Evaluation of Adaptation Measures for Livestock Sector in Mongolia

P. Batima, B. Bat, and Ts. Tserendorj

AIACC Working Paper No. 41
October 2006

Direct correspondence to:
P. Batima, mcco@magicnet.mn

An electronic publication of the AIACC project available at www.aiaccproject.org.

AIACCWorking Papers

Distributed by:
The AIACC Project Office
International START Secretariat
2000 Florida Avenue, NW
Washington, DC 20009 USA
www.aiaccproject.org

AIACC Working Papers, published on-line by Assessments of Impacts and Adaptations to Climate Change (AIACC), is a series of papers and paper abstracts written by researchers participating in the AIACC project. Papers published in *AIACC Working Papers* have been peer reviewed and accepted for publication in the on-line series as being (i) fundamentally sound in their methods and implementation, (ii) informative about the methods and/or findings of new research, and (iii) clearly written for a broad, multi-disciplinary audience. The purpose of the series is to circulate results and descriptions of methodologies from the AIACC project and elicit feedback to the authors.

The AIACC project is funded by the Global Environment Facility, the Canadian International Development Agency, the U.S. Agency for International Development, and the U.S. Environmental Protection Agency. The project is co-executed on behalf of the United Nations Environment Programme by the global change SysTem for Analysis Research and Training (START) and The Academy of Sciences for the Developing World (TWAS).

Assessments of Impacts and Adaptations to Climate Change (AIACC) seeks to enhance capabilities in developing countries for responding to climate change by building scientific and technical capacity, advancing scientific knowledge, and linking scientific and policy communities. These activities are supporting the work of the United Nations Framework Convention on Climate Change (UNFCCC) by adding to the knowledge and expertise that are needed for national communications of parties to the convention and for developing adaptation plans. AIACC supports 24 regional assessments in Africa, Asia, Latin America and small island states in the Caribbean, Indian and Pacific Oceans with funding, mentoring, training and technical assistance. More than 340 scientists, experts and students from 150 institutions in 50 developing countries and 12 developed countries participate in the project.

For more information about the AIACC project, and to obtain copies of other papers published in *AIACC Working Papers*, please visit our website at **www.aiaccproject.org.**

Evaluation of Adaptation Measures for Livestock Sector in Mongolia[1]

P. Batima, B. Bat, and Ts. Tserendorj

1. Introduction

The pastoral livestock sector directly engages half of the Mongolian population and provides food and fiber to the other half. Livestock and livestock-processed exports amount to about one-third of foreign exchange earnings. Mongolia's development is highly dependent on pastoralism. This sector already suffers from climate variability, particularly due to severe winters and summer droughts (Natsagdorj, 2003). A climate change study conducted in Mongolia recognized that global climate change has increased the threat of severe winters and droughts (Batima, 2003). Given the overriding importance of the sector to the national economy, its vulnerability remains a key threat to the country's potential for sustainable development.

For the potential climate change, we adopted the Special Report on Emissions Scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC) scenario runs performed with three coupled general circulation models: the HadCM3, ECHAM3, and CSIRO Mk2. For all of the models, we analyzed the response to the middle forcing scenarios A2 and B2. Future climate change was presented for three 30-year time slices, centered on the 2020s, 2050s, and 2080s, each relative to the climatological baseline period 1961–1990.

[1] The research reported in this paper was supported by grant number AS06 from Assessments of Impacts and Adaptations to Climate Change (AIACC), a project that is funded by the Global Environment Facility, the Canadian International Development Agency, the U.S. Agency for International Development, and the U.S. Environmental Protection Agency and co-executed on behalf of the United Nations Environment Programme and by the Global Change SysTem for Analysis, Research and Training and The Academy of Sciences for the Developing World. Correspondence regarding this paper should be directed to Punsalma Batima, mcco@magicnet.mn.

