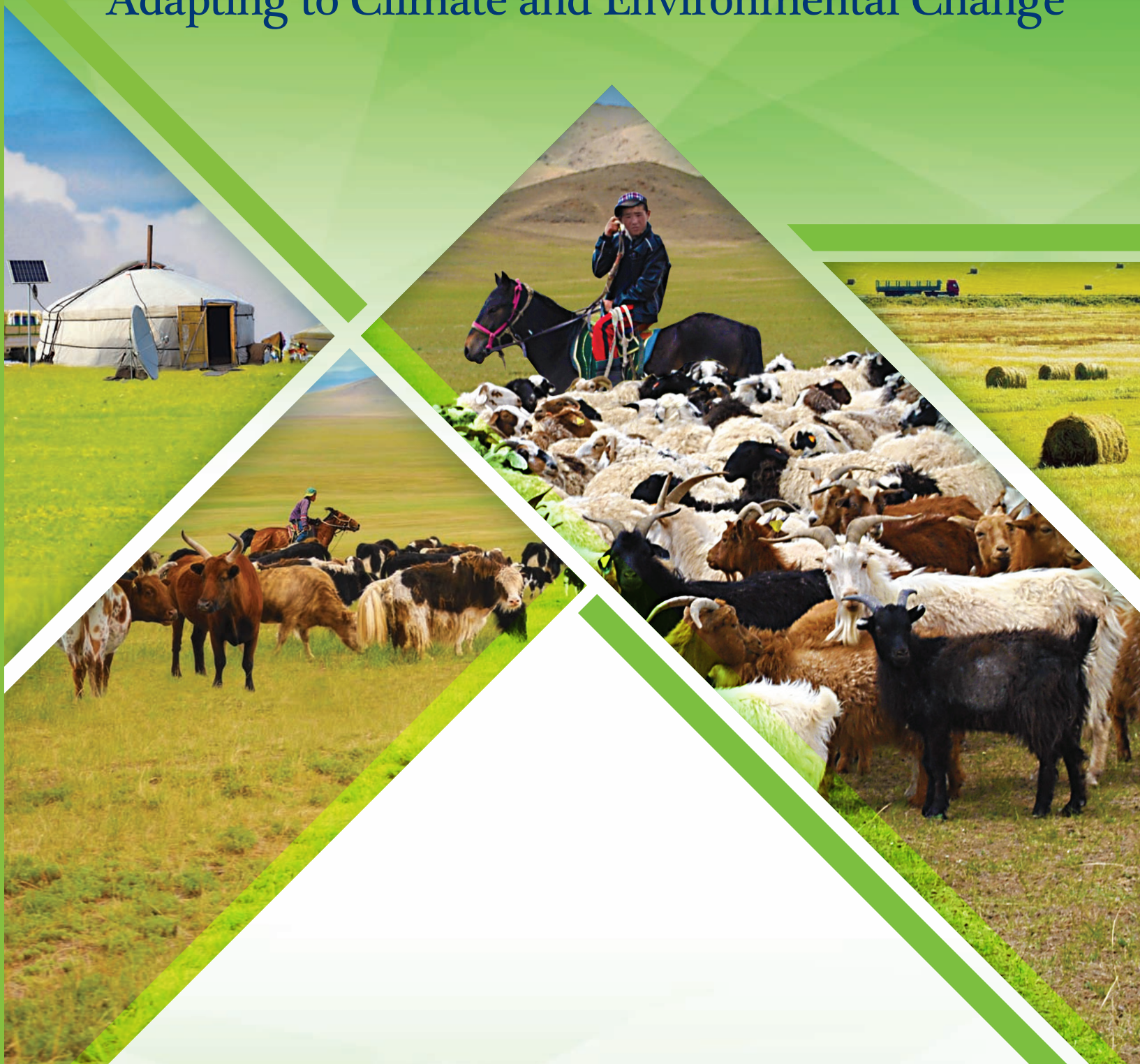
GOVERNMENT OF MONGOLIA

MINISTRY OF ENVIRONMENT AND GREEN DEVELOPMENT

Making Grasslands Sustainable in Mongolia

Adapting to Climate and Environmental Change



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Foreword

Mongolia is severely impacted by desertification and climate change. The Gobi desert continues to expand northward, with over 70% of Mongolia's land degraded through overgrazing, deforestation, and climate change. Degradation is a downward spiral, as degraded lands are less resilient to climate change impacts. Average mean temperature increases are more than 2°C. Climate models indicate that temperatures will continue to rise, and more than 80% of the country's territory is defined as highly vulnerable to climate extremes. Climate-related disasters, including droughts, severe storms, and flashfloods, with high social and economic costs (particularly for herders) have doubled in frequency.

The Asian Development Bank (ADB) supports regional cooperation among the countries of Northeast Asia to combat dust and sandstorms resulting from desertification. ADB is strengthening the capacity of the governments of Mongolia and the People's Republic of China in accessing carbon financing to sustainably manage grasslands. ADB recognizes that healthy ecosystems are more productive, more resilient, and provide valuable ecosystem services, such as carbon sequestration. Healthy ecosystems form the firm foundation for herders' natural resource-based livelihoods.

In close cooperation with Mongolia's Climate Change Coordination Office of the Ministry of Environment and Green Development, this knowledge product was prepared for local government officials, other donors, and nongovernment organizations to raise awareness of climate change impacts on people, livestock, and grassland ecosystems, and to provide potential responses. This publication aims to (i) explain how good pasture management and livestock productivity are important for combating and adapting to climate change; (ii) provide information on adaptation practices, including those that have been prioritized by the Government of Mongolia and promoted under the government's Mongolian Livestock Program; and (iii) evaluate the feasibility and effectiveness of potential adaptation practices.

The threats posed by climate change have significant impacts on Mongolia's grassland ecosystems and herders' livelihoods. This publication identifies potential adaptation practices which the Mongolian government and relevant stakeholders can modify and incorporate into their specific strategies and plans.

Ayumi Konishi
Director General
East Asia Department
Asian Development Bank

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This report is one of a number of reports generated by an Asian Development Bank (ADB) regional technical assistance project, Strengthening Carbon Financing for Regional Grassland Management in Northeast Asia, with additional funding from the Regional Cooperation and Integration Trust Fund. This report was prepared by Sabine Schmidt and Carey Yeager with inputs from Bolormaa Damdinsuren, Batbuyan Batjav, and Munkhjargal Begzsuren.

Leadership and inspiration were provided by the staff of the Mongolian Ministry of Environment and Green Growth, and significant contributions were made throughout the project by the Ministry of Industry and Agriculture, the Ministry of Finance, and members of the steering committee. Community members and local government staff were a vital component of the project and their participation and insights were essential.

ADB Management and technical/administrative staff, particularly Yue-Lang Feng, Frank Radstake, and Karen Chua, provided valuable guidance and support during the project. Charles Rogers, Andreas Wilkes, Alvin Lopez, Ongonsar Purev, and Takeshi Ueda provided substantive comments that improved the quality of the document. Joy Quitazol-Gonzalez and Heidee Luna supported the entire process from initial formatting and compilation of technical reviews through to final publication. Publication support was ably provided by the team of Anna Sherwood, including Rodel Bautista, Caroline Ahmad, Kae Sugawara, Ma. Cecilia Abellar, Jasper Lauzon, and Principe Nicdao.

Abbreviations

ADB	Asian Development Bank
ALACGAC	Administration for Land Affairs, Construction, Geodesy and Cartography
ha	hectare
kg	kilogram
MNET	Ministry of Nature, Environment and Tourism
NAMEM	National Agency for Meteorology and Environmental Monitoring
NLP	National Livestock Program
UNFCCC	United Nations Framework Convention on Climate Change

Glossary

AB/B	Soil layers distinguishable by physical characteristics are referred to as soil horizons. The letter A refers to the top layer or "topsoil," which contains dark decomposed organic materials (i.e., humus). The B layer is subsoil and consists of mineral layers, which may include clay.
aimag	Province
burd	Oasis or wetland in the Mongolian language
dzud	Extreme weather event or condition that can be caused by sudden heavy snowfall, long-lasting or frequent snowfall, extreme cold or ice, or storms that cause often massive livestock deaths from hunger, exhaustion, and cold. Mongolian herders distinguish different types of *dzud* caused by snow, cold, ice, lack of grass due to drought in previous year, or combinations of these.
khot ail	Group of herder households, often kinship groups, that camp together and share herding tasks
nukhurlul	Rural civil society organization (partnership of households) in Mongolia for nature conservation and natural resource management; a legal entity based on the civil code and regulated by environmental law
otor	Long-distance migration of Mongolian herders, typically in autumn, to fatten livestock for winter
soum	District; an *aimag* is divided into *soums*

Executive Summary

The significance of mobile pastoralism and the potential role of mobile pastoralists in the conservation of drylands is globally recognized. Mobility has been a traditional practice for millennia in Mongolia's nomadic culture and is recognized as a key management strategy for the sustainable use of semi-arid and arid grasslands. Its decline, with subsequent overgrazing, has led to widespread pasture degradation.

In Mongolia's recent history, institutional, political, and socioeconomic developments have had significant impacts on the functioning of traditional systems of grassland and livestock management and on their capacity for adaptation and resilience. The most recent political and social transformation, the democratic revolution in 1990, replaced the highly subsidized and regulated system of livestock and pasture management of the socialist period with a de facto open access system characterized by an initial vacuum of institutions for natural resources management and the loss of marketing structures and access to markets. These developments created many of the current barriers to sustainable grasslands and livestock management, such as unclear pastureland regulation and perverse incentives for overstocking.

Unlike in many countries, mobile pastoralists in Mongolia are not culturally marginalized, and they are a large part of the country's cultural identity. Despite this, pastoralists face enormous challenges as a result of competition for land use with the extractive industry. The total economic value of grassland environmental services has not been established, but it may be undervalued in the face of increasing contributions to gross domestic product by the growing mining sector.

Climate change poses a new threat that will have a measurable impact on grassland ecosystems and herders' livelihoods. Mongolia's climate is rapidly warming: the country's annual mean temperature rose by 2.1°C during 1940–2007. In view of these changes, this study reviews grassland management and traditional nomadic pastoralism in the local Mongolian context, and identifies potential adaptation strategies and practices.

Current Situation

Five pilot *soums* (districts) in the steppes and forest steppes of Mongolia's three eastern *aimags* (provinces) were selected for in-depth study based on guidance from a technical working group. These pilot *soums* were Bayankhutag, Norovlin, Sergelen, Sukhbaatar, and Tsagaan-Ovoo, and they are located in the eastern *aimags* of Dornod, Khentii, and Sukhbaatar.

The average household size was 3.6, and 54.1% of the *soum* households made their livelihoods as herders. The average area per herder household was 1,353.8 hectares (ha), with an average herd size of 77.1 livestock—primarily sheep and goats. The livestock density was 4.6 animals/ha. Vegetation cover ranged from 41.8% to 67.0%, and bare ground ranged from 24.9% to 44.0%. In overgrazed areas of this rangeland, vegetation cover has changed significantly. Sagebrush (*Artemisia frigida*, *A. adamsii*) and sedge (*Carex duriuscula*) have increased, to 18.9%–70.8% of the total vegetation cover. The peak of pasture biomass (August) declined by approximately 20%–30% from

about 1970–2010, and the spring biomass (April and May) has decreased in the forest steppe and the steppe. During 1980–2000, the average weight of sheep declined by approximately 4 kilograms (kg), goats by 2 kg, and cattle by 10 kg.

Previous research has projected future climate trends through 2090 based on three general circulation models: the HadCM3 (developed by the Hadley Centre for Climate Prediction and Research), ECHAM3 (developed by the Plank Institute for Meteorology), and CSIRO Mk2 (developed by the Commonwealth Scientific and Industrial Research Organisation). The results indicated that temperatures will increase by 1.3°C–8.6°C in summer and 0.9°C–8.7°C in winter. Winter precipitation will increase by 12.6%–119.4%; however, summer precipitation is less clear, with models predicting anywhere from a 2.5% decrease to an 11.3% increase. The frequency and magnitude of drought and *dzud* (extreme events) are likely to increase with climate change. More than 80% of the country's territory was defined as highly vulnerable to climate extremes. The desert region is projected to expand by nearly 25% by 2040. Gradual changes in climate and extreme events have severe impacts on rural livelihoods and food security.

Official Regulation of Use of Pastureland and Pasture Reserves

The Law on Land, passed by the Mongolian National Parliament in 2002, requires a state certification of land characteristics and quality to be undertaken every 5 years. The Administration for Land Affairs, Construction, Geodesy and Cartography oversees these certifications and assessments. Qualified contractors undertake field surveys every 5 years to assess the grasslands. The results of these assessments are used to determine and map rangeland degradation levels countrywide. Long-term pasture monitoring is based on the national network of meteorological stations of the National Agency for Meteorology and Environmental Monitoring (NAMEM). The Ministry of Industry and Agriculture and the National Emergency Management Agency manage and regulate pastureland using the pasture carrying capacity data provided by NAMEM. The officers of the *soum* livestock unit undertake the data collection on indicators to monitor implementation of the five priority areas of the National Livestock Program—policy and/or good governance, breeding, animal health, pastureland management, and marketing.

Vulnerability and Resilience to Climate Change Impacts in Mongolian Pastoral Communities

Herders in Mongolia directly depend on pasture and water resources for their livestock, and are therefore among the most vulnerable groups to climate change impacts. Access to key resources, such as emergency grazing areas and water, was compromised following the 1990 revolution and the disintegration of pasture management systems. Climate change impacts reported by herders include (i) increased frequency of *dzud* and drought; (ii) decreased precipitation; (iii) earlier melting of snow cover; (iv) drying up of lakes, rivers, and springs; (v) decrease in the number of pasture plant species; and (vi) decreased biodiversity.

Grassland ecosystems and the livestock they support are highly vulnerable to climate change impacts. In such ecosystems, the main climate change impacts are (i) decreasing pasture biomass; (ii) intensifying pasture degradation and desertification; (iii) increases in harmful insects, locusts, and rodents; and (iv) loss of biodiversity and rare species. For livestock, the decrease in food abundance and extreme cold temperatures lead to lower productivity and higher mortality rates. Based on reported calculations of an ecological

vulnerability index, which incorporates risks from *dzud*, drought, and overgrazing, ecological vulnerability has increased by more than 20% from 1970–1975 to 1996–2008.

Recent research on resilience in the Mongolian pastoral social-ecological system has found that "storage" (animal fat and/or weight gain, hay, fodder, and grazing reserves) was a crucial adaptation strategy. Fall migration, feeding livestock stored hay, and grazing them on reserved spring pasture were also extremely important measures. Flexibility in the social organization of herders, movement patterns, and livestock management practices (such as controlling livestock reproduction rates and timing, or selling livestock before the winter to reduce feed amounts and costs) were also identified as strategies employed by herders with lower livestock mortality rates.

Adaptation Strategies in Livestock and Grassland Management

Adaptation strategies for livestock husbandry and grassland management have some global commonalities, many of which are relevant for adaptation practices in Mongolia. Based on a literature review, a survey of adaptation actions and practices, and focus group discussions, the study identified a number of adaptation actions and practices in social organization, and pasture and livestock management. Practices related to social organization included organizing in herder groups for pasture management and sharing knowledge of traditional herding practices. For pasture management, rotation and resting of pasture, *otor* (long-distance migration) movement to fatten animals in fall and/or winter, rehabilitating wells, protecting water sources through fencing, irrigation of pasture, planting of fodder species, and preparation of hay and fodder were found to be important practices. For livestock management, practices identified included breed improvement, regulating and improving herd composition, reducing stocking rates to adhere to carrying capacity (including decreasing the number of goats and slaughtering older animals), repairing winter shelters, and taking out livestock insurance. The most common actions based on the herder survey were destocking (reducing the number of livestock) and *otor*. The adaptation actions and practices were evaluated for effectiveness, costs, technical feasibility, acceptance (cultural and/or traditional), adequacy for the current climate, and implementation speed.

Herders and local government representatives identified the lack of a legal framework to regulate pasture use and weak enforcement of pastureland management rules as key constraints for implementing improvements and adaptive practices. Additional constraints identified included the lack of technical and financial capacities in local government to perform land management functions, the lack of financing for herders for pasture management measures, and limited opportunities for processing and marketing. Markets are emerging with increased development in the region, but herders do not have the capacity to take advantage of these opportunities. Herder groups have been successful in coordinating movements of member households and in reserving seasonal pastures, but unregulated movements of herders with large herds have frequently undermined these efforts. Customary rules alone are insufficient to have an effective regulatory impact.

The Mongolian Second National Communication to the United Nations Framework Convention on Climate Change cites shortcomings in institutional capacity and financial resources as two of the central barriers to adaptation policy implementation. The complexity of climate change impacts and socioeconomic challenges in natural resources management and pastoral livelihood development, such as regulating land use, protecting ecosystem services, and developing functioning marketing systems, require integrated

approaches. However, available institutional and human capacities are insufficient, particularly in rural areas.