Mongolia consists of a unique ecology that includes the southernmost fringes of boreal forests of the Great Siberia, deserts, and vast steppes of Central Asia and the Chains of Altai, Khangai, Khentei, and Khyangan mountain massifs (Figure 1). The Mongolian environment as a whole is characterized by great diversity and a particular complex spatial structure of soil and vegetation cover. Most of the mountain ranges are forested but the plains are dominated by steppe and desert vegetation. In a short distance, one may encounter a variety of features of forest, mountain, steppe, desert, as well as unique ecosystems. Administratively, Mongolia is divided in 22 *aimags* (states).

1.1 Objectives and research questions

The study was undertaken under Assessments of Impacts and Adaptations to Climate Change (AIACC) aimed to formulate adaptation measures that focus on those issues of national concern. It also aimed at evaluating concrete and practical adaptations that could possibly decrease the livestock sector's vulnerability to climate change. This paper discusses some possible adaptation measures, addressing questions like:

- What are adaptation measures?
- How are adaptation measures assessed and prioritized?
- What criteria are used to evaluate adaptation options?
- To what risks, threats, or impacts is adaptation directed?
- When and where does adaptation take place?
- Who is responsible for adaptation?
- Who should pay for the costs of adaptation?

- What are the barriers and constraints?

Activities conducted in adaptation assessment include a review of adaptation options that have been identified in previous studies related to climate change such as the U.S. Country Study Programme, National Action Programme on Climate Change and Initial National Communication, review of national, as well as sector policy, and legislative documents on livestock sector, current AIACC impact and vulnerability assessment of livestock sector to climate change, and interviews and discussions with local officials and herders.

1.2 Methods

Different methods were used to identify adaptation options. These include computer modeling, household survey, focus group discussion, multi- workshops, and adaptation screening matrix.

Assessing the preference among these options in different sectors is a complicated task for policy/decision makers, as there are multiple problems and objectives to be solved and met. Therefore, a simple approach, or the *Screening Matrix* of adaptation was used to examine the priority of measures. Adaptation options are qualitatively ranked as high, medium, and low against the criteria to indicate the preference.

More than 700 herders' households from 19 *aimags* were interviewed during a three-year field survey was carried out over Mongolia in order to verify our research and to describe major risks perceived by pastoralists and how they cope with problems caused by climate-induced phenomenon. On the basis of this household survey, expert judgments, and previously conducted climate change studies, the long list of adaptation options has been prepared.

The identified adaptation options have been discussed in three-level multistakeholder workshops in order to prioritize the potential adaptation options. More than 200 participants attended the workshops, including local governors and animal experts such as veterinarians, environmentalists, climatologists, and herders.

Locally developed models EKZNJTZ• and EKUKJTZ• were used to simulate ewe weight changes in summer–autumn and winter–spring, respectively. The models predict ewe weight changes, taking into account the pasture resources and their dynamics, both in terms of quantity and quality, and weather conditions (i.e., temperature, wind speed, snow cover, and precipitation).

The models were developed by Tuvaansuren (2002). The models estimate such parameters as the daily grazing time of a ewe in winter and spring seasons, amount of daily intake and water, basic metabolism, pasturing, growth and development of the fetus, milk yield, the possible impact of external factors, energy expenditure for keeping the body temperature constant in cold weather conditions, and energy intake during grazing. The model has two parts. The output of the model is the ewe's weight change. EKZNJTZ predicts ewe weight change for the period from November 1 to April 30. EKUKJTZ predicts ewe weight change for the period from May 1 to October 31.

• These are acronyms of the model name in Mongolian language.

.