Contributions to *soum* development funds from the central budget increased in 2013. Support to adaptation measures under pastureland management plans and the local implementation of the National Livestock Program may be expanded if there is sufficient public demand and political will. This would enhance opportunities for cofinancing adaptation measures in pasture and livestock management from climate finance. The Government of Mongolia is exploring opportunities through the Special Climate Change Fund of the Global Environment Facility, the Green Climate Fund, and potential carbon markets in grasslands.

The adaptation actions and practices suggested in this report are only a modest beginning. The government and stakeholders are urged to review the appendixes and modify them, as needed, for their strategies and plans.

Introduction

The significance of mobile pastoralism and the potential role of mobile pastoralists in the conservation of drylands is globally recognized. These include the Dana Declaration on Mobile Peoples and Conservation, the World Alliance of Mobile Indigenous Peoples, and the World Initiative for Sustainable Pastoralism.[1]

Mobility has been a traditional practice for millennia in Mongolia's nomadic culture, and is recognized as a key management strategy for the sustainable use of semi-arid and arid grasslands.[2] The decline in mobility and the overgrazing that has ensued have led to widespread pasture degradation. Large parts of Mongolia's grasslands—the desert steppe—are a nonequilibrium ecosystem where external factors (mainly rainfall) are the key determinants of pasture productivity.[3] Traditionally, nomadic movements were based on ecological conditions. Grasslands evolved with grazing by large herds of wildlife, and well-managed grazing that mimics wildlife impacts can promote grassland health.[4] Sustainable grassland management benefits both climate change mitigation (through the maintenance or sequestration of soil carbon) and adaptation (by building the adaptive capacity of pastoral communities). Grassland and livestock management practices cannot be easily separated.

Institutional, political, and socioeconomic developments in Mongolia's recent history have had significant impacts on the functioning of traditional systems of grassland and livestock management, and on their capacity for adaptation and resilience. The most recent political and social transformation—the democratic revolution of 1990—replaced the highly subsidized and regulated system of livestock and pasture management of the socialist period with a de facto open access system characterized by an initial vacuum of institutions for natural resources management and the loss of marketing structures and access to markets.[5]

Under the central command economy, migration patterns and other pasture management practices were planned by the *soums*, and support for transport required during migration was provided. Remote pasture areas had water supplies and other services provided by the local government. With the transition to a market economy, livestock and many agricultural assets were privatized, while land remained state-owned. The *negdels* (collectives) disintegrated, resulting in unprecedented levels of unemployment. For most of the unemployed, subsistence herding was the only way to survive in the short term. Many of the new herders were inexperienced, as they had held other jobs

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1 The Dana Declaration on Mobile Peoples and Conservation. www.danadeclaration.org/

2 D. J. Bedunah and S. M. Schmidt. 2004. Pastoralism and Protected Area Management in Mongolia's Gobi Gurvansaikhan National Park. *Development and Change.* 35 (1). pp. 167–191.

3 C. Leisher, S. Hess, T. M. Boucher, P. van Beukering, and M. Sanjayan. 2012. Measuring the Impacts of Community-Based Grasslands Management in Mongolia's Gobi. *PLoS ONE.* 7 (2). e30991. doi:10.1371/journal.pone.0030991

4 S. D. Fuhlendorf and D. M. Engle. 2001. Restoring Heterogeneity on Rangelands: Ecosystem Management Based on Evolutionary Grazing Patterns. *BioScience.* 51 (8). pp. 625–632. http://courses.washington.edu/esrm479/grazing3.pdf

5 M. Fernandez-Gimenez. 1999. Sustaining the Steppes: A Geographical History of Pastoral Land Use in Mongolia. *The Geographical Review.* 89 (3). pp. 315–342.

in the collectives. The number of herding households nearly doubled, but most of them had very small herds and insufficient means to undertake movements. The breakdown of infrastructure and services in rural areas, particularly in the more remote locations, caused the concentration of herds around water points and settlements. Weakened institutions led to a decline in coordination of pasture management, including livestock movements and rotation. The market for livestock raw materials and products—mainly the former Soviet Union—collapsed as well.[6] These developments created many of the current barriers to sustainable grassland and livestock management, such as unclear pastureland regulation and perverse incentives to overstock.

Unlike in many countries, mobile pastoralists in Mongolia are not culturally marginalized, and they are a large part of the country's cultural identity (footnote 2). Despite this, pastoralists face enormous challenges as a result of competition for land use with the extractive industry. The total economic value of grassland economic services has not been established, making it difficult to resist pressures for land conversion in the face of increasing contributions to gross domestic product by the growing mining sector.

Climate change poses a new threat that will have a measurable impact on grassland ecosystems and herders' livelihoods. Mongolia's climate is warming rapidly: the country's annual mean temperature rose by 2.1°C during 1940–2007.[7] This report reviews grassland management and traditional nomadic pastoralism in the local Mongolian context against the background of these major political, socioeconomic, and environmental changes, and identifies potential adaptation strategies and practices.

Mobile Pastoralism and the Mongolian Grasslands. Mongolian herder groups have migrated across the grasslands with their livestock for thousands of years. However, their mobility patterns have changed, and the distance traveled during the seasonal movements has generally decreased (Figure 1).[8]

In Mongolia, herders typically migrate longer distances with their livestock, generally in autumn, to fatten livestock for the winter. This practice is known as *otor*. This study found that during 2009–2011, 36.9% of herders moved once a year for *otor* and 17.8% moved more than once a year for *otor*.[9] In contrast, the rotational use of summer pasture is typically a short-term movement, such as monthly or bimonthly.

While frequent moves are customarily an indicator of good pastoral practices, the mobility patterns observed currently are being driven by the need to find dwindling water sources, and by pressure from outside herders moving into or through local areas. The coming and going of households to and from the countryside and between administrative areas has increased. In addition, rotational use of summer pastures has declined, placing pastures under continuous pressure. The government has identified declining rotational use of summer pastures as a key driver of pasture degradation.

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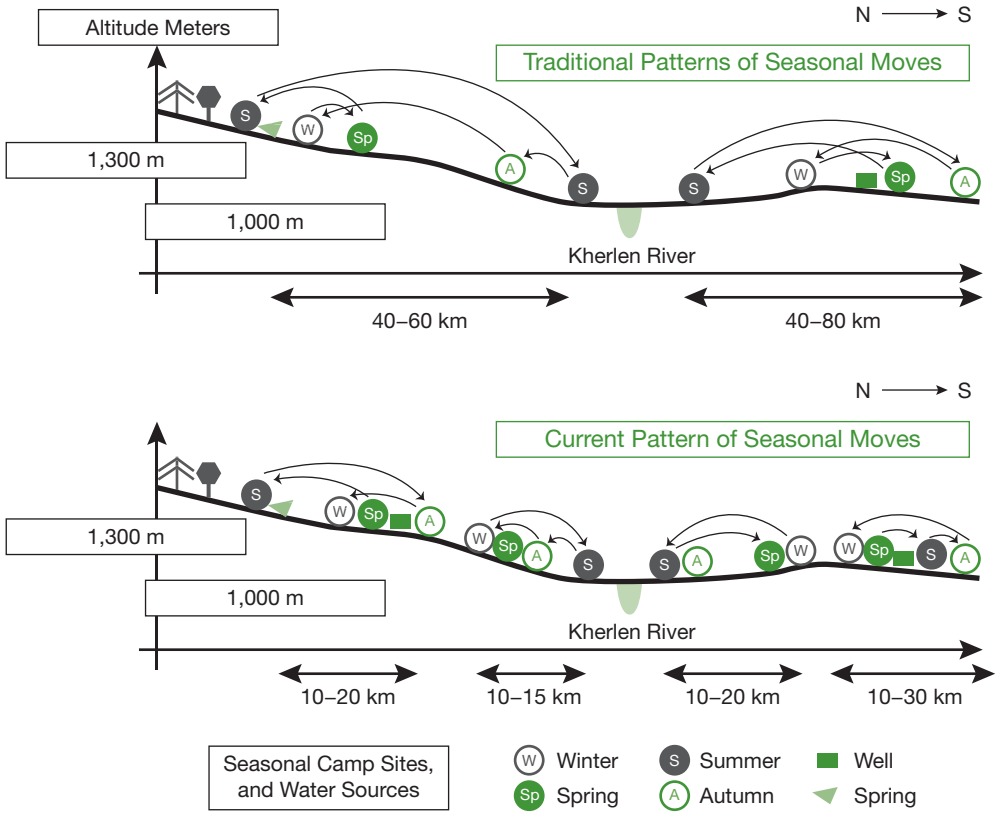
6 S. M. Schmidt. 2006. Pastoral Community Organization, Livelihoods and Biodiversity Conservation in Mongolia's Southern Gobi Region. *USDA Forest Service Proceedings RMRS-P-39*. pp.18–29.

7 Ministry of Nature, Environment and Tourism (MNET). 2010. *Mongolia's Second National Communication under the United Nations Framework Convention on Climate Change*. Ulaanbaatar. http://unfccc.int/resource/docs/natc/mongnc2.pdf; and MNET. 2010. http://unfccc.int/essential_background/library/items/3599.php?such=j&author=%22Ministry+of+Nature%2C+ Environment+and+Tourism%22#beg

8 M. Fernandez-Gimenez. 2006. Land Use and Land Tenure in Mongolia: A Brief History and Current Issues. *USDA Forest Service Proceedings RMRS-P-39*. pp. 30–36.

9 The study was conducted under the Asian Development Bank (ADB) technical assistance project "Strengthening Carbon Financing for Regional Grassland Management in Northeast Asia."

Figure 1: Changes in Patterns of Movement from Traditional to Current Practices



km = kilometer, m = meter.
Source: Project team.

Current Situation

Five pilot *soums* in the steppes and forest steppes of Mongolia's three eastern *aimags* were selected for in-depth study based on guidance from a technical working group.[10] The pilot *soums* were Bayankhutag, Norovlin, Sergelen, Sukhbaatar, and Tsagaan Ovoo, and the three eastern *aimags* were Dornod, Khentii, and Sukhbaatar (Maps 1 and 2). *Soums* were selected based on factors such as (i) their ecological and socioeconomic characteristics, (ii) opportunities to maximize adaptation, (iii) mitigation potential and co-benefits to local communities through improved grassland and/or livestock management, and (iv) favorable governance and institutional relationships.

Between June and September 2011, a series of field visits was undertaken to conduct (i) semi-structured interviews with key informants in the *aimags* and *soums*; (ii) focus group discussions involving herders, local government officers, and other citizens; (iii) a survey of herders; and (iv) studies of the biophysical conditions. There were 90 participants in the focus group discussions and 73 participants in the herder survey. These field studies were undertaken in close coordination with officers of the National Agency for Meteorology and Environmental Monitoring (NAMEM). Biophysical studies collected data on changes in species composition, weedy plant invasion, and soil surface and vegetation cover.[11]

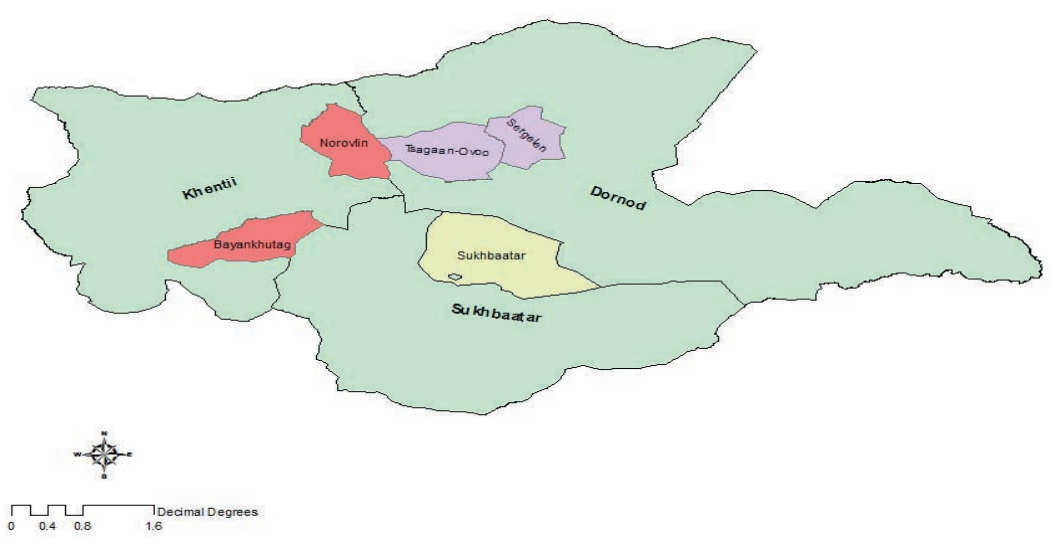
Map 1: Map of Mongolia with the Eastern *Aimags*

Boundaries are not necessarily authoritative.
Source: Project team.

[10] The technical working group was established to support ADB's technical assistance project "Strengthening Carbon Financing for Regional Grassland Management in Northeast Asia."

[11] Additional details of the methodology are provided in the consultant's final report of this project (ADB. Forthcoming. *Strengthening Carbon Financing for Regional Grassland Management in Northeast Asia*. Consultant's report. Manila).

Map 2: Location of the Five Pilot *Soums* in the Three Eastern *Aimags*



Boundaries are not necessarily authoritative.
Source: Project team.

Demographics

Average household size was 3.6, and 54.1% of households made their livelihoods as herders in the five pilot *soums* (footnote 11). The average area per herder household was 1,353.8 hectares (ha), and the average herd size was 77.1 animals, primarily sheep and goats (Table 1). Livestock density was 4.6 animals/ha.

Livestock Productivity

During 1980–2000, the average weight of sheep declined by 4 kilograms (kg), goats by 2 kg, and cattle by 10 kg. In approximately the same period, sheep wool productivity decreased by more than 8% and cashmere productivity decreased by about 2% (footnote 6).[12] In surveys, herders stated that the worst seasons for livestock losses were spring (90%) and winter (62%).[13]

[12] P. Batima. 2006. Climate Change Vulnerability and Adaptation in the Livestock Sector of Mongolia. *A Final Report submitted to the Assessments of Impacts and Adaptations to Climate Change*. Project No. AS 06. Washington, DC: International START Secretariat. www.start.org

[13] T. Narantuya. 2006. Comprehensive Analysis of Climate Change Impacts on Food Security and Sustainable Livelihood of Rural People. In *Climate Change and Sustainable Livelihoods of Rural People in Mongolia*. Ulaanbaatar: MNET of Mongolia and Netherlands Climate Change Studies Assistance Programme.

Table 1: Population, Land Resources, and Livestock in the Five Pilot *Soums*
(data collected in 2012)

Item	Norovlin	Bayankhutag	Tsagaan Ovoo	Sergelen	Sukhbaatar	Total
Population	2,294	2,508	3,672	2,200	3,144	13,818
Households	695	647	994	616	869	3,821
Herder Households	287	407	320	361	692	2,067
Livestock						
Camels	165	386	312	537	1,303	2,703
Horses	8,702	11,741	11,987	11,625	13,926	57,981
Cattle	9,191	7,144	6,808	4,572	7,867	35,582
Sheep	40,519	106,736	50,351	44,282	86,365	328,253
Goats	26,755	62,441	31,495	20,405	49,871	190,967
Total Number of Livestock	**83,332**	**188,448**	**100,953**	**81,421**	**159,332**	**613,486**
Territory ('000 hectares)	533.3	602.9	650.2	416.9	1,276.1	3,479
Pasture ('000 hectares)	390.9	551.6	352.1	264.1	1,239.6	2,798

Source: *Soum* governments' statistics and data collected during field study conducted by the project team in 2012.

Grassland Species and Biomass

The needlegrass–forbs vegetation type, which is common in the steppe ecological zone, covers 64% of the territory of the five pilot *soums*.[14] Pastures are characterized by an average of 25–27 plant species, dominated by *Stipa krylovii* and *Stipa drandis*. *Agropyron cristatum*, *Cleistogenes squarrosa*, *Heteropappus hispidis*, *Aster alpinus*, *Sibbaldianthe adpressa*, *Potentilla acaulis*, *P. bifurca*, and *Allium anisopodium* are common. The vegetation cover is 41.8%–67.0%, and bare ground accounts for 24.9%–44.0% (footnote 11).

The structure of the plant community is closely related to grazing pressure. In overgrazed grassland areas, plants with nutrient value for livestock have decreased in abundance. Plants with low nutrient value, such as sagebrush (*Artemisia frigida*, *A. adamsii*) and sedge (*Carex duriuscula*), have increased to 18.9%–70.8% of the total vegetation cover.[15] In needlegrass–forbs type, increases in invasive species, such as *Artemisia frigida*, *Carex duriuscula*, and *Leymus cheninsis,* are the most effective quantitative indicators of grazing pressure. Degradation of pasture results in reduced yield of plants palatable to livestock.

The peak of pasture biomass (August) declined by approximately 20%–30% from about 1970–2010, and spring biomass (April and May) has decreased in the forest steppe and the steppe. In addition, the emergence of pasture plants has shifted to an earlier date.

[14] S. Tserendash. 2011. Pasture Management and Fodder Production. *Handout for Animal Breeders*. Ulaanbaatar: Munkhiin Useg Printing Company.

[15] S. Tserendash. 2011. Pasture Rotation in the Forest Steppe Zone. In Research Institute of Animal Husbandry. *50th Anniversary of the Research Institute of Animal Husbandry*. Ulaanbaatar: Munkhiin Useg Printing Company.

Soils

Soils in Mongolia are classified into two major groups: mountain and steppe type. These are further divided into several subtypes based on the origin of formation.[16] The amount of carbon present and the carbon sequestration rate in soils depend on the soil characteristics, soil potential, grazing pressure, productivity, and degradation level. Peat soils have the highest level of sequestered carbon and constitute approximately 2% of the total land area. Mongolia is ranked among the top 10 countries in the world for peat land emissions due to overgrazing, anthropogenic fires, and climate change.[17]

Primary factors affecting soil productivity are the amount of humus, the depth of AB/B soil horizon, pH, soil texture, and the percentage of clay. A soil quality assessment identified meadow cryomorphic dark soils as the most productive soil of the high mountain zone, and desert sandy brown soil as the least productive.[18] The most common type of soil in the five pilot *soums* is steppe brown, which is typically sandy clay. This soil type has an AB soil horizon at about 30 centimeters deep, a humus content of 2.8%–3.8%, and a pH of 6.0–7.0 (moderately acid to neutral). Usually, these soils are rich in calcium but deficient in phosphate.[19] Phosphate deficiencies may limit agricultural productivity.

Bare ground has increased, and the topsoil is becoming sandy. A key factor is overgrazing, as livestock concentrates around the few usable wells and water bodies. Overgrazing results in the reduction or elimination of vegetation cover. This leads to increased loss of soil moisture, and exacerbates soil erosion by wind and rain.

Air Temperature, Precipitation, Evapotranspiration, Droughts, and *Dzud*

Average mean temperatures have increased significantly in Mongolia since the 1940s, rising by 3.6°C in winter and 1.8°C in summer. Summer heat waves have increased in duration by 6–18 days, while cold waves in winter have decreased by 13–20 days. Precipitation has increased by 4%–9% in fall and winter, and decreased by 7.5%–10% in spring and summer. Evapotranspiration has increased by 7%–12%. These trends vary significantly across regions.

Over the same period, drought frequency, magnitude, and severity have increased significantly, particularly in the last decade. The drought in the summers of 1999–2002 affected at least 50% of the country. The trend toward more frequent droughts has led to a significant loss of water sources throughout the country. Almost one-third of Mongolia's territory is defined as very vulnerable. About 3,000 water sources, including 680 rivers and 760 lakes, have dried up since 2000 (footnote 12).

The spring melt has advanced by about 3 weeks compared with the 1980s. The date of snow cover has also shifted to earlier in the year by about 3–10 days since 1981 and is projected to advance further. The ice cover duration has become shorter by 10–30 days depending on the region.

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16 D. Dorjgotov. 2003. *Soils of Mongolia*. Ulaanbaatar: ADMON Printing Company.

17 H. Joosten, M. Tapio-Biström, and S. Tol, eds. 2012. *Peatlands-Guidance for Climate Change Mitigation through Conservation, Rehabilitation, and Sustainable Use*. Second Edition. Rome: Food and Agriculture Organization of the United Nations and Wetlands International. www.fao.org/docrep/015/an762e/an762e00.htm

18 L. Nyambat and B. Enkhmaa. 2010. *Evaluation of Soil Quality and Agricultural Land in Mongolia*. Ulaanbaatar.

19 ALACGAC. 2008. *Condition of Land Quality of Rangeland in Soums*. Ulaanbaatar.

Severe *dzud* occurred in the winters of 1944–1945, 1967–1968, 1978–1979, 1999–2002, and 2009–2010. Losses amounted to 32.2% of livestock (8.76 million) in 1944–1945, and 11.9% (2.6 million) in 1967–1968. Total livestock losses from the *dzud* of 1999–2002 are estimated at 25% (10 million), and approximately 16% (7 million) were lost during 2009–2010.[20]

Observed Climate Change Trends and Future Projections

Mongolia's terrestrial ecosystems have undergone major changes since 1990.[21] There have been significant decreases in surface water (19%), grassland (7%), and forest areas (26%). Barren land (without grass) has increased by 98,000 square kilometers to a total of 149,000 square kilometers. Mountain snowcaps have decreased by approximately 30% since 1940. The frequency of climate-related disasters with high social and economic costs, such as flashfloods, thunderstorms, and hail, has doubled since 1990.

Projections of Future Climate Change Trends

Previous research has projected future climate trends through 2090 (or 2099 depending on the model) based on three general circulation models: the HadCM3 (developed by the Hadley Centre for Climate Prediction and Research), ECHAM3 (developed by the Plank Institute for Meteorology), and CSIRO Mk2 (developed by the Commonwealth Scientific and Industrial Research Organisation). The results varied greatly between models, but there were general trends: temperatures are predicted to increase through 2090 (relative to the baseline average calculated for 2061–1990) in both summer (1.3°C–8.6°C) and winter (0.9°C–8.7°C) (footnote 12). Winter precipitation is forecast to increase (12.6%–119.4%), but summer precipitation is less clear (models predicted anywhere from a 2.5% decrease to an 11.3% increase). Evapotranspiration in summer is predicted to increase by 13.0%–90.9% during the same period.

Extreme Events: Drought and *Dzud*

The frequency and magnitude of drought and *dzud* are likely to increase with climate change. The frequency of *dzud* tripled during the 1990s compared with the 1960s. It should be noted that although the winter temperatures may be warmer than previously, *dzud* is a complex phenomenon that refers not only to temperature, but also to other climate aspects, such as snow and ice cover, which result in livestock starvation. *Dzuds* following summer droughts have larger negative impacts. More than 80% of the country's territory is defined as highly vulnerable to climate extremes (footnote 12).

Snow Cover and Water Bodies

Changes in snow cover extent have been negligible, but declines of 27%–56% are projected for 2020–2080. The area under continuous snow cover for more than 140 days is projected to decline, while the area under snow cover for 120–140 days is projected

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[20] (i) National Statistical Office. 2003 and 2010. *Mongolian Statistical Yearbooks (2003, 2010)*. Ulaanbaatar; and (ii) M. Fernandez-Gimenez, B. Batjav, and B. Baival. 2011. *Mongolia—Understanding Resilience in Mongolian Pastoral Social-Ecological Systems: Adapting to disaster before, during, and after 2010 Dzud*. Washington, DC: World Bank. http://documents.WorldBank.org/curated/en/2011/05/16436665/mongolia-understanding-resilience-mongolian-pastoral-social-ecological-systems-adapting-disaster-before-during-after-2010-dzud

[21] MNET. 2009. *Mongolia: Assessment Report on Climate Change 2009*. Ulaanbaatar. www.unep.org/pdf/MARCC2009_BOOK.pdf

to increase (footnote 12). The volume of river runoff and the number of water bodies are projected to decrease due to a reduction in summer precipitation and an increase in temperatures.

Ecological Zones

Herders have observed a shift in the boundaries of current ecological zones. For example, herders in the central region have noticed typical Gobi plants occurring further north than previously. A general northward shift of ecological zones is predicted based on climate modeling. In particular, the current dry steppe zone in the east is predicted to spread north into current forest-steppe areas, resulting in larger dry steppe areas and less forest steppe in the Altai, Khangai, Khentei, and Khuvsgul mountain ranges. The desert region is projected to expand by nearly 25% by 2040. Pasture biomass is projected to decrease in the forest steppe and steppe, and increase in the high mountains and desert (footnote 12).

Livestock

More frequent drought and *dzud* are considered the key risks to livestock associated with climate change. Livestock in Mongolia obtain about 90% of their feed intake from extensive grazing on open rangelands. The impacts of drought include decreased abundance of pasture plants (particularly palatable species), reduced water availability, absence of grass in pastures, and reduced ability to prepare winter feed (hay). During droughts, animals are not able to gain sufficient strength and body weight reserves in the summer to survive the harsh winter and spring storms. During winter and spring storms, animals can only obtain 40%–60% of their daily feed requirements and must depend on their fat reserves (footnote 12).

Temperature stress on animals has been observed, and is expected to increase. Based on projected future climate change trends, conditions that inhibit or prevent livestock grazing will increase in the summer in the eastern and central steppe and in the winter in the northwestern mountainous region. This effect is predicted to be variable depending on the ecological zone, with forest-steppe and steppe regions heavily affected. Reductions in grazing time and reduced yield and pasture quality are expected to have a particularly adverse impact on livestock. For example, summer ewe live-weight is a major determinant of growth, fertility, productivity, and overall resilience in sheep. In the steppe, ewe weight could decrease by 1.8 kg–7.2 kg. A decrease in ewe weight is also predicted for the high mountain zone, while in the Gobi desert increased biomass may result in a slight increase in ewe weight (footnote 12).

Livelihoods and Food Security

Gradual changes in climate and in extreme events, particularly *dzud* and drought, have severe impacts on rural livelihoods and food security. In 2010, a year noted for the severe *dzud* that occurred, rural poverty was 49.0%. This subsequently declined to 35.5% in 2012 with international and government assistance.[22] Drought reduces the available pasture area and pasture yield, leading to reductions in grazing time and reduced livestock productivity. It has a direct effect on herder households' food supply, nutrition, and income. Herders depend on dairy products (such as milk, dried curd, clotted cream,

[22] World Bank. 2013. *Poverty Rate Came Down by 27.4 Percent in 2012.* Press release. 21 May. www.worldbank.org/en/news/press-release/2013/05/21/poverty-rate-came-down-to-27-4-percent-in-2012

and butter) and meat for food as well as cash income to purchase household necessities, including foodstuffs.

Official Regulation of Use of Pastureland and Pasture Reserves

The Law on Land, passed by the Mongolian National Parliament in 2002, requires a state grassland assessment and certification to be undertaken every 5 years to capture changes in land characteristics and to inform land-use planning. The Administration for Land Affairs, Construction, Geodesy and Cartography (ALACGAC) oversees the assessments and certifications. The results are used to determine and map grassland degradation levels countrywide.

Long-term pasture monitoring in Mongolia is based on NAMEM's national network of meteorological stations. This includes approximately 1,550 sites where soil and vegetation quality data are collected annually. Monitoring of pasture phenology has been undertaken at the *soum* level for the past 40 years. NAMEM has undertaken annual estimates of carrying capacity since 2001, and has monitored grasshopper and rodent infestation since 2002—both at the *soum* level. The Ministry of Industry and Agriculture and the National Emergency Management Agency also manage and regulate pastureland using NAMEM's pasture carrying capacity data.

The implementation of annual vegetation sampling at the established monitoring sites by ALACGAC is weak. Constraints include lack of capacity, poor enforcement of the requirement, and omission of the task in land officers' contracts. ALACGAC also maintains an annually updated record of the boundaries of the areas of rangelands that were under rotational use, set aside for resting, and treated for rodent control. However, evaluation of the impacts of these pasture management practices has been largely lacking. Implementation monitoring indicators for livestock management are monitored by the *soum* livestock unit, which consists of three officers tasked with extension, monitoring, coordination, veterinary services, and technical services related to animal breeding.

A lack of *soum*-level cooperation among the multiple government offices was identified as a key barrier for joint planning, implementation, enforcement, and monitoring and evaluation in pastureland management.[23] The lack of a *soum*-level database and limited exchange and analysis of data on the local level were identified as other constraints. At present, there is no framework for information sharing between herders and the local government.

[23] This finding was reported during the project's Working Group Stakeholder Workshop held in Ulaanbaatar in November 2011.

Vulnerability and Resilience in Mongolian Pastoral Communities

Vulnerability has been defined as susceptibility to damage or harm, encompassing exposure and sensitivity, as well as adaptive capacity to respond constructively to harm (footnote 20). Herders in Mongolia directly depend on pasture and water resources for their livestock, and are among the more vulnerable groups to climate change impacts. Pastoralist households are less resilient if they have lower incomes, depend on a limited number of products or a single economic sector, and have fewer means to move location. In addition, the weak institutional and regulatory framework, leading to open commons and ensuing environmental degradation, has resulted in a decrease in the pastoralists' adaptive capacity.

Local Institutions and Legislation

Access to key resources, such as emergency grazing areas and water, was compromised following the 1990 revolution and the subsequent disintegration of multiple governance systems, including pasture management. Necessary infrastructure was not maintained due to a lack of defined responsibilities and regulatory functions, and insufficient financial resources. Community responses varied. Some set up traditional pre-Socialist structures or Socialist-era collective units (brigades and groups of 10 households); while others developed new institutions, such as *nukhurlul* (partnerships of households), which are now recognized in the Civil Code of Mongolia.

Legislation relevant to pastureland management has been interpreted differently among *soums*. Some *soum* governors have been willing to grant group possession rights to pasture under the Law on Land, while others have been reluctant to follow this interpretation. Local institutions need to become more flexible and locally responsive in the development and interpretation of regulations to increase their resilience. Additional capacity building and support are required.

Grassland Ecosystems and Livestock

Grassland ecosystems and livestock are highly vulnerable to climate change impacts. In grassland ecosystems, the main climate change impacts are (i) decreased pasture biomass, (ii) intensifying pasture degradation and desertification, (iii) an increase in harmful insects (particularly locusts) and rodents, and (iv) deterioration of biodiversity and declining populations of rare species (footnote 7). In the livestock sector, decreased food abundance and/or availability, and increased climate variability (e.g., higher temperatures resulting in

snow melt followed by colder temperatures and ice-overs preventing access to forage) lead to decreased productivity and higher mortality rates. The government regards climate change impacts on grassland and livestock so severe that the impacts are considered at the level of national security management (footnote 21).

Climate change impacts reported by herders include (i) increased frequency of *dzud*; (ii) decreased precipitation (decrease in total number of rainfall hours); (iii) earlier melting of snow cover; (iv) drying up of lakes, rivers, and springs; (v) fewer pasture plant species; (vi) more frequent droughts; and (vii) declining biodiversity and populations of rare wildlife species (footnote 11). Herders stated that droughts were the main cause of pasture degradation, as opposed to overgrazing which also plays a major role.

Ecological Vulnerability Index

The vulnerability of pastoral social-ecological systems has previously been assessed in temporal (1970–2008) and spatial dimensions using an ecological vulnerability index.[24] The index was based on drought, *dzud*, and pasture use indices overlaid on poverty index data. The index showed that ecological vulnerability increased by more than 20% between 1970–1975 and 1996–2008.

Resilience

Recent research on resilience in the Mongolian pastoral social-ecological system has identified storage, mobility, diversity, reciprocity, and flexibility as the coping and adaptive strategies for extreme events (primarily *dzud*) (footnote 20). Storage (including animal fat and/or weight gain, hay, fodder, and grazing reserves) was a crucial strategy. In the desert steppe, households that fed their livestock stored hay or grazed them on reserved spring pasture had lower losses. In the forest steppe, mobility was an important strategy, with herders that migrated in the fall suffering significantly lower losses than those that did not. Diversity helped reduce risk of economic loss and included herding multiple species, diversifying income sources and social networks. Reciprocity included reciprocal pasture access and mutual assistance during disasters. Effective designation and use of *soum* emergency grazing reserves was emphasized as a critical strategy for the future. Flexibility in the social organization of herders and in livestock management practices, such as controlling livestock reproduction rates and timing, or selling livestock before the winter to reduce feed amounts and costs, were also identified as strategies employed by herders with lower livestock mortality rates.

[24] M. Altanbagana and T. Chuluun. 2010. Vulnerability Assessment of Social-Ecological System of Mongolia. *Proceedings of the 4th International and National Workshop: Applications of Geo-informatics for Natural Resource and Environment*. Ulaanbaatar, Mongolia. June.

Adaptation Strategies in Livestock and Grassland Management

Adaptation strategies for livestock husbandry and grassland management have some commonalities globally, many of which are relevant to adaptation practices in Mongolia. Common strategies include[25]

(i) improving the management of water, soil, and vegetation resources through halting land conversion and mining; integrated agricultural and/or mixed livestock farming systems (a combination of stall-feeding and pasture grazing); and best practices, including conservation set-asides and managed intensive rotation grazing;
(ii) developing new breeds, including identifying and strengthening local breeds that are adapted to local climatic stress and feed sources, and improving local genetics through crossbreeding;
(iii) development of insurance systems to cover loss of livestock;
(iv) establishing livestock early warning systems that warn of impending severe storms and drought, as well as fodder shortages;
(v) building awareness, knowledge, and skills to cope with climatic changes;
(vi) training in agroecological technologies and practices for the production and conservation of fodder to increase the supply of animal feed and improve nutrition;
(vii) adjusting livestock management systems, such as reducing livestock numbers, while increasing productivity, adjusting herd composition, and improving livestock health; and
(viii) introducing appropriate techniques for irrigation and water harvesting, small-scale reservoirs, soil improvement, and pasture rotation management.