The daily energy balance W_e in kcal/day of ewes is calculated as

$$W_e^i = W_p^i - (W_o^i + W_m^i + W_n^i + W_c^i + W_t^i + W_f^i + W_l^i)$$

where

W_p is energy intake,

W_o is energy requirement for basic metabolism,

W_m is energy requirement for grazing,

W_n is energy requirement for warming ingested material,

W_c is energy requirement for digestion,

W_t is energy requirement for maintaining body temperature,

W_f is energy requirement for foetus growth, and

W_l is energy requirement for milk production,

The rate of change in liveweight is subsequently calculated by the dividing the energy balance (net energy intake) by the energy requirement for liveweight gain:

$$dM_j = We_j/Cp_j$$

where, Cp_j is the energy requirement for liveweight gain (kcal/kg).

Then sheep weight on day j is calculated by the following equation:

$$Mo_j = Mo_{j-1} + dM_j$$

The impact of global warming on ewe weight was assessed through changes in climatological parameters of EKZNJTZ and EKU1KJTZ with downscaled HadCM3 outputs to Mongolia for the A2 and B2 IPCC SRES scenarios (IPCC, 2000) for the time period 2020, 2050, and 2080. The model was also used to analyze adaptation measures for increased livestock productivity such as increasing livestock weight by modifying grazing schedules and increasing pasture biomass.

2. Impacts of Climate Change and Variability

The climate change studies conducted under the U.S. Country Studies (1996) and Netherlands Climate Change Studies Assistance Program (2000) concluded that global warming would have a significant impact on natural rangeland, livestock, and rural livelihood in Mongolia. Detailed climate change impact, vulnerability, and adaptation assessments under the AIACC AS06 Project confirmed these findings and concluded that negative threats from global climate change have increased.

Research conducted on pasture productivity under climate change confirms significant negative impacts of changing climate conditions (Bolortsetseg and Gantsetseg, 2003). Estimates show that the peak standing biomass will be reduced by up to 44.1% for the case in which temperature increases by 5ºC (Table 1). Pasture quality alteration is equally important, as it reflects changes in levels of productivity. During the past 60 years in Mongolia, high-nutrient plants decreased by 1.5–2.3 times and are expected to decline further because of increased temperature and decreased precipitation. Low-nutrient plants like *Carex duriuscula-Artemisia* became dominant in pasture communities. Pasture diversity is expected to change, as plants follow the shifting ecological/climate zones to the north as a result of increased temperature and moisture decline. For example, by 2050, 11% of the steppe pasture in Mongolia would be replaced by desert and, accordingly, the pasture quality will be degraded too.

A climatic factor that is associated with animal grazing in summer is high temperature. Because two-thirds of the year is cold in Mongolia, the high air temperature in summer makes it difficult for animals to graze on pasture. The threshold temperatures, above which animals cannot graze, have been established on the basis of observed data. The threshold temperatures are different in different regions depending on acclimation of animals to the climate in which they live: 16–19°C in the high mountains, 20–22°C in the steppe, and 26°C in the Gobi Desert (Tuvaansuren et al., 1996). With climate warming, greater temperature stress on animals is expected. Under the present conditions of climate change, sheep, goat, and cattle weight have been decreased by 4 kg, 2 kg and 10 kg, respectively for the period 1980–2002, and it is expected to decrease by more than 50% from the current level by 2080 (Bayarbaatar and Tuvaansuren, 2002).

Table 2 shows expected ewe weight changes estimated for climate change projections from the HadCM3 model as an example of animal weight decline under future climate change. Decline in ewe weight gain is much higher in forest steppe and steppe regions, which covers half of the pasture land of the country. It is also projected that temperature stress on animal behavior will lead to serious problems. According to the simulation results (Tuvaansuren and Bayarbaatar, 2003), further increase in air temperature by 2-5^{o}C tends to reduce a summer grazing time of animals on pasture by 0.7 to 2.0 h/day. Reduced grazing time would result in decreased daily intake, even though there is enough forage on the pasture. High temperatures also will reduce reproductive efficiency. Other effects of climatic variability on animal physiology are indirect. Changes in precipitation intensity, humidity, wind, and snowstorms may reduce the immunity of animals.