The survey of adaptation practices by herders in the five pilot *soums* identified five practices to improve rangeland health (Table 2). The most common practices were destocking and *otor*. A number of other adaptation practices were identified during focus group discussions with multiple stakeholders. Practices related to social organization included organizing in herder groups for pasture management and sharing knowledge of traditional herding practices. Adaptation practices in pasture management included rotation and resting of pasture, *otor* movement to fatten animals in fall and/or winter, rehabilitating wells, protecting springs through fencing, irrigating pasture, planting fodder species, and preparing hay and other fodder. For livestock management, adaptation practices identified included breed improvement, regulating and improving herd composition, decreasing the number of goats, reducing stocking rates to adhere to carrying capacity, slaughtering old animals, repairing winter shelters, and taking out livestock insurance.

Official Adaptation Strategies in Mongolia's Livestock Sector. Mongolia's Second National Communication to the United Nations Framework Convention on Climate

[25] International Fund for Agricultural Development (IFAD). 2010. *Strengthening IFAD's Capacity to Mainstream Climate Change Adaptation in Its Operations. IFAD's Response to Climate Change through Support to Adaptation and Related Actions*. Rome. www.ifad.org/climate/resources/adaptation.pdf

Table 2: Adaptation Practices of Herders in the Five Pilot *Soums*

Practices Implemented by Herders in the Five Pilot *Soums* to Improve Rangeland Health	Percentage of Respondents Who Implemented the Practices
Slaughter of weak animals in fall to avoid loss from *dzud*	61.6
Fall and summer *otor*	47.9
Winter *otor*	28.7
Livestock insurance	23.2
Reserve pasture for emergency use (during *dzud*)	20.5

Source: Project survey.

Change (UNFCCC) outlined adaptation strategies based on findings from long-term climate monitoring and modeling (footnote 12). Decreased weight and productivity were identified as the main impacts of climate change in the livestock sector. Productivity and long-term resilience of Mongolia's pastoral system were identified as dependent upon the condition of the natural resource base, primarily grassland, livestock "bio-capacity" (i.e., resilience) to cope with environmental stresses, and on human capacity to manage livestock and pasturelands. The communication stated that adaptation should focus on (i) conserving the natural resources on which livestock husbandry depends; (ii) strengthening the capacity of livestock to cope with environmental and climate stress; (iii) developing the capacity of herders and expanding livelihood opportunities for rural communities; (iv) increasing food security; and (v) enhancing monitoring, interpreting, and forecasting capacity. The government developed the National Action Program on Climate Change in 2000 to promote selected adaptation measures and coping strategies.

For animal husbandry, the following adaptation measures were selected to address the key impacts of climate change and associated declines in incomes: (i) developing semi-intensive farming in suitable areas, (ii) improving local breeds, (iii) managing risk and promoting insurance systems, (iv) diversifying herders' livelihoods, (v) supporting small enterprises, (vi) developing the capacity of herders for livestock management and alternative livelihood skills, (vii) introducing modern processing technologies for livestock products, (viii) developing a regulatory framework (pasture use fee and/or tax) to achieve appropriate stocking rates and create incentives for pasture improvements, and (ix) providing renewable energy for herder households.

For grassland ecosystems, adaptation measures were selected to respond to declining pasture productivity, increasing desertification, and loss of biodiversity. The measures include (i) regulating pasture use and possession, (ii) conducting comprehensive assessments of land degradation at the *aimag* level, (iii) establishing an effective system of land use monitoring, (iv) strengthening the early warning system in NAMEM, (v) cultivating forage plants, (vi) undertaking soil conservation measures, (vii) improving pastureland irrigation, and (viii) introducing new drought- and pest-resistant plant varieties.

The communication also identified measures to strengthen arable farming, promote soil conservation, and combat desertification. These included improvements to land cultivation management systems, research into new crop varieties that are adapted to climate change (e.g., earlier-maturing and drought-resistant strains), better marketing infrastructure and road networks (to reduce multiple tracks), and restoration of saxaul forest in desert steppe areas.

The National Livestock Program (NLP), established in 2010, is important to achieving the government's adaptation and mitigation goals. The purpose of the program is to develop a livestock sector that (i) is adapted to climate change and supports sustainable development, (ii) is economically viable and competitive in the market economy, (iii) provides a safe and healthy food supply, (iv) delivers quality raw materials to processing industries, and (v) increases exports. Veterinary and livestock breeding units have been established in every *soum* under the NLP. The program's five priority areas are policy and/or governance, pasture management, breeding, animal health, and marketing. Approximately 1.5% of the national budget is allocated to implementing the NLP, primarily to support agricultural cooperatives. Additional financing in this sector, such as funds from international development partners, must be aligned with the NLP.

Constraints and Opportunities for Implementing Adaptation Strategies

The Second National Communication to the UNFCCC cites shortcomings in institutional capacity and insufficient financial resources as two of the central barriers to policy implementation for addressing primary adaptation needs. The complexity of the climate change impacts and socioeconomic challenges in natural resources management and pastoral livelihood development (including regulating land use, protecting ecosystem services, and developing functioning marketing systems) requires integrated approaches for which institutional and human capacity are not readily available. This is particularly true in the rural areas where climate change adaptation must be put into practice.

Herders and local government representatives identified the lack of a legal framework to regulate pasture use and weak enforcement of pastureland management rules as the key constraints to implementing improvements and adaptive practices. They also highlighted the lack of technical and financial capacities of local governments for performing their land management functions, a shortage of finance among herders to carry out pasture management measures, and limited opportunities for processing and marketing. With the increase in development in the region, markets are emerging; however, herders do not have the capacity to take advantage of these opportunities. The herders and government representatives also reported that informal and formally established herder groups had been successful in coordinating movements of member households and reserving seasonal pastures, but unregulated movements of herders with large herds had in several cases undermined these efforts. They concluded that customary rules alone are insufficient to have an effective regulatory impact. These constraints and opportunities are now discussed in more detail.

Territorial Organization and Pastoral Mobility

Historically, the number of seasonal movements and the average distance traveled tended to be significantly greater than they are today (footnote 8). For example, herders would undertake seasonal movements of several hundred kilometers between the Gobi desert and the central Khangai mountain range. However, the current regulatory system of territorial organization limits travel distances and seasonal movements, and thus restricts adaptation. Some *soums* have fragmented pastoral landscapes that do not include all seasonal pastures, leading to livestock and overgrazing becoming highly concentrated in certain areas. In addition, there is insufficient pasture in some *soums* to be able to set aside and rest degraded pasture areas.

The fragmentation is increasing rapidly with the expansion of extractive industries that affect land and water resources. One proposed solution is the creation of larger administrative units based on the concept of “cultural landscape restoration” (combining several *soums*

into one unit to restore cultural landscapes).[26] Other options to improve mobility include providing additional water sources for pastureland, and drawing up agreements between adjacent *soums* for communal use of *otor* and reserve pastures.

In addition, unregulated movements by herders with large herds often undermine efforts to coordinate movements and reserve seasonal pastures. Much of the planning for adaptation therefore seeks to restore the institutions, regulatory framework, and services that will support pastoral mobility.

Competition for Natural Resources

Extractive industry and extensive livestock husbandry are increasingly at odds. Mining operations require large amounts of water, and mineral deposits are often located in lands used by herders. This leads to increasing resource competition, with herders often being displaced. The loss of access to key resources, such as grazing reserves, seasonal pastures, and water resources, has a very severe impact on pastoral communities. The projected use of water in mining operations is significant, even if portions of the water are recycled.

The competition for water and loss of water sources through drought and overharvesting has triggered the government to draw up preliminary plans for water harvesting and storage strategies. Practical water-related adaptation measures with multiple benefits, such as rainwater harvesting, floodplain restoration, more efficient water use, improved water storage, and reuse of wastewater, are under consideration by the government. However, it has also been stressed that increased buffering capacity through better management of soil moisture, and a combination of surface water and groundwater storage will be important. While appropriate storage of water is important for adaptation, poorly planned flood, water-storage, and transfer infrastructure are maladaptations (footnote 25). Deep-engineered wells planned to provide remote pastures with water are a potential maladaptation if water extraction is greater than the aquifer recharge rate, causing the water table to drop.

Lack of Capacity for Value Addition to Livestock Products and Marketing

Herders still face great challenges in accessing credit to acquire equipment for processing or to invest in semi-intensive dairy farming. This limits their capacity for value addition. The NLP and new legislation on marketing agricultural commodities are designed to support rural marketing cooperatives that can more effectively access credit and markets. The establishment of herders' marketing cooperatives, however, remains challenging due to cultural resistance and lack of capacity. There is also a potential for "elite capture," whereby current traders (rather than herders) convert their operations into legally registered cooperatives, gaining government support, and retaining the majority of revenues generated through price control.

[26] T. Chuluun. 2010. Opportunities for Synergies between Climate Change, Desertification, Conservation and Human Development at Multiple Scales. In T. Chuluun and M. Watanabe, eds. *Proceedings for Consultative Meeting on Integration of Climate Change Adaptation into Sustainable Development in Mongolia*. Ulaanbaatar, Mongolia. 17–18 June. pp. 105–127.

Financial Constraints and New Opportunities

Mongolia's Second National Communication to the UNFCCC stated that a lack of financial resources was a key constraint to the implementation of adaptation measures. There is currently insufficient financial support for required investments in pastureland management, soil conservation, ecological restoration, and provision of extension services to educate herders. However, contributions to *soum* development funds from the central budget increased in 2013. In addition, support for adaptation measures under pastureland management plans and the local implementation of the NLP may be extended by budget allocations through transparent and needs-based budgeting procedures at the *soum* level.[27] Additional funding provides an opportunity to increase support for the implementation of pastureland management activities, the work of the *soum* livestock unit in implementing the NLP, and participatory planning. Furthermore, plans drawn up by herders' institutions for pastureland improvement, value addition, livelihoods diversification, and marketing can potentially receive significant support under needs-based budgeting.

Outreach and Extension

Information on climate change and climate trends is neither readily available nor well understood at the local level. Despite newly established *soum* veterinary and livestock breeding units, extension and outreach are still weak, and developing effective outreach to migratory herders is a significant challenge due to the large territories and seasonal movements. Access to information and technology is still severely limited for rural communities.

The knowledge of ecological restoration techniques and skills necessary to combat the unprecedented environmental degradation are limited among resource users and local officers. The officers of the livestock unit mandated with extension tasks are not all sufficiently qualified, and, more importantly, do not have the means to maintain continuous contact with herders. Increases in *soum* development funds should provide opportunities in the future for staff capacity building and more frequent travel and outreach to herder communities.

Land Tenure

Lack of land tenure (use and/or possession of pastureland) remains an important barrier to investment by herders in adaptation measures. However, flexibility and the principle of reciprocity have to be retained to allow for nomadic movements as a key adaptation practice. The concept of privatization of pastureland is therefore not supported by most pastoralists and can generate anger and dismay.[28]

Tenure agreements need to include group-based pasture use and possession, and common access to key pasture reserves and water resources. At the same time, the agreements need to provide for flexibility to undertake movements in times of emergency beyond the area used under normal conditions. This requires reciprocity rules because

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27 The State Great Hural (Parliament of Mongolia). 2010. The State Budget Law of 2011. The States Information No. 47. Ulaanbaatar: Secretariat of the Parliament.

28 A. Marin. 2009. Angry Spirits of the Land: Cultural and Ethical Elements of Climate Change Adaptation among Mongolian Pastoralist Nomads. *The Institute of Physics (IOP) Conference Series: Earth and Environmental Science.* 6 (57). 3. http://iopscience.iop.org/1755-1315/6/57/572029/pdf/1755-1315_6_57_572029.pdf

the need for emergency movements can arise for all groups at certain times. Developing a tenure system and legal framework is therefore a very complex challenge. Several donor-supported projects have assisted collective action among herders and developed herders' organizations.[29] A model based on a larger group of households organized for pasture management and smaller subgroups pursuing separate income-generating and marketing activities is emerging as the most suitable approach to addressing the challenges of natural resources management, livelihood development, and institutional structure.

Lack of Technology

Although some agencies, such as NAMEM, have long-term climate records and others, such as ALACGAC, have records of changes in pastureland quality and condition, technology support is needed to establish climate change monitoring stations and improve the forecasting system for extreme events.

Mongolia's Second National Communication to the UNFCCC also identified lack of technology as a barrier for improving pasture yield, pasture water supply, animal productivity, veterinary services, livestock breeding, renewable energy supplies, enterprise development, livestock insurance, and farming (dairy, meat, chicken, vegetables) in peri-urban areas. With finance becoming available, the main constraints now relate to coordination and institutional structures at the central level, and capacity at all levels of society and government.

Vulnerability to Climate Change

While regional climate modeling has been undertaken and impact predictions have been defined for different ecological zones, local predictions of climate change and its impacts remain uncertain. A recent study on the contributions of nomadic herders' observations to analyzing climate change in the desert steppe area of Mongolia suggests that the scale of the models used may be too coarse and their parameters may be of limited relevance for local resource users.[30] Climate models need to be refined to generate more accurate predictions of climate change and allow better planning for adaptation.

Extreme Events

Adaptation to extreme events is constrained by (i) ecological variation in the productivity and distribution of resources; (ii) lack of knowledge and disaster preparation; (iii) poor communication and exchange of information; (iv) limited cooperation, support, and assistance beyond the *khot ail* (group of herder households) scale; (v) limited access

[29] (i) ADB. 2008. Proposed Grant Assistance to Mongolia for the Water Point and Extension Station Establishment for Poor Herding Families. Manila; (ii) Swiss Agency for Development and Cooperation (SDC). Green Gold Project Phase IV (2002–2016). http://www.swiss-cooperation.admin.ch/mongolia/en/Home/Agriculture_and_Food_Security/Green_Gold_Programme; (iii) European Union (EU) and The Agency for Livestock Veterinary and Breeding. EU-Mongolia Animal Health and Livestock Marketing Project (2008–2012). http://eeas.europa.eu/delegations/mongolia/projects/list_of_projects/18005_en.htm; (iv) Millennium Challenge Account-Mongolia. Peri-Urban Rangeland Project. http://www.mca.mn/en/index.php?option=view&parent=72; and (v) World Bank. 2013. Third Sustainable Livelihoods Project (P125232). http://www.worldbank.org/projects/P125232/third-sustainable-livelihoods-project?lang=en&tab=overview

[30] A. Marin. 2010. Riders under Storms: Contributions of Nomadic Herders' Observations to Analyzing Climate Change in Mongolia. *Global Environmental Change: Human and Policy Dimensions.* 20 (1). pp. 162–176.

to financial and technical resources; (vi) institutional barriers to migration and pasture management; (vii) governance issues; and (viii) insufficient coordination between development partners and local government (footnote 20).

Knowledge Gaps

Significant knowledge gaps regarding coupled human-ecological pastoral systems hinder the development of appropriate adaptation strategies in the region.[31] The lack of in situ measurements of biophysical and socioeconomic variables and factors is cited as undermining not only a holistic diagnosis of the causes of ecosystem degradation, but also the development of strategies to cope with both climate change and socioeconomic factors. Gaps include (i) estimates of spatial and temporal climate variability, (ii) the potential impacts of permafrost and glacier melting, (iii) understanding of hydrological processes and recharge rates, and (iv) the impacts of mining on grassland ecosystem services and herder livelihoods.

Legal and Regulatory Framework

The legal and regulatory framework is not cohesive, and enforcement of grassland management plans and regulations is weak. Customary rules have also become less effective in regulating management. The Law on Prevention of Desertification and Soil Protection (2012) regulates responsibilities regarding desertification control and soil conservation and rehabilitation.[32] It also provides the legal basis for implementing (i) soil conservation practices for arable farming, (ii) new techniques for arresting sand movements and stabilizing soils in the desert and desert steppe, and (iii) measures to protect native dryland forests. A draft law on land that will include regulation of pastureland use is still being discussed.

[31] J. Qi, J. Chen, S. Wan, and L. Ai. 2012. Understanding the Coupled Natural and Human Systems in Dryland East Asia. *Environmental Research Letters.* 7 (1). http://iopscience.iop.org/1748-9326/7/1/015202/

[32] The law was adopted on 17 May 2012 and published on *The State Information No. 22* by the Secretariat of the Parliament.

Adaptation Actions and Their Contribution to Building Adaptive Capacity and Reducing Vulnerability

Appendix 1 contains an evaluation of 90 actions that are considered adaptive or contribute to adaptation based on climate change projections. These actions are derived from a literature review, herder surveys, and focus group discussions. They are mostly practical and/or technical, but also include planning and organizational and/or institutional actions, as these are crucial for coordination and budget allocation to implement integrated approaches and to facilitate participation of herders as the key resource users. The actions fall into five major areas: (i) pasture management, (ii) livestock management, (iii) ecosystems conservation and/or restoration, (iv) economic and/or livelihood development, and (v) mainstreaming of adaptation through strategic planning.

The evaluations are based on professional opinions, are qualitative (actions are ranked high, medium, or low for each criteria), and require further analysis. They should be considered a starting point and need to be followed by further stakeholder consultations. The adaptation actions were evaluated for effectiveness, cost, technical feasibility, cultural and/or traditional acceptance, adequacy for the current climate, and implementation speed.[33] As weightings of categories require stakeholder input, consultations are recommended as the next step. Additional steps should also include designating actions as "no regret," "low regret," "provides co-benefits," or "tailored specifically to projected climate change impacts." The main constraints and capacity development and technology support needs for each adaptation practice are in Appendix 2. Table 3 lists the most effective adaptation actions for each major area.

The adaptation practices listed in Table 3 were further evaluated for their contribution to building social, ecological, and environmental resilience and reducing vulnerability to extreme events in local pastoral communities. The results are shown in Table 4.

These evaluations are unweighted. Increases in incomes from diversification of livelihoods, for example, may be more effective than research in helping herders adapt. It is recommended that the rankings and methodology are used as a starting point by government and stakeholders in developing strategies and plans for *aimags* and *soums*.

[33] The underlying assumption is that these actions are needed and are appropriate for projected future climates.

Table 3: Most Effective Adaptation Actions for Each Major Area

Pasture
Management of movements (annual, seasonal, and emergency)
Strengthening of institutions and allocation and/or tenure of resources
Risk management and disaster preparedness
Livestock
Fodder and/or feed production
Herd management and herding practices
Dairy farming in suitable, peri-urban areas
Ecosystems
Water resources protection and/or management: wetlands, rivers, lakes, ponds, and *burd* (oases)
Ecosystem management and/or protection
Livelihoods
Diversification of income across sectors to increase resilience
Marketing
Mainstreaming Adaptation
Strategic planning, budgeting, and policy
Capacity building and research

Source: Project team.

Table 4: Evaluating Adaptation Practices for Their Contribution to Building Adaptive Capacity

Adaptation Practices	Adaptive Capacity to Slow Onset of Climate Change			
	Building Social Resilience	Building Ecological Resilience	Building Economic Resilience	Reducing Vulnerability to Extreme Events
Pasture				
Management of movements (annual, seasonal, and emergency)		x	x	x
Strengthening of institutions, collaboration, planning, and allocation and/or tenure of resources	x	x	x	x
Improvement of pasture water supply		x	x	x
Rodent control		x	x	
Management of pasture quality		x	x	x
Risk management and disaster preparedness	x	x	x	x
Livestock				
Improvement of livestock productivity and/or quality (breeding, health, nutrition)		x	x	x
Increase of fodder and/or feed production		x	x	x
Improvement of herd management and herding practices		x	x	x
Dairy farming in suitable, peri-urban areas		x	x	x
Ecosystems				
Agricultural land management		x	x	x
Water resources protection and/or management (riparian conservation and restoration, and protection of wetlands, lakes, ponds, and *burd* [oases])		x	x	x
Ecosystem management and/or protection		x	x	x
Water harvesting and conservation		x	x	x
Livelihoods				
Value addition to livestock products (diversification within sector) to increase resilience	x		x	x
Diversification of income across sectors to increase resilience	x		x	x
Marketing	x		x	
Mainstreaming Adaptation				
Strategic planning, budgeting, and policy	x	x	x	x
Capacity building and research	x	x	x	x

Source: Project team.

Conclusions and Recommendations

Mongolia faces numerous threats and challenges from climate change, and its herder population is highly vulnerable. The loss of mobility as a grassland management strategy and the weakening of institutions for the management of pastoral resources are still a key issue more than 2 decades after the transition to a market economy. The government has already identified many of the threats, and is taking a proactive approach to tackling them. Implementation of the country's NLP and new land use legislation will address many of the existing and potential issues.

Planned increases in financing from central government will enhance opportunities for cofinancing adaptation measures in pasture and livestock management from climate finance. The government is exploring opportunities through the Special Climate Change Fund of the Global Environment Facility, the Green Climate Fund, and potential carbon markets in grasslands.

The adaptation actions and practices suggested here are only a modest beginning. The government and stakeholders are urged to review the appendixes and modify them, as needed, for their strategies and plans.

Appendix 1

Evaluation of Adaptation Practices

	Adaptation Practices	Effectiveness	Cost	Technical Feasibility	Acceptance (Cultural and Traditional)	Ease of Implementation	Adequacy for Current Climate	Implementation Speed
A.	PASTURE							
i.	**Management of movements (annual, seasonal, emergency)**	**H**	**M–L**	**M**	**H**	**M**	**H**	**M**
1	Designate *otor* (long-distance migration) areas and/or common reserve and/or emergency reserve pasture	H	L	H	H	M	H	M
2	Plan and/or organize *otor* and/or long-distance movements—for rehabilitation of pasture, and in drought and/or *dzud* (extreme weather events)	H	M	M	H	M	H	H
3	Provide mobile government services in *otor* areas and in summer pastures	H	M	M	H	M	H	H
4	Promote inter-*soum* (district) and inter-*aimag* (province) cooperation to regulate *otor* movements and cross-boundary migrations and/or residence	H	L	M	H	M	H	M
ii.	**Strengthening of institutions and allocation and/or tenure of resources**	**H**	**M**	**M–H**	**H**	**M**	**H**	**M–H**
5	Strengthen herders' collective action institutions (traditional networks, pasture user groups, and other groups for natural resources management and/or conservation) through recognition and delineation of group pasture area	H	M	H	H	M	H	M
6	Provide community and/or group funds for risk management, credit for members, and joint investments in pasture management	H	H	H	H	H	H	H
7	Allocate possession certificates for winter and spring camps and/or pastures	H	M	H	H	M	H	H
8	Collect pasture use fees to reduce overgrazing	H	H	L	L	L	H	M
9	Develop *soum*-level comanagement procedures for pastureland management and monitoring	H	L	H	H	M	H	M
10	Prepare and implement pasture management plan by pasture user groups and at the *soum* level	H	H	M	H	M	H	H

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Appendix 1 Table *continued*

	Adaptation Practices	Effectiveness	Cost	Technical Feasibility	Acceptance (Cultural and Traditional)	Ease of Implementation	Adequacy for Current Climate	Implementation Speed
iii.	**Improvement of pasture water supply**	**M**	**M**	**M**	**M**	**M–H**	**H**	**M**
11	Construct deep-engineered wells in unused pastures[a]	M	H	M	H	M	H	M
12	Build hand-dug wells in unused pastures	M	L	H	H	M	H	H
13	Manage livestock access to streams, lakes, and ponds to prevent degradation and overextraction	H	L	M	M	H	H	H
14	Establish watering troughs off-site to prevent degradation of water points	M	H	L	M	L	H	H
iv.	**Rodent control**	**M**	**L**	**H**	**M**	**M–H**	**M–H**	**M–H**
15	Control rodents through protection and/or support of natural predators (e.g., install posts as perches for birds of prey to hunt rodents and protect predators, such as foxes)	M	L	H	M	H	H	H
16	Use manual control (e.g., traps)	M	L	H	M	M	M	M
v.	**Management of pasture quality**	**M–H**	**M**	**H**	**H**	**M–H**	**H**	**M**
17	Seed and/or reseed with native grasses and forbs (with fencing and/or livestock exclusion to allow establishment)	H	H	H	H	M	H	M
18	Rotate and rest pasture (summer and/or autumn)	H	M	H	H	H	H	H
19	Avoid grazing on steep slopes by small livestock to reduce degradation and increase resilience	H	L	H	L	M	H	M
20	Protect bushes and/or shrubs, forest understory (and riparian areas) for emergency grazing	L	L	H	H	H	H	M
vi.	**Risk management and disaster preparedness**	**H**	**M**	**M**	**M–H**	**M**	**H**	**M**
21	Produce accurate and timely forecasts (by National Agency for Meteorology and Environmental Monitoring and others): e.g., livestock early warning systems of weather, disasters, and livestock forage conditions	H	H	L	M	M	H	M
22	Develop information and communication technology for rural areas and/or herders[b]	H	M	M	H	M	H	M
23	Develop index-based livestock insurance to increase resilience	M	H	H	M	M	H	M
24	Prepare *soum* risk-management and contingency plans	H	L	H	H	M	H	M
B.	LIVESTOCK							
i.	**Livestock productivity and/or quality (breeding, health, nutrition)**	**M**	**M**		**H**	**M**	**H**	**M–H**

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Appendix 1 Table *continued*

	Adaptation Practices	Effectiveness	Cost	Technical Feasibility	Acceptance (Cultural and Traditional)	Ease of Implementation	Adequacy for Current Climate	Implementation Speed
25	Improve local breeds through establishing core stock of better-adapted animals (nucleus herd)	H	L		H	M	H	M
26	Increase the use of artificial insemination to develop more resistant or more productive species (e.g., highly productive dairy cattle in peri-urban areas)	M	H		M	L	M	M
27	Vaccinate to increase resilience	M	M		H	M	H	H
28	Monitor and treat infectious diseases to increase resilience	M	M		H	H	H	H
29	Treat for parasites (sheep dipping) to increase resilience	M	M		H	H	H	H
ii.	**Fodder and/or feed production**	**H**	**M–H**	**M–H**	**H**	**M**	**H**	**H**
30	Build hay and/or fodder storage facilities to reduce loss and increase resilience	H	H	H	H	H	H	H
31	Allocate hay fields to groups of households to increase resilience	M	L	H	H	M	H	H
32	Improve hay yield (by using drought-tolerant species, higher quality seed, organic fertilizer, irrigation)	H	H	M	H	M	H	H
33	Grow fodder (drought-tolerant species)	H	H	M	H	M	H	H
34	Grow maize (drought-tolerant species) for silage	H	H	L	M	M	H	H
35	Increase silage production from native species to increase resilience (dependent on ecological zone): *Urtica canabina*, *Chenopodium album*, *Allium polyrrhizum*, *Allium mongolicum*, and *Glycyrrhiza uralensis* (sweet grass) (unpalatable in early stages of maturity)	H	L	M	H	M	H	H
36	Produce supplementary feed and/or minerals (pressed blocks) to increase resilience	H	M	H	H	M	H	H
37	Buy supplemental fodder (oats and bran) to increase resilience	H	H	H	H	M	H	H
iii.	**Herd management and herding practices**	**H**	**M**	**H**	**M**	**M**	**H**	**M–H**
38	Adjust herd structure to establish traditional ratio of small to large livestock and decrease number of goats to reduce overgrazing	H	H	H	L	H	H	H
39	Sell or slaughter animals before winter to reduce losses from mortality and feeding costs	H	L	H	M	M	H	H
40	Slaughter animals at a younger age to reduce losses from mortality and feeding costs	M	L	H	L	M	H	H

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Appendix 1 Table *continued*

	Adaptation Practices	Effectiveness	Cost	Technical Feasibility	Acceptance (Cultural and Traditional)	Ease of Implementation	Adequacy for Current Climate	Implementation Speed
41	Establish local or mobile slaughterhouses and cold storage	H	H	M	H	L	H	M
42	Herd and/or manage livestock more actively to prevent grazing in riparian areas, wetlands, steep slopes, forest, and degraded grassland	H	L	H	M	H	H	H
43	"Mobgraze"—high density grazing whereby livestock is moved frequently, grazing small pasture areas, and leaving nearly 50% of forage[c]	H	M	M	L	L	H	M
44	Build livestock shelters in remote common reserve *otor* areas to increase resilience	H	M	H	H	H	H	H
iv.	**Dairy farming in suitable peri-urban areas**	**H**	**H**	**H**	**H**	**M**	**H**	**M**
45	Build warm livestock shelters (closed stables) for dairy cattle	H	H	H	H	M	H	M
46	Build milk storage facilities	H	H	H	H	M	H	M
C.	ECOSYSTEMS, AGRICULTURE, AND NATURAL RESOURCE USE							
i.	**Agricultural land management**	**M–H**	**M**	**M–H**	**M**	**M**	**H**	**M**
47	Increase cooperation among *aimag* and *soum* government officers in grassland and livestock management	H	L	H	M	M	H	H
48	Introduce sylvopastoralism: tree planting (elm, tamarisk, or sea-buckthorn); and possible intercropping with sweet grass, willow, or crop species (currants) depending on ecoregion in grazing areas, and shelterbelts (tree and/or bush planting around and/or along vegetable and fodder fields) to increase resilience	M	L	H	M	M	H	L
49	Stabilize sand and/or sand dunes: (i) square barriers and/or straw grids to prevent sand movement; planting shrubs and/or trees inside grid; (ii) grids and/or mechanical barriers with clay, netting, stones, and/or wood; planting shrubs on the lower one-third of sand dunes' windwardside to decrease wind velocity near the base of the dune to prevent sand from moving; (iii) higher velocity winds at the top of the dune level it off, and trees can be planted atop the flattened surface; (iv) planting grass and other plants in checkerboard patterns to prevent erosion; and (v) lignin sand stabilizing material—an innovative method used in the People's Republic of China[d]	M	M	H	M	M	H	H

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Appendix 1 Table *continued*

	Adaptation Practices	Effectiveness	Cost	Technical Feasibility	Acceptance (Cultural and Traditional)	Ease of Implementation	Adequacy for Current Climate	Implementation Speed
50	Use soil conservation techniques in cultivation, including contour plowing, grassland and/or crop strip rotation, and multi-crop rotation	M	L	H	M	H	H	H
51	Prevent erosion (e.g., using berms, vegetation planting) to increase resilience	M	L	H	L	H	H	H
52	Increase moisture retention capacity of soil (e.g., by mulching in vegetable and crop fields)	H	L	H	M	H	H	H
ii.	**Water resources protection and/or management: wetlands, rivers, lakes, ponds, and *burd* (oases)**	**H**	**M–H**	**H**	**M–H**	**M**	**H**	**M**
53	Protect and restore riparian areas	H	H	H	M	M	H	M
54	Manage access to water points to prevent degradation and overextraction	H	M	H	M	M	H	H
55	Establish and/or strengthen watershed administrations (government institutions) and watershed councils and sub-councils (civil society institutions)	H	M	H	H	M	H	L
56	Prepare and implement river basin and sub-basin management plans	H	H	M	H	M	H	L
iii.	**Ecosystem management and/or protection**	**M–H**	**M**	**M–H**	**M–H**	**M**	**H**	**M**
57	Enforce the existing *aimag* land use plan (e.g., mining licensing and rehabilitation of mining areas)	H	M	M	M	M	H	M
58	Manage forests and/or grasslands to reduce fire risk during droughts	H	M	M	H	M	H	M
59	Reduce ecosystem conversion and/or degradation to increase resilience	H	M	H	M	M	H	M
60	Establish and support user groups to plan and implement sustainable management	H	M	H	H	M	H	H
61	Introduce and promote fuel-efficient stoves and pressed fuels to reduce forest degradation and increase resilience	M	M	M	M	M	H	M
62	Protect and rehabilitate saxaul (*Haloxylon* sp.) forest (desert steppe) to stabilize sand and as camel forage	H	H	M	H	M	H	L
63	Designate local protected areas to increase resilience	M	M	H	M	M	H	M
64	Manage protected area system and biological corridors to retain capacity for ecosystem services and biodiversity given climate change projections	M	M	M	M	M	H	M
iv.	**Water harvesting and conservation**	**M**	**M–L**	**M**	**M**	**M**	**H**	**M–H**
65	Construct small-scale dams and reservoirs to manage water flows	M	M	L	H	M	H	M

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Appendix 1 Table *continued*

	Adaptation Practices	Effectiveness	Cost	Technical Feasibility	Acceptance (Cultural and Traditional)	Ease of Implementation	Adequacy for Current Climate	Implementation Speed
66	Trap and/or capture water for irrigation, watering livestock, increasing soil moisture, and household use	M	L	M	L	M	H	M
67	Collect snow for irrigation, watering livestock, increasing soil moisture, and household use	M	L	H	M	H	H	H
68	Irrigate during nighttime to reduce evaporation losses	M	M	M	M	H	H	H
69	Drip irrigate to reduce evaporation losses	M	M	M	M	M	H	H
70	Institute water conservation measures in urban areas and mining operations	H	M	M	L	M	H	M
D.	LIVELIHOODS							
i.	**Value addition to livestock products (diversification within sector) to increase resilience**	**M**	**M**	**M–L**	**H**	**M**	**H**	**M**
71	Establish herder groups and/or women's groups as small enterprises and/or cooperatives for processing and/or access to credit to develop and/or produce new products	H	L	H	H	M	H	H
72	Develop new cow and/or camel milk products	M	M	L	H	M	H	M
73	Develop new wool and fiber products (sheep, yak, camel)	M	M	L	H	M	H	M
74	Develop new meat products (processed, dried, canned)	M	M	L	H	M	H	M
ii.	**Diversification of income sources (across sectors)**	**M**	**M**	**M**	**H**	**M**	**H**	**M**
75	Encourage vegetable growing (using climate-resilient species)	H	M	H	H	H	H	H
76	Cultivate new crops such as bushes and/or berries (sea-buckthorn, currants, etc.)	H	M	M	H	M	H	M
77	Develop non-timber forest products	M	M	M	H	M	M	M
78	Promote sustainable tourism	L	M	M	H	L	H	M
79	Provide vocational training and employment in small- and medium-sized enterprises or industry	M	M	M	H	M	H	M
iii.	**Marketing**	**H**	**M**	**M**	**H**	**M**	**H**	**M**
80	Increase access to markets for products	H	M	M	M	M	H	M
81	Develop branding and certification (for international marketing)	M	H	M	H	L	H	L
82	Establish and/or strengthen cooperatives for marketing	H	M	M	H	M	H	M