Fluctuating rainfall and the occurrence of drought are common features in Mongolia. Drought has been intricately bound to the lives of the Mongolian pastoralists for centuries, having subjected communities to famine and destitution. Rainfall has consequences on pasture and livestock productivity and can be used for predicting the effects on human populations depending on the livestock sector. The incidence of drought is expected to increase in the future (Natsagdorj, 2003). The summer condition is the major determining factor for the impending winter. Increased drought severity will tend to reduce the amount and nutritive value of reserve forage and therefore make the livestock more vulnerable during the following winter.

Recent increases in winter temperatures are associated with abnormal weather phenomenon such as wind storms in winter months and short (3-7 days) rapid rise of air temperature. The latter phenomenon causes an impenetrable ice-cover to form on the surface due to untimely melting of snow cover, which prevents animals from grazing. All this brought additional stress to increased extremes. Projected increase in snowfall and winter temperature will likely result in high negative impacts. Such changes will have impacts on plants and animals and most seriously on the herders' way of life and livelihoods, changing the existing harmony between pastoralists and the climate. There is also a strong relationship between drought/*dzud* and animal deaths (Natsagdorj et al., 2003). The death rates of domestic animals are also expected to increase in the drought and *dzud*-prone area.

Dzud can be described as livestock famine and can result in mass death of animals because of hunger, freezing and exhaustion. The *dzud* is very complex and long lasting phenomenon that is mainly caused by natural elements such as heavy snow fall within a short time period, long lasting or frequent snow fall, extremely low temperatures, and drifting wind storm. Such conditions reduce, or sometimes completely prevent, access by animals to grass and pasture and negatively impact the food security of livestock. *Dzud* also represents a high risk of humans in the affected areas because of their reliance on livestock for livelihoods and food.

In addition to climate variability and climate change, new socio-economic developments are affecting the herders' perspective on the use of natural resources for the purpose of livestock production and livelihood sustainability. For example, traditional herding practices have almost been lost completely, following the privatization of the livestock sector during the transition from the socialist system to a market economy. These developments are changing the vulnerability of Mongolian herders to climatic and other stresses and their capacity to cope and adapt.

The secret why nomadic pastoralism existed for centuries feeding Mongolians was its capacity to keep ecological balances. How? Traditional grazing technologies— seasonal pastures with sufficient reserves for emergency cases and grazing with due consideration of growth phases of vegetation and recovery after previous grazing - were the fist secret. The moderate demand resulted from the subsistence nature of Mongolians' lifestyle was the second secret (Enkh-Amgalan, 2002). The traditional vertical movement cycle practice within ecological zones for livestock herding is usually determined according to the access to forage, water, and, in some cases, availability of shelter for livestock. Many herders now undertake much shorter transhumance circuits than previously. Recent experiences show that most herders move only twice a year, many of them even stay at one place, grazing the same pastures year-round (Shiirev-Adya, 2004).

Livestock privatization also provided tremendous incentives for increasing livestock numbers and possessing more pasture resources for free. Increasing overstocking, overgrazing, and distortion of traditional grazing technologies have started to destroy ecological balances. The absence of appropriate mechanisms for motivating herders in conserving pastures signals a major danger to the sustainability of the pasture ecosystem. The projections are that human activities may bring about more change in rangeland ecosystems than any other force of global change and may interact quite strongly with climate change impacts. Any alteration of the standing capacity of grasslands will be economically important, given the scale of livestock production in Mongolia. The need for grazing regulations is becoming more critical at the local level. Some areas have been abandoned because of lack of water supply or overuse (Tserendorj, 2004).

3. Adapting to climate stresses

As described above, the impacts of climate variability and climate change on the pastoral livestock system of Mongolia are both near-term and long-term. In the near term, extreme events such as droughts and *dzud* severely impact livestock survival, the production of food and other livestock products, and the incomes and food security of pastoral households. The frequency and intensity of these extremes has increased in recent years and climate change could bring further changes in extremes in the not too distant future. Over the longer-term, climate change will bring changes in temperatures, precipitation, snowfall, and the duration of snow cover, as well as changes in the frequency of droughts and *dzud*. These long-term trends have the potential to degrade pasturelands and decrease the amount of land suitable for pasture. Recognizing the near and long-term risks, adaptation planning should take into account both the need to increase the current ability of pastoral communities to lessen and cope with the impacts of extremes as well as the need to conserve and improve the resilience of pastureland.

The near-term productivity and longer-term resilience of the pastoral system of Mongolia depends on three primary components of the system: the stock and condtion of natural resources, primarily pasture, which are strongly affected by climatic conditions; animals' biocapacity to cope with environmental stresses; and the human element that manages and depends on livestock and pasture lands (Bizya, 2003). Therefore, our investigation of adaptation options focused on conserving the natural resources of the livestock system and building their resilience against the changing climate, strengthening animal biocapacity to cope with environmental and climate stresses, and enhancing capacities of herders and livelihood opportunities in rural communities. In addition, adaptation options for increasing food security in Mongolia and increasing understanding of climate extremes and forecasting abilities were also examined.

The identification and evaluation of options for adapting the Mongolian pastoral livestock system to climate change followed a two-step process. In the first step, a team of technical experts identified a large number of adaptation options, screened the options against a small number of broad criteria, and selected a subset for further evaluation by stakeholders. In the second step, workshops were held with three different levels or groups of stakeholders to evaluate and prioritize potential adaptation measures.

3.1 Identifying and screening adaptation options

Technical experts from the case study team prepared a preliminary list of 89 adaptation options for the livestock sector of Mongolia. The options were drawn from responses to the household survey that was carried out during 2002-2004, findings and recommendations of previously conducted climate change studies, and expert judgments of the team. The preliminary list of options was then screened to identify options that warrant further consideration. A number of factors were judged by the team to be important in the context of Mongolia's livestock sector for screening options. As in many developing countries, the people and government of Mongolia tend to be more concerned with immediate and pressing domestic issues, such as economic development, poverty, public health, education and environmental problems that impact on these issues. Consequently, emphasis is given to adaptation measures that are consistent with and therefore might be more easily integrated into existing policies, plans, and programs in these areas.

More specifically, the preliminary list of options was screened to identify those that satisfy three criteria: (i) would the option advance climate change adaptation as well as existing objectives for development, poverty reduction, public health and education, (ii) is the option consistent with government policy, plans and programs for agriculture, and (iii) would the option cause any adverse impacts on the environment? Options that were judged to satisfy at least two of these criteria were passed for further evaluation. This shortened the list of adaptations to be considered from 89 to 56.

3.2 Evaluation of options by stakeholders

The shortened list of adaptation options that passed the initial screening were evaluated by three different levels or groups of stakeholders in a series of workshops and consultations. These included local workshops with a range of community stakeholders, meetings and consultations with scientists, and workshops policy and decision makers from national ministries. Stakeholders applied six additional criteria to evaluate the potential of each option, not only for reducing vulnerability to climate change, but also in promoting sustainable development:

- Current adaptive capacity. *What are the* current capabilities to implement the option successfully?
- Importance of climate as driver of outcomes. How important is climate relative to other exogenous factors as a driver of the risk that is targeted by the adaptation option?
- Near-term effectiveness. *How effective is the option expected to be for* reducing negative near-term impacts of drought, dzud and other extremes that are important sources of current climate related risks?
- Long-term benefits. Will the option produce long-term benefits for reducing vulnerability to climate change by, for example, conserving the pasture and its ecosystem?
- Cost. Whate are the expected investment, operation, and maintenance costs of the option?
- Barriers. *Are there significant* technical, social, financial, and institutional obstacles that could impede the implementation or performance of an option?