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Appendix 1 Table *continued*

	Adaptation Practices	Effectiveness	Cost	Technical Feasibility	Acceptance (Cultural and Traditional)	Ease of Implementation	Adequacy for Current Climate	Implementation Speed
E.	MAINSTREAMING OF ADAPTATION							
i.	**Strategic planning, budgeting, and policy**	**M–H**	**L**	**H**	**H**	**M**	**H**	**M–H**
83	Prepare governors' action plans, *soum* development plans, and *soum* development strategies that mainstream adaptation	M	L	H	H	H	H	H
84	Establish needs-based budget planning for implementation of pasture management plan, livestock program activities, and adaptation practices—identify costs and provide budget from the *soum* development fund	M	L	H	H	H	H	H
85	Incorporate sustainable grassland management policy into new laws regulating land use	M	L	H	H	M	H	H
86	Enforce land use regulations to reduce degradation and loss of adaptive capacity	H	M	H	H	L	H	M
87	Generate additional funding for adaptation activities from climate finance and carbon markets, based on implementation of the Nationally Appropriate Mitigation Action that addresses grassland and livestock	M	L	H	H	M	H	M
ii.	**Capacity building and research**	**H**	**M**	**M**	**M**	**M**	**H**	**M**
88	Conduct further research on adaptation and mitigation, such as opportunities for changing feed to reduce livestock methane emissions that are feasible in Mongolia, and drought-resistant fodder species	H	M	M	H	M	H	M
89	Increase technical capacity to address climate change impacts	H	H	H	M	M	H	M
90	Increase community awareness regarding climate change impacts	H	M	M	M	L	H	L

Rankings: H = high, M = medium, L = low.

[a] This should be done with proper prior assessment, monitoring of recharge, and management structures in place.

[b] E.g., local FM repeater and radios, cell phone coverage and/or capacity, and alerts of forecasts, TV stations, internet access.

[c] The rationale for "mobgrazing" (also called managed intensive rotational grazing) is that trampling by a high-density herd improves the soil as it transfers organic matter into the ground. The grazed sections then need a long rest period. The method is used in many parts of the world, including Australia and the United States. It requires very intensive planning and very active herd management. This is especially suitable for smaller, limited grazing land areas.

[d] Lignin is extracted from the black liquor of straw paper mills. The new material is called sand stabilizing lignin and is proving effective, economic, environmental, and plant-friendly in fugitive dune fixation. It can be used with forest and/or grass planting simultaneously. This technique not only creates a new method for desertification control but also reduces water contamination. It is most feasible where lignin is produced as a by-product (described in H. Wang, D. Dagvadorj, and A. Pitman. 2005. *The Degraded Ecosystem Restoration in the Arid and Semi-Arid Northern [the People's Republic of] China-Mongolia Region*. Final report for APN project 2005-23-NSY-Wang. Asia-Pacific Network for Global Change Research).

Source: Project team.

Appendix 2

Adaptation Practices: Constraints, Capacity Development, and Technology Support Needs

A.	**PASTURE**
i.	**Management of movements (annual, seasonal, emergency)**
1	**Designate *otor* and/or common reserve pasture and/or emergency reserve pasture** 1. Main constraints • Insufficient areas to set aside that are appropriate (e.g., have pasture water supplies) to meet level of demand • Legal and regulatory issues with respect to land use 2. Capacity development needs (a) Technical and/or institutional • Pastureland use planning and management • Enforcement of land use regulations (b) Community level • Pastureland planning and management • Information on *otor* areas and regulations on inter-*aimag* (provincial administrative unit) and/or inter-*soum* (rural administrative and territorial unit) migrations 3. Technology and infrastructure needs • Pasture water supply and/or wells • Hay and/or fodder storage • Livestock shelters • ICT • GPS, GIS, and/or surveying equipment to establish boundaries
2	**Organize *otor* and/or long-distance movements (for rehabilitation of pasture, and in drought and/or *dzud*)** 1. Main constraints • Insufficient areas set aside that are appropriate (e.g., have pasture water supplies) to meet level of demand • Legal and regulatory issues with respect to land use • Lack of communication and information 2. Capacity development needs (a) Technical and/or institutional • Pastureland use planning and management • Enforcement of land use regulations (b) Community level • Pastureland use planning and management • Increased awareness on need to move to *otor* areas and for rotational use in summer pastures • Information on *otor* areas and regulations on inter-*aimag* and/or inter-*soum* migrations

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Appendix 2 Table *continued*

	3. Technology and infrastructure needs • Pasture water supply and/or wells • Hay and/or fodder storage • Livestock shelters • ICT
3	**Provide mobile government services in *otor* areas and remote summer pastures** 1. Main constraints • Lack of funding • Insufficient staff with appropriate skills • Lack of communication 2. Capacity development needs (a) Technical and/or institutional • Extension/outreach skills (b) Community level • Awareness of potential extension services and increased access 3. Technology and infrastructure needs • Transport, mobile facilities • ICT
4	**Promote inter-*aimag* and inter-*soum* cooperation to regulate *otor* movements and cross-*aimag* and/or cross-*soum* boundary migrations and/or residence** 1. Main constraints • No clear mandate and procedures for cooperation • Herders unclear about regulations 2. Capacity development needs (a) Technical and/or institutional • Clarification of roles and responsibilities • Develop cooperation procedures (b) Community level • Information on *otor* areas and regulations on inter-*aimag* and/or inter-*soum* migrations 3. Technology needs • ICT
ii.	**Strengthening of institutions and allocation and/or tenure of resources**
5	**Strengthen herders' collective action institutions (traditional networks, pasture user groups, and other groups for natural resource management and/or conservation) through recognition and delineation of pasture area** 1. Main constraints • Lack of clear regulations regarding pasture use and role of herder collectives • Reluctance of local government to conclude contracts with herder collectives • Lack of organization skills among herders • Cultural barriers to forming non-kin groups 2. Capacity development needs (a) Technical and/or institutional • Legal framework and regulations

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Appendix 2 Table *continued*

	(b) Community level • Organizational development and management skills 3. Technology needs • ICT
6	**Provide community/group funds for risk management, credit for members, and joint investments in pasture management** 1. Main constraints • Lack of clear regulations regarding herder collectives' rights and pasture ownership • Reluctance of local government to conclude contracts with herder collectives • Lack of organization skills among herders • Cultural barriers to forming non-kin groups • Reluctance of formal banking sector to provide funding 2. Capacity development needs (a) Technical and/or institutional • Legal framework and regulations (b) Community level • Organizational development and management skills • Basic financial skills 3. Technology needs • ICT, including mobile banking
7	**Allocate possession certificates for winter and spring camps and/or pastures** 1. Main constraints • Competition for scarce appropriate pasture • Inequity in access to local government • Lack of clear regulations regarding herder collectives' rights and pasture ownership • Reluctance of local government to conclude contracts with herder collectives • Cultural barriers to forming non-kin groups 2. Capacity development needs (a) Technical and/or institutional • Training legal and/or regulatory framework • Awareness raising on need for equitable access to key resources (b) Community level • Legal information on rights, procedures, and options 3. Technology needs • ICT • GPS, GIS, and surveying equipment to establish boundaries
8	**Collect pasture use fees to reduce overgrazing** 1. Main constraints • No consensus on fee system or enforcement • No legal basis 2. Capacity development needs (a) Technical and/or institutional • Consultations and/or discussions and analysis of lessons learned from other countries • Legal framework and regulations

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Appendix 2 Table *continued*

	(b) Community level • Consultations and/or discussions 3. Technology needs • ICT • Pasture monitoring equipment
9	**Introduce *soum*-level comanagement institutions and/or procedures for pastureland management and monitoring** 1. Main constraints • Requires functioning herders' institutions as prerequisite • Comanagement not required by legal framework • Insufficient funding to hold meetings 2. Capacity development needs (a) Technical and/or institutional • Legal framework and regulations, and procedures for comanagement (b) Community level • Organizational development 3. Technology needs • ICT
10	**Prepare and implement pasture management plans by pasture user groups and at the *soum* level** 1. Main constraints • Lack of clear legal rights for pasture user groups • Lack of clear regulations regarding pasture use • Lack of inclusive and/or participatory decision making in designing pasture use plans • Lack of funding to implement pasture management measures (e.g., seeds, fencing, water supplies) • Insufficient understanding of ecological processes and calculations of carrying capacity • Lack of enforcement of existing pasture regulations 2. Capacity development needs (a) Technical and/or institutional • Legal framework and regulations • Training in planning and community participation • Training in sustainable pasture management, including calculating carrying capacities, and monitoring • Enforcement of existing pasture regulations (b) Community level • Training in organizational development and collaborative management • Training in sustainable pasture management and monitoring 3. Technology and infrastructure needs • ICT • GIS and GPS to delineate pasture uses • Equipment (e.g., to dig wells)
iii.	**Improvement of pasture water supply**
11	**Construct deep-engineered wells in unused pastures**[a] 1. Main constraints • Lack of financial sources • Weaknesses in defined responsibilities, skills, and funds for well maintenance

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Appendix 2 Table *continued*

2. Capacity development needs
   (a) Technical and/or institutional
      - Legal framework and regulations
   (b) Community level
      - Training in well maintenance
3. Technology and infrastructure needs
   - Heavy equipment
   - Well-testing equipment

12 **Build hand-dug wells in unused pastures**

1. Main constraints
   - Lack of financial sources to identify underground water locations
   - Adequate water quality
   - Weaknesses in defined responsibilities, skills, and funds for well maintenance
2. Capacity development needs
   (a) Technical and/or institutional
      - Legal framework and regulations
   (b) Community level
      - Training in construction and maintenance of well
3. Technology and infrastructure needs
   - Well-testing equipment

13 **Manage livestock access to streams, lakes, and ponds to prevent degradation and overextraction**

1. Main constraints
   - Lack of knowledge regarding active livestock management
   - Changes in herding practices, such as motorized (motorcycle) herding
   - Lack of sufficient labor given herd size
2. Capacity development needs
   (a) Technical and/or institutional
      - Training extension officers in active livestock management
   (b) Community level
      - Awareness raising and training in active livestock management and sustainable pasture and water management
3. Technology needs
   - Not applicable

14 **Establish watering troughs off-site to prevent degradation of water points**

1. Main constraints
   - Lack of funding
   - Insufficient water sources and quantity to meet demand
2. Capacity development needs
   (a) Technical and/or institutional
      - Training in construction techniques
   (b) Community level
      - Training in construction techniques and riparian ecology and restoration
3. Technology needs
   - Solar-powered water pumps

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Appendix 2 Table *continued*

iv.	**Rodent control**
15	**Control rodents through protection and/or support of natural predators (e.g., install posts as perches for birds of prey to hunt rodents, and protect predators such as foxes)** 1. Main constraints • Lack of knowledge and/or awareness • Predators are hunted 2. Capacity development needs (a) Technical and/or institutional • Training in predator and/or prey species ecology • Develop and enforce conservation regulations (b) Community level • Training in predator and/or prey species ecology and conservation regulations 3. Technology needs • Not applicable
16	**Use manual control (e.g., traps)** 1. Main constraints • Lack of knowledge and/or awareness • Labor intensive 2. Capacity development needs (a) Technical and/or institutional • Training in trap construction (b) Community level • training in trap construction 3. Technology needs • Not applicable
v.	**Management of pasture quality**
17	**Seed and/or reseed with native grasses and forbs (with fencing and/or livestock exclusion to allow establishment)** (*Agropyron cristatum*, *Allium* species, *Astragalus adsurgens*, *Bromus inermis, Elymus dahuricus, Elymus gmelini, Elymus sibiricus, Festuca lenensis, Hordeum bogdanii, Medicago falcata, Poa pratensis, Polygonum divaricatum, Psathyrostachys juncea, Puccinellia marcranthera, Puccinellia tenuiflora, Stipa capillata*, and *Stipa krylovii* have been identified as the species with the highest potential.)[b] 1. Main constraints • Access to seeds for herders • Maintenance of seed banks • Ability to protect and/or fence for recovery 2. Capacity development needs (a) Technical and/or institutional • Skills and knowledge in seed banks and land rehabilitation techniques (b) Community level • Skills and knowledge in land rehabilitation techniques 3. Technology needs • Not applicable

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Appendix 2 Table *continued*

18 **Rotate and rest pasture (summer and/or autumn)**

1. Main constraints
   - Insufficient areas available that are appropriate (e.g., have pasture water supplies) to meet level of demand
   - Legal and regulatory issues with respect to land use
   - Lack of communication and/or coordination
   - Weaknesses in developing, implementing, and monitoring pastureland management plans
   - Weaknesses in enforcement of pastureland management plans
   - Insufficient funds available to improve services and implement pastureland management plans
2. Capacity development needs
   (a) Technical and/or institutional
   - Training of *soum* land officers in pastureland use planning and monitoring
   - Legal framework and regulations
   - Enforcement of pastureland management plans

   (b) Community level and/or resource users
   - Training in pastureland ecology, management, and monitoring
   - Organizing and strengthening herder groups for pastureland management
3. Technology needs
   - ICT

19 **Avoid grazing on steep slopes by small livestock to reduce degradation and increase resilience**

1. Main constraints
   - Weak planning and enforcement
   - Poor herding practices
   - Lack of sufficient labor given herd size
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in pasture management and soil conservation and/or erosion control

   (b) Community level
   - Training in pasture management and soil conservation and/or erosion control
3. Technology needs
   - Not applicable

20 **Protect bushes/shrubs and forest understory (and riparian areas) for emergency grazing**

1. Main constraints
   - Lack of knowledge regarding active livestock management
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in livestock management and ecology (forest, riparian)

   (b) Community level
   - Training in livestock management and ecology (general, forest, riparian)
3. Technology and infrastructure needs
   - Fencing

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Appendix 2 Table *continued*

vi.	**Risk management and disaster preparedness**
21	**Produce accurate and timely forecasts produced by NAMEM and others (e.g., LEWS) regarding weather, disaster, and livestock forage conditions** 1. Main constraints • Insufficient weather and pasture monitoring stations for forecasting • Insufficient access to weather and pasture forecasts (weak FM radio coverage) 2. Capacity development needs (a) Technical and/or institutional • Technical training in LEWS (b) Community level • Awareness of forecast availability 3. Technology needs • ICT • FM repeaters for *soums* • Expansion of monitoring stations (e.g., LEWS) • Upgrade of *soum* meteorological equipment, as needed
22	**Develop information and communication technology for rural areas and/or herders** 1. Main constraints • Lack of funding • Lack of cell phone towers • Insufficient electrical power • Insufficient access to electrical power 2. Capacity development needs (a) Technical and/or institutional • Training in ICT (b) Community level • Training in ICT 3. Technology and infrastructure needs • FM radios and FM repeaters • Cell phone towers and repeaters • Solar and/or wind power systems
23	**Develop index-based livestock insurance** 1. Main constraints • Lack of knowledge and/or awareness 2. Capacity development needs (a) Technical and/or institutional • Training on concept and/or implementation of IBLI (b) Community level • Awareness raising and promoting and/or piloting group-based IBLI 3. Technology needs • IT

continued on next page

Appendix 2 Table *continued*

24 **Prepare *soum* risk management and contingency plans**

1. Main constraints
   - Lack of information
   - *Otor* areas not available
   - Insufficient facilities
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in risk management planning

   (b) Community level
   - Training in risk management planning
3. Technology needs
   - ICT, LEWS, and weather forecast/outreach capability

B. LIVESTOCK

i. Livestock productivity and/or quality (breeding, health, nutrition)

25 **Improve local breeds through establishing core stock of better-adapted animals (nucleus herd)**

1. Main constraints
   - Lack of knowledge regarding breeding and/or selection
   - Lack of information
   - Lack of transport to bring and/or exchange breeding stock
2. Capacity development needs
   (a) Technical and/or institutional
   - Livestock unit—training on breeding and/or selection