The adaptation options were qualitatively rated as *high* (H), *medium* (M), and *low* (L) against the six criteria by each of the participants in the workshops. The aggregated results are shown in Table 3 for those adaptation measures that emerged as high priorities, classified into five main groups as follows:

(1) conserving the natural resources, (2) strengthening animal biocapacity, (3) enhancing capacities and livelihood opportunities of rural communities, (4) increasing food security and supply, and (5) improving understanding of climate extremes and forecasting. Adaptation measures that are identified as high priority were judged by the participating stakeholders to be effective, technically feasible, socially acceptable, financially recoverable and feasible within the existing or an improved institutional and legal framework in Mongolia. The participation of local stakeholders, scientists, and policy and decision makers in the evaluation of adaptation measures is described below.

Local stakeholders

Much of the actual implementation of adaptation measures will be carried out at the level of the household or community. Some of the factors that will lead to implementation at the local level include the likelihood that the local community and herders would be the primary beneficiaries of successful adaptation, the substantial indigenous knowledge and experience on how best to manage pasture and animals that has accumulated within local communities, and the devolution of responsibility for management of the livestock sector to local authorities, including the Aimag Governors' office, *Sum* Governors' office, and other local authorities.

In view of the prominent role of local actors in the implementation of climate change adaptation, it is critical that the evaluation of adaptation options incorporate their perspectives and priorities. To obtain local level input to the evaluation, local community workshops were held in different eco-regions, namely the *Gobi-steppe region, steppe region, high mountain, and forest region.* More than 200 participants attended the workshops, including local governors, herders, environmentalists, climatologists, and animal experts such as veterinarians.

Almost all of the adaptation options prepared by the expert team were accepted as feasible by the local stakeholders, including herders. An important exception are measures that would promote private ownership of pasture and water supply. These measures were rejected by more than 98% of participants. Mongolian pastoralists are not nomadic but rather are transhumant. Having access to pasture, water and shelter to permit seasonal movement of livestock rotation and optimal production has been the focus of Mongolian pastoralism. Direct land ownership, in the opinion of herders and other community stakeholders, is not conducive to maintaining the traditional or even current pastoral livestock system of Mongolia. Almost all the responders expressed the view that it is more likely that individualized, private ownership of pastureland, under Mongolian conditions, would increase conflict and jeopardize environmental stability.

It was revealed that financial and material shortage, inadequate information, and remoteness from market were among the major constraints. A shortage of educated people in the rural areas t take care of rural education, grazing management and social and economic issues was also raised in the workshops as a serious concern. Participants emphasized the importance of education and training, the return of students after graduation to their home provinces, and financial and management support in the implementation of adaptation measures. Most importantly, the participants stressed the need for interaction between scientific and local indigenous knowledge to cope with climate variability and to move from study, assessment, and discussion to actual implementation of adaptation measures.

Scientific community

The implementation of many adaptation measures requires the support and interaction of scientific and advanced knowledge. Therefore, the results from local workshops regarding the selected adaptation options were discussed with leading scientists of animal husbandry and pasture management, through lectures with students of state, as well as private agricultural universities. The focus of these discussions was on the following issues:

- What is the role of scientists in the implementation of adaptation measures?
- What should be done to introduce new varieties of pasture plants that are resistant to drought to facilitate adaptations to improve pasture quality and develop cultivated or irrigated pasture?
- What should be done to improve the productivity of animals?
- How should know-how be transferred on mechanical and automatic equipment or appliances to facilitate the manual labor of herders?
- What is the scientific, technical, and financial capacity of the institutions to support the implementation of adaptation measures?
- What should be done to improve the capacity of institutions and how should the barriers, if any, be overcome?

The discussions demonstrated that scientists are seriously concerning about livestock sector problems and are willing to cooperate in implementation of adaptation measures. They emphasized development of genetic engineering to increase livestock productivity and conduct various experiments for grassland adaptation to warmer climate. Financial constraints and lack of collaboration among different institutions were identified as major obstacles. The collaboration established by the AIACC study between local people and scientists was acknowledged as a useful model and it was suggested that an institutional mechanism be created to continue the collaboration.

Policy and decision makers

Successful implementation of adaptation measures directly and indirectly depends on actions and decisions of leading, as well as planning organizations. Thus, the adaptation measures (Table 3) were presented to policy makers, including those from the Ministry for Nature and Environment, Ministry of Food and Agriculture, Agency of Civil Defence, Ministry of Building and City Infrastructure, Institute of Meteorology and Hydrology, and the Institute of Geography. The focus of the meetings with policy makers was to draw their attention to the impacts of climate change and urge their action in implementation of adaptation measures and integration of adaptation measures in developing a plan.

Participants from the different ministries demonstrated good understanding of current vulnerability of the livestock sector to climate extremes such as severe drought and *dzud* and also of the low technological advancement of the sector. *Less well understood by the ministries are human caused climate change and the potential effects of climate change in the livestock sector. Knowledge of the design and implementation of adaptation to climate variability and climate change differs markedly across the ministries. Common to most is the perspective that adaptation measures can be synergistic with development policies in the livestock sector and that they should be implemented within that context. But the policy makers made no clear distinction between adaptation measures implemented at a project level* and broader policy and institutional measures that could be enabling mechanism for implementing adaptation across different sectors and policy and decision making contexts.

4. Discussion of Selected Adaptation Measures

Livestock depends to a great extent on the availability of pasture resources. The demands of the animal to survive and be productive must continually be balanced with the availability of feed and water.

Therefore, its vulnerability depends on sustainable pasture management. The latter is aimed at increasing livestock productivity, as well as the high-level maintenance of pastures.

Adaptation measures to reduce the impacts of long-term changes on the livestock sector will mainly focus on improved pasture yield, including the revival of traditional pasture management, which involves the use of one pasture only for the length of one season; restoration of degraded pasture, including reforestation of floodplains and increased vegetation cover; expansion/rehabilitation of pasture water supply, development of irrigated pasture, modifying the schedule of grazing; and others. It is also important that the livestock do not exceed the carrying capacity of the pasture. Even though the feasibility of these adaptation measures is promising, it will require adequate training, time, management, and financing.

Modification of grazing schedule from mid-day hours to early-morning or late-evening hours to allow livestock to spend extended time on the pasture to compensate for the reduced grazing time due to summer high temperature stress could be one of the adaptation options to climate change. As simulation results show in the future a climate condition, the grazing time should be extended by at least six hours by 2020, and even longer by 2050 and 2080 (Tables 4). To extend the grazing time by 6–8 hours is practically impossible. Thus, modification of the grazing schedule should be combined with other relevant measures.

Adaptation measures for increased livestock productivity would be to increase livestock weight or livestock biocapacity by using different kinds of supplementary feed, not only in winter but also in summer to increase daily feed intake. Simulation results show 1.9–3.3 kg/day supplemental feed will be required to feed a sheep in the summer of 2020 in order to compensate the projected weight decrease by this time (Table 5).

Adaptation measures to reduce the vulnerability to summer drought and winter *dzud* include an increased feed reserve for livestock and pasture reserve for harsh winter. The latter means allocating plots of pasture *that* are not used in summer. Fattening of animals during the warm season also greatly improves the adaptive capacity of animals during winters. The reservation of sufficient amounts of supplemental feed is essential so that animals can rebuild their strength during drought and *dzud* conditions; that is, the primary objective in supplementary feeding is to minimize the loss of animals. The feed reserve can be improved by increasing hay making, sown fodder, feed manufacturing, and increasing indigenous (plant and nonplant) feed preparation.

Establishment of cultivated pasture will reduce the livestock dependency on nature and climate. A successful implementation of this measure would greatly reduce not only the expected impact of climate change but also the vulnerability