   (b) Community level
   - Training on breeding and/or selection, and record keeping
3. Technology and infrastructure needs
   - ICT
   - Transport (e.g., vehicles, roads, railway)

26 **Introduce artificial insemination and "speeding adaptation" to develop more resistant or more productive species**

1. Main constraints
   - Lack of knowledge regarding breeding and/or selection
   - Lack of information
   - Lack of funding
   - Lack of transport to bring and/or exchange breeding stock
2. Capacity development needs
   (a) Technical and/or institutional
   - Livestock unit—training on breeding and/or selection

   (b) Community level
   - Awareness raising and information
3. Technology and infrastructure needs
   - Breeding stations and equipment
   - Transport (e.g., vehicles, roads, railway)

27 **Vaccinate to increase resilience**

1. Main constraints
   - Shortages of high-quality vaccines
   - Lack of funding
   - Transport difficulties

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Appendix 2 Table *continued*

	2. Capacity development needs (a) Technical and/or institutional • Training/continuing education of veterinarians and vet technicians (b) Community level • Awareness raising and training in giving vaccinations 3. Technology and infrastructure needs • Transport (e.g., vehicles, roads, railway) • Veterinary equipment (mobile)
28	**Monitor and treat infectious diseases to increase resilience** 1. Main constraints • Lack of knowledge and awareness • Lack of laboratory facilities in rural areas • Transport difficulties 2. Capacity development needs (a) Technical and/or institutional • Training livestock unit in livestock health care and management of infectious diseases (b) Community level • Training in livestock health care and awareness raising 3. Technology needs • Diagnostics equipment at *soum* level • Transport (e.g., vehicles, roads, railway)
29	**Treat for parasites to increase resilience** 1. Main constraints • Lack of knowledge and awareness • Lack of laboratory facilities in rural areas • Transport difficulties 2. Capacity development needs (a) Technical and/or institutional • Training livestock unit in livestock health care and management of parasitic diseases (b) Community level • Training in livestock health care, awareness raising 3. Technology needs • Simple diagnostic equipment • Transport (e.g., vehicles, roads, railway)
ii.	**Fodder and/or feed production**
30	**Build hay and/or fodder storage facilities to reduce loss and increase resilience** 1. Main constraints • Insufficient access to storage facilities • Lack of funding 2. Capacity development needs (a) Technical and/or institutional • Budget preparation (b) Community level • Training in construction 3. Technology and infrastructure needs • Large-scale storage facilities

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Appendix 2 Table *continued*

31 **Allocate hay fields to groups of households to increase resilience**

1. Main constraints
   - Insufficient hay fields given level of demand
   - Conflicts between users
   - Inequity in access to local government
   - Lack of clear regulations regarding herder access rights
   - Weak herder groups
2. Capacity development needs
   (a) Technical/institutional
   - Training in annual pastureland management planning

   (b) Community level
   - Training and/or support to institutions and/or collective action
3. Technology needs
   - Maps, GPS, and ICT

32 **Improve hay yield (drought-tolerant species, higher-quality seed, organic fertilizing, irrigation)**

1. Main constraints
   - Lack of funding for inputs and supplies
   - Lack of knowledge and/or skills regarding organic fertilizing, seeding, and irrigation techniques
   - Lack of access to drought-tolerant species and high-quality seeds
2. Capacity development needs
   (a) Technical and/or institutional
   - Training of extension officers in best practices in hayfield improvement

   (b) Community level
   - Training and/or experience sharing on best practices in hayfield improvement
   - Seed collection and growing of perennials
3. Technology needs
   - Not applicable

33 **Grow fodder (drought-tolerant species, e.g., Siberian wild rye)**

1. Main constraints
   - Soil and climate unfavorable in higher elevations and drylands
   - Lack of funding for inputs and supplies
   - Lack of access to drought-tolerant species and high-quality seeds
   - Lack of equipment for soil preparation
   - Lack of skills and knowledge regarding soil and water conservation techniques, and crop cultivation
   - Lack of extension services
   - Labor intensive
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in soil and water conservation techniques and crop cultivation
   - Seed banks for drought-tolerant and high-quality seed

   (b) Community level
   - Training in soil and water conservation techniques and crop cultivation
3. Technology and infrastructure needs
   - Heavy equipment
   - Storage facilities

continued on next page

Appendix 2 Table *continued*

34 **Grow maize (drought-tolerant species) for silage**

1. Main constraints
   - Unfavorable soil and climate, depending on ecological zone and/or altitude
   - Lack of funding for inputs and supplies
   - Lack of skills and knowledge regarding crop cultivation
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in crop cultivation and processing

   (b) Community level
   - Training in crop cultivation and processing
3. Technology and infrastructure needs
   - Storage facilities

35 **Increase silage production from native species to increase resilience (dependent on ecological zone): *Urtica canabina, Chenopodium album, Allium polyrrhizum, Allium mongolicum, and Glycyrrhiza uralensis* (sweet grass) (unpalatable in early stages of maturity)**

1. Main constraints
   - Lack of knowledge and skills regarding crop cultivation
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in crop cultivation

   (b) Community level
   - Training in crop cultivation
3. Technology needs
   - Storage and/or silage facility

36 **Produce supplementary feed and/or minerals (pressed blocks) to increase resilience**

1. Main constraints
   - Lack of funding for inputs (feed, vitamins, minerals) and supplies
   - Lack of access to equipment
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in animal nutrition

   (b) Community level
   - Training in animal nutrition and on equipment required
3. Technology needs
   - Hand or mechanized presses

37 **Buy supplemental fodder (oats and bran) to increase resilience**

1. Main constraints
   - High price of fodder
   - Shortage of fodder (large mill selling fodder out of country)
   - Transport issues
2. Capacity development needs
   (a) Technical and/or institutional
   - Not applicable

   (b) Community level
   - Information on market prices
   - Cooperation for bulk purchases

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Appendix 2 Table *continued*

	3. Technology and infrastructure needs • Storage facilities • Transport (e.g., vehicles, roads, railway)
iii.	**Herd management and herding practices**
38	**Adjust herd structure to establish traditional ratio of small to large livestock and decrease number of goats to reduce overgrazing** 1. Main constraints • Maintaining income levels (loss of wool, cashmere, and other products) • Low diversification of products • Cultural—status is correlated with number of livestock • Lack of livestock insurance • Weak enforcement of stocking rate adherence to carrying capacity • Unclear regulations 2. Capacity development needs (a) Technical and/or institutional • Legal framework and regulations • Enforce regulations (b) Community level • Training in sustainable land use, carrying capacity, value addition, diversification, and marketing • Awareness of livestock insurance options 3. Technology needs • Not applicable
39	**Sell or slaughter animals before winter to reduce losses from mortality and feeding costs** 1. Main constraints • Lack of local slaughterhouses • Transport issues 2. Capacity development needs (a) Technical and/or institutional • Training on sanitary regulations and registration of animals (b) Community level • Training on sanitary regulations and registration of animals 3. Technology and infrastructure needs • Slaughterhouses • Transport (e.g., vehicles, roads, railway)
40	**Slaughter animals at younger age to reduce losses from mortality and feeding costs** 1. Main constraints • Not a traditional practice • Lack of local slaughterhouses • Lack of transport 2. Capacity development needs (a) Technical and/or institutional • Training livestock unit officers in herd management (b) Community level • Training in herd management 3. Technology needs • Slaughterhouses • Transport (e.g., vehicles, roads, railway)

continued on next page

Appendix 2 Table *continued*

41 **Establish local or mobile slaughterhouses and cold storage**

1. Main constraints
   - Lack of funding
   - Lack of access to technological advances
   - Transport issues
2. Capacity development needs
   (a) Technical and/or institutional
   - training in new technology and sanitary regulations

   (b) Community level
   - Training in new technology and sanitary regulations
3. Technology and Infrastructure needs
   - Cold storage and slaughterhouses
   - Transport (e.g., vehicles, roads, railway)

42 **More active herding and/or managing of livestock (to prevent grazing in riparian areas, wetlands, steep slopes, forest)**

1. Main constraints
   - Lack of knowledge regarding active livestock management
   - Changes in herding practices, such as motorized (motorcycle) herding
   - Lack of sufficient labor given herd size
2. Capacity development needs
   (a) Technical and/or institutional
   - Training extension officers in active livestock management

   (b) Community level
   - Awareness raising and training in active livestock management and sustainable pasture and water management
3. Technology needs
   - Not applicable

43 **"Mobgraze"—high-density grazing whereby livestock is moved frequently, grazing small pasture areas, and leaving nearly 50% of forage**[d]

1. Main constraints
   - Approach largely untested in Mongolia (although aspects are incorporated in traditional practice)
   - Requires intensive herding and detailed planning and implementation
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in method

   (b) Community level
   - Training in method
3. Technology needs
   - Not applicable

44 **Livestock shelters in remote common reserve pasture (*otor*) areas to increase resilience**

1. Main constraints
   - Lack of cooperation among herders
   - Lack of funding
2. Capacity development needs
   (a) Technical and/or institutional
   - Coordination and/or allocation of shelter to households and/or groups

continued on next page

Appendix 2 Table *continued*

	(b) Community level • Information and/or training on regulations 3. Technology and infrastructure needs • Livestock shelters
iv.	**Dairy farming in suitable peri-urban areas**
45	**Build warm livestock shelters (closed stables) for dairy cattle** 1. Main constraints • Lack of tenure security to invest in land and infrastructure • High costs for investments (exotic cattle, warm sheds, well, fodder production) • Lack of knowledge and/or skills • Lack of access to credit 2. Capacity development needs (a) Technical and/or institutional • Training in dairy farming (b) Community level • Training in all aspects of dairy farming, fodder, and/or silage 3. Technology and infrastructure needs • Warm livestock shelters
46	**Build milk storage facilities** 1. Main constraints • Lack of tenure security to invest in land and infrastructure • High construction and maintenance costs • Lack of knowledge and/or skills • Lack of access to credit 2. Capacity development needs (a) Technical and/or institutional • Training in sanitation (b) Community level • Training in sanitation 3. Technology and infrastructure needs • Cold storage facilities for milk and milk products
C.	**ECOSYSTEMS, AGRICULTURE, AND NATURAL RESOURCE USE**
i.	**Agricultural land management**
47	**Increase cooperation of *aimag* and *soum* government officers in grassland and livestock management "environmental units"** 1. Main constraints • Few *aimags* have issued resolutions to formalize environmental units • Lack of facility and/or equipment and/or space for the units 2. Capacity development needs (a) Technical and/or institutional • Integrated, ecosystem-based approaches • Procedures for cooperation (b) Community level • Training and/or awareness raising on responsibilities of *aimag* and/or *soum* government officers and the service they offer

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Appendix 2 Table *continued*

	3. Technology and infrastructure needs • ICT and/or office equipment • Facilities
48	**Introduce sylvopastoral practices: tree planting (poplar, elm, tamarisk, or sea-buckthorn), and possible intercropping with sweet grass, willow, or crop species (currants) depending on ecoregion in grazing areas, and shelterbelts (tree and/or bush planting around and/or along vegetable and fodder fields) to increase resilience** 1. Main constraints • Insufficient water for seedling growth • Labor intensive • Lack of knowledge and skill on proper planting technique and intercropping • Lack of access to seedlings • Lack of protection of seedlings and saplings 2. Capacity development needs (a) Technical and/or institutional • Training in sylvopastoral practices (b) Community level • Training in sylvopastoral practices 3. Technology and infrastructure needs • Irrigation (appropriate technology)
49	**Stabilize sand/sand dunes: (i) square barriers and/or straw grids to prevent sand movement, planting shrubs and/or trees inside grid; (ii) grids and/or mechanical barriers with clay, netting, stones, wood; planting shrubs on the lower one-third of sand dunes' windward side to decrease wind velocity near the base of the dune to prevent sand from moving; (iii) higher velocity winds at the top of the dune level it off, and trees can be planted atop the flattened surface; (iv) planting grass and other plants in checkerboard patterns to prevent erosion; and (v) lignin sand stabilizing material, an innovative method used in the People's Republic of China.**[c] 1. Main constraints • Little information available regarding techniques • Lack of access to inputs (e.g., straw, lignin) 2. Capacity development needs (a) Technical and/or institutional • Training in sand and/or sand dune stabilization (b) Community level • Training in sand and/or sand dune stabilization 3. Technology and infrastructure needs • Equipment to make straw grids and extract lignin
50	**Use soil conservation techniques in cultivation, including contour plowing, grassland and/or crop strip rotation, and multicrop rotation** 1. Main constraints • Low knowledge and/or skill levels • Lack of concern regarding environmental impacts • Unclear legal framework • Lack of enforcement of soil conservation 2. Capacity development needs (a) Technical and/or institutional • Training in soil conservation measures

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Appendix 2 Table *continued*

	(b) Community level • Training in soil conservation measures 3. Technology needs • Heavy equipment
51	**Prevent erosion (e.g., berms, vegetation planting) to increase resilience** 1. Main constraints • Low knowledge and/or skill levels • Lack of concern regarding environmental impacts • Unclear legal framework • Lack of enforcement of soil conservation 2. Capacity development needs (a) Technical and/or institutional • Training in soil conservation measures (b) Community level • Training in soil conservation measures 3. Technology needs • Not applicable
52	**Increase moisture retention capacity of soil (e.g., mulching in vegetable and crop fields, cultivation under plastic film and/or sheets)** 1. Main constraints • Lack of knowledge and awareness • Lack of access to materials • Lack of funding for inputs and supplies 2. Capacity development needs (a) Technical and/or institutional • Training in soil moisture retention (b) Community level • Training in soil moisture retention 3. Technology and infrastructure needs • Technologically appropriate irrigation
ii.	**Water resources protection and/or management** **(riparian conservation and restoration and protection of wetlands, lakes, ponds, and/or *burd* [oases])**
53	**Protect and restore riparian areas** 1. Main constraints • Lack of funding for inputs and supplies (e.g., temporary fencing) • Low levels of knowledge regarding stream functions • Insufficient water supplies and overuse of resource • Lack of enforcement of water and/or land use regulations 2. Capacity development needs (a) Technical and/or institutional • Training in riparian ecology and restoration techniques • Enforcement of land use regulations

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Appendix 2 Table *continued*

(b) Community level
- Training in riparian ecology and restoration techniques
- Training in water and/or land use regulations

3. Technology and infrastructure needs
- Temporary fencing

54 **Manage access to water points to prevent degradation and overextraction**

1. Main constraints
- Lack of funding for inputs and supplies (e.g., temporary fencing)
- Insufficient water supplies to meet demand
- Weak management and poor collaboration
- Lack of enforcement of water and/or land use regulations

2. Capacity development needs

(a) Technical and/or institutional
- Training in wetland ecology and/or management, and pastureland management planning
- Enforcement of water and/or land use regulations

(b) Community level
- Training in wetland ecology and/or management, and pastureland management planning

3. Technology and infrastructure needs
- Temporary fencing

55 **Establish and/or strengthen watershed administrations (government institutions) and watershed councils and subcouncils (civil society institutions)**

1. Main constraints
- Legislation (water law, national water program) is relatively new, and details of administrative structure and/or mandate are not regulated
- Administrations are being established, and most details of collaboration between administrations and councils are not defined
- Few existing and/or functioning councils
- Little or no budget allocation and/or funding for councils' work

2. Capacity development needs

(a) Technical and/or institutional
- Training in water basin management

(b) Community level
- Training in water basin management, and organizational development and/or management

3. Technology needs
- ICT

56 **Prepare and implement river basin and sub-basin management plans**

1. Main constraints
- Legislation (water law, national water program) is relatively new, and there is a lack of clarity regarding regulations
- Lack of funding to develop plans or implement management measures
- Insufficient understanding of ecological processes and calculations of recharge rates
- Lack of data

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Appendix 2 Table *continued*

	2. Capacity development needs (a) Technical/institutional • Training in river basin management and management planning (b) Community level • Training in river basin management and management planning 3. Technology needs • ICT
iii.	**Ecosystem management and/or protection**
57	**Enforce the existing *aimag* land use plan (e.g., mining licensing, rehabilitation of mining areas)** 1. Main constraints • Lack of transparency • Lack of enforcement of environmental impact assessment procedures 2. Capacity development needs (a) Technical and/or institutional • Training on legal framework, regulations, planning, and enforcement (b) Community level • Training and/or information on legal framework, and information on planning processes 3. Technology needs • IT and GIS
58	**Manage forests and/or grasslands to reduce fire risk during droughts** 1. Main constraints • Weak local cooperation • Poor enforcement of regulations and land use plans • Lack of knowledge regarding fire prevention 2. Capacity development needs (a) Technical and/or institutional • Training in fire prevention (b) Community level • Training in fire prevention 3. Technology needs • Firefighting equipment
59	**Reduce ecosystem conversion and/or degradation to increase resilience** 1. Main constraints • Poor enforcement of regulations and land use plans • Insufficient quality land available • Lack of alternate heat source 2. Capacity development needs (a) Technical and/or institutional • Training in enforcement and land use planning (b) Community level • Training in enforcement and land use planning • Develop fuel wood alternatives 3. Technology needs • Not applicable

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Appendix 2 Table *continued*

60 **Establish and support user groups to plan and implement sustainable management**

1. Main constraints
   - Institutional weakness
   - Lack of extension support
   - Lack of skills and knowledge
   - Weak enforcement
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in sustainable land management

   (b) Community level
   - Training in sustainable land management and ecology
   - Training in organizational development principles
3. Technology needs
   - Survey and/or inventory equipment, mapping, GIS, and GPS, etc.
   - ICT

61 **Encourage uptake of fuel-efficient stoves and pressed fuels to reduce forest degradation and increase resilience**

1. Main constraints
   - Lack of access to and/or availability of more fuel-efficient stoves
   - Lack of funding for more fuel-efficient stoves
2. Capacity development needs
   (a) Technical and/or institutional
   - Research institutions and/or manufacturers to develop appropriate technology

   (b) Community level
   - Information on fuel efficiency and available products
3. Technology and infrastructure needs
   - Small- and/or medium-scale production equipment

62 **Protect and rehabilitate saxaul (*Haloxylon sp.*) forest (desert steppe) to stabilize sand and as camel forage**

1. Main constraints
   - Weak local cooperation
   - Poor enforcement of regulations and land use plans
   - Lack of knowledge regarding rehabilitation methods
2. Capacity development needs
   (a) Technical and/or institutional
   - Training on saxaul ecology, protection, and regeneration

   (b) Community level
   - Training in seedling cultivation and protection
3. Technology needs
   - Not applicable

63 **Designate local protected areas to increase resilience**

1. Main constraints
   - Building local consensus
   - Perceived insufficient land resources
   - Lack of funding for establishment and maintenance

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Appendix 2 Table *continued*

	2. Capacity development needs (a) Technical and/or institutional • Training—ecology and management planning local government officers (b) Community level • Training—ecology and management planning 3. Technology needs • Survey equipment, GIS, GPS • ICT
64	**Manage protected areas system and biological corridors to retain capacity for ecosystem services and biodiversity given climate change projections** 1. Main constraints • Insufficient areas available that are appropriate for biological corridors • Weaknesses in developing, implementing, and monitoring protected area management plan • Weaknesses in enforcement of the protected area management plan • Insufficient funds available to implement the protected area management plan • Insufficient ecological data 2. Capacity development needs (a) Technical and/or institutional • Training in protected area use planning and monitoring, and ecological data collection • Enforcement of the protected area management plan (b) Community level and/or resource users • Awareness of protected area regulations and allowable use 3. Technology needs • ICT
iv.	**Water harvesting and conservation**
65	**Construct small-scale dams and reservoirs to manage water flows** 1. Main constraints • Few functioning models and/or practices in-country for harvesting and managing seasonal and glacial runoff from highlands • Lack of knowledge among resource users 2. Capacity development needs (a) Technical and/or institutional • Training in design and construction and/or management of dams and/or reservoirs among professional organizations (b) Community level • Training in small-scale design and construction and/or management by professional organizations 3. Technology needs • Construction equipment • Computer models • ICT
66	**Trap and/or capture water for irrigation, watering livestock, increasing soil moisture, and household use (contour lines and/or stone dams on sloped land, shallow ditch patterns)** 1. Main constraints • Lack of knowledge among resource users

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Appendix 2 Table *continued*

2. Capacity development needs
   (a) Technical and/or institutional
      - Training in water harvesting
   (b) Community level
      - Training in water harvesting
3. Technology needs
   - Machinery and/or equipment (tractor, vehicle)

67 **Collect snow for irrigation, watering livestock, increasing soil moisture, and household use**

1. Main constraints
   - Lack of knowledge among resource users
2. Capacity development needs
   (a) Technical and/or institutional
      - Training in snow harvesting
   (b) Community level
      - Training in snow harvesting
3. Technology needs
   - Machinery and/or equipment (tractor, vehicle)

68 **Irrigate at nighttime to reduce evaporation losses**

1. Main constraints
   - Lack of knowledge
   - Lack of access to materials
   - Lack of funding for inputs and supplies
2. Capacity development needs
   (a) Technical and/or institutional
      - Training in irrigation
   (b) Community level
      - Training in irrigation
3. Technology needs
   - New irrigation technologies

69 **Drip irrigate to reduce evaporation losses**

1. Main constraints
   - Lack of knowledge
   - Lack of access to materials
   - Lack of funding for inputs and supplies
2. Capacity development needs
   (a) Technical/institutional
      - Training in irrigation
   (b) Community level
      - Training in irrigation
3. Technology needs
   - New irrigation technologies

70 **Institute water conservation measures in urban areas and mining operations**

1. Main constraints
   - Weak enforcement
   - Mining operation's economic significance and/or potential overrides environmental concerns

continued on next page

Appendix 2 Table *continued*

- Lack of current and efficient infrastructure and/or equipment
- Lack of awareness of environmental impacts
- Lack of incentives

2. Capacity development needs
   (a) Technical and/or institutional
   - Training in integrated water management, water conservation, and fee systems
   - Enforcement of water conservation

   (b) Community level
   - Awareness raising and education on water conservation

3. Technology needs
   - State-of-the-art water monitoring equipment and mining industry water-saving and/or recycling technology

D. LIVELIHOODS

i. Value addition to livestock products (diversification within sector) to increase resilience

71 **Establish herder groups/women's groups as small enterprises and/or cooperatives for processing and/or access to credit to develop and/or produce new products**

1. Main constraints
   - Lack of knowledge and skills
   - Lack of access to information
   - Cultural resistance to forming non-kin groups

2. Capacity development needs
   (a) Technical and/or institutional
   - Training—group formation, cooperative establishment and/or management and for extension staff

   (b) Community level
   - Training—group formation, cooperative establishment and/or management

3. Technology needs
   - ICT

72 **Develop new dairy (cow, yak, camel) products**

1. Main constraints
   - Lack of cold storage
   - Lack of storage and/or packaging equipment
   - Lack of access to credit
   - Poorly developed value chains
   - Transportation issues

2. Capacity development needs
   (a) Technical and/or institutional
   - Training—technical and/or processing

   (b) Community level
   - Training—technical and/or processing, and small enterprise development

3. Technology and infrastructure needs
   - Small- and/or medium-scale processing, packaging, and cold storage
   - Transport (e.g., vehicles, roads, railway)

continued on next page

Appendix 2 Table *continued*

73 **Develop new wool and fiber products (sheep, yak, camel)**
1. Main constraints
   - Lack of processing and packaging equipment
   - Lack of access to credit
   - Poorly developed value chains
2. Capacity development needs
   (a) Technical and/or institutional
   - Training—technical and/or processing

   (b) Community level
   - Training—technical and/or processing and small enterprise development
3. Technology and infrastructure needs
   - Small- and/or medium-scale processing and packaging

74 **Develop new meat products (processed, dried, canned)**
1. Main constraints
   - Lack of cold storage
   - Lack of canning and/or packaging equipment
   - Lack of access to credit
   - Poorly developed value chains
   - Transportation issues
2. Capacity development needs
   (a) Technical and/or institutional
   - Training—technical and/or processing

   (b) Community level
   - Training—technical and/or processing and small enterprise development
3. Technology and infrastructure needs
   - Small- and/or medium-scale processing, packaging, and cold storage
   - Transport (e.g., vehicles, roads, railway)

ii. Diversification of income across sectors to increase resilience

75 **Encourage vegetable growing (using climate-resilient species)**
1. Main constraints
   - Lack of access to seeds and equipment
   - Lack of skills and knowledge
   - Lack of storage facilities
   - Transportation issues
2. Capacity development needs
   (a) Technical and/or institutional
   - Training extension service in cultivation and irrigation

   (b) Community level
   - Training in vegetable growing, storage, and small enterprise development
3. Technology and infrastructure needs
   - Irrigation, greenhouses, and storage facilities
   - Transport (e.g., vehicles, roads, railway)

76 **Cultivate new crops such as bushes and/or berries (sea-buckthorn, currants, etc.)**
1. Main constraints
   - Lack of access to seeds
   - Lack of skills and knowledge

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Appendix 2 Table *continued*

- Lack of storage facilities
- Transportation

2. Capacity development needs
   (a) Technical and/or institutional
   - Training extension service in cultivation and irrigation

   (b) Community level
   - Training in new crop growing, storage, and small enterprise development

3. Technology and infrastructure needs
   - Irrigation, greenhouses, and storage facilities
   - Transport (e.g., vehicles, roads, railway)

77 **Develop non-timber forest products**

1. Main constraints
   - Unsustainable practices in place; harvesting is unregulated
   - Lack of knowledge regarding processing and branding
   - Poorly developed value chains
   - Transportation issues

2. Capacity development needs
   (a) Technical and/or institutional
   - Training in ecology, sustainable harvesting, monitoring, and enforcement

   (b) Community level
   - Training in sustainable harvesting techniques, processing, and small enterprise development

3. Technology needs
   - Processing equipment, etc.
   - Transport (e.g., vehicles, roads, railway)

78 **Promote sustainable tourism**

1. Main constraints
   - Insufficient products and support services for tourists (e.g. lodging in remote areas)
   - Poorly marketed
   - Environmental impacts from unregulated development
   - Low skills and knowledge regarding products and services required
   - Transportation issues

2. Capacity development needs
   (a) Technical and/or institutional
   - Strategic planning, branding, and/or marketing

   (b) Community level
   - Awareness raising
   - Education on ecotourism opportunities
   - Small enterprise development and product and service development

3. Technology needs
   - ICT and green technology
   - Transport (e.g., vehicles, roads, railway)

79 **Provide vocational training and/or employment in small- and medium-sized enterprises or industry**

1. Main constraints
   - Vocational training institutions weak
   - Lack of funding

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Appendix 2 Table *continued*

	2. Capacity development needs (a) Technical and/or institutional • Develop vocational training institutions and/or curricula (b) Community level • Information and awareness raising on opportunities 3. Technology and infrastructure needs • ICT • Distance learning • Training facilities
iii.	**Marketing**
80	**Increase access to markets for products** 1. Main constraints • Lack of identified markets • Lack of funding • Poor quality products for sale 2. Capacity development needs (a) Technical and/or institutional • Training in sanitary and phytosanitary requirements, quality control, identifying appropriate markets, and negotiating deals (b) Community level • Awareness raising regarding external market demand levels and quality preferences 3. Technology needs • ICT
81	**Develop branding and certification (for international marketing)** 1. Main constraints • Lack of knowledge regarding international requirements and sanitary and/or phytosanitary standards • Lack of funding for certification 2. Capacity development needs (a) Technical and/or institutional • Training and study exchanges on certification opportunities and options, standards, procedures for quality control • Assessment of capacity development needs locally and among producers (b) Community level • Awareness raising and education on certification of products, significance, advantages of certification, and requirements for producers 3. Technology needs • ICT
82	**Establish and/or strengthen cooperatives for marketing** 1. Main constraints • Lack of organizational skills • Lack of cooperation • Cultural barriers to forming non-kin groups 2. Capacity development needs (a) Technical and/or institutional • Training for extension staff

continued on next page

Appendix 2 Table *continued*

	(b) Community level • Training for rural citizens, groups, and/or enterprises 3. Technology needs • ICT
E.	**MAINSTREAMING ADAPTATION**
i.	**Strategic planning, budgeting, and policy**
83	**Prepare governors' action plans, *soum* development plans, and *soum* development strategies that mainstream adaptation** 1. Main constraints • Insufficient information and/or data on resource condition, and current and projected impacts • Lack of knowledge and awareness 2. Capacity development needs (a) Technical and/or institutional • Strengthen cooperation with professional and/or research organizations • Strategic planning skills (b) Community level • Education on climate change, impacts, and adaptation options 3. Technology needs • ICT
84	**Establish needs-based budget planning for implementation of pasture management plan, livestock program activities, and adaptation practices; identify costs and provide budget from the *soum* development fund** 1. Main constraints • Lack of transparency • Lack of knowledge and awareness regarding budgeting processes • Lack of budgeting skills • Lack of participation 2. Capacity development needs (a) Technical and/or institutional • Training in budgeting processes (b) Community level • Awareness raising • Legal information 3. Technology needs • ICT
85	**Incorporate sustainable grassland management policy into new laws regulating land use** 1. Main constraints • Lack of knowledge and awareness regarding sustainable grassland management • Lack of demand for regulatory change 2. Capacity development needs (a) Technical and/or institutional • Training in policy and legislation development (b) Community level • Awareness raising • Legal information 3. Technology needs • ICT

continued on next page

Appendix 2 Table *continued*

86 **Enforce land use regulations to reduce degradation and loss of adaptive capacity**

1. Main constraints
   - Lack of knowledge and awareness of regulations
   - Lack of demand for enforcement
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in enforcement

   (b) Community level
   - Awareness raising
   - Legal information
3. Technology needs
   - ICT

87 **Generate additional funding for adaptation activities from climate finance and carbon markets, based on implementation of NAMA that addresses grassland and livestock**

1. Main constraints
   - Lack of stable carbon markets and insufficient funding available for climate finance funds
   - Lack of knowledge and awareness regarding climate finance and carbon markets
   - Lack of completed and approved NAMA
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in climate finance and carbon markets

   (b) Community level
   - Awareness raising and information
3. Technology needs
   - ICT

ii. Capacity building and research

88 **Conduct further research on adaptation and mitigation, such as opportunities for changing feed to reduce livestock methane emissions that are feasible in Mongolia, and drought-resistant fodder species**

1. Main constraints
   - Lack of available funding
   - Lack of modern research facilities, labs, and equipment
   - Insufficient science and/or research staff qualified to address climate change issues
2. Capacity development needs
   (a) Technical and/or institutional
   - Training, climate change monitoring and modeling, and environmental monitoring, including soil carbon

   (b) Community level
   - Awareness raising and education on adaptation practices
3. Technology and infrastructure needs
   - Laboratory facilities
   - Monitoring stations
   - Computer modeling software
   - ICT

continued on next page

Appendix 2 Table *continued*

89 **Increase technical capacity to address climate change impacts**

1. Main constraints
   - Lack of available funding
   - Lack of access to information on new technologies
   - Lack of access to new technologies
   - Insufficient staff familiar with new technologies
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in new technologies

   (b) Community level
   - Awareness raising and education on adaptation practices
3. Technology needs
   - New technologies (e.g., new, more efficient drip irrigation)
   - ICT

90 **Increase community awareness regarding climate change impacts**

1. Main constraints
   - Lack of available funding
2. Capacity development needs
   (a) Technical and/or institutional
   - Training in climate change impacts and adaptation

   (b) Community level
   - Training in climate change impacts and adaptation
3. Technology and infrastructure needs
   - ICT

GIS = global information system, GPS = global positioning system, IBLI = index-based livestock insurance, ICT = information and communication technology, IT = information technology, LEWS = livestock early warning system, NAMA = Nationally Appropriate Mitigation Action, NAMEM = National Agency for Meteorology and Environmental Monitoring.

[a] With proper prior assessment, monitoring of recharge, and management structures in place.

[b] D.A. Johnson et al. 2006. Collection and Evaluation of Forage Germplasm Indigenous to Mongolia. Forest Service General Technical Reports. www.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115=169637&pf=1

[c] Lignin is extracted from the black liquor of straw paper mills. The new material is called sand-stabilizing lignin; and is proving effective, economic, environmental, and plant-friendly in fugitive dune fixation. It can be used with forest and/or grass planting simultaneously. This technique not only creates a new method for desertification control, but also reduces water contamination. It is most feasible where lignin is produced as a by-product (described in H. Wang, D. Dagvadorj, and A. Pitman. 2005. *The Degraded Ecosystem Restoration in the Arid and Semi-Arid Northern [the People's Republic of] China-Mongolia Region*. Final report for APN project 2005-23-NSY-Wang. Asia-Pacific Network for Global Change Research).

[d] The rationale for "mobgrazing" is that trampling by a high-density herd improves the soil as it transfers organic matter into the ground. The grazed sections then need a long rest period. The method is used in many parts of the world, including Australia and the United States. It requires very intensive planning and very active herd management. This is especially suitable for smaller, limited grazing land areas.

Source: Project team.

Making Grasslands Sustainable in Mongolia
Adapting to Climate and Environmental Change

Climate change threatens grassland ecosystems and herders' livelihoods in Mongolia. Herders depend on pasture and water resources for their livestock, and are thus among the most vulnerable groups to climate change impacts. However, although climate change impacts on grassland ecosystems are measurable, current institutional capacity and financial resources limit implementation of adaptation practices. This publication reviews grassland management and traditional nomadic pastoralism in the local Mongolian context, and identifies potential adaptation strategies and practices, such as rotation and resting of pasture, long-distance migration of animals in fall and/or winter, and reduction of livestock stocking rates.

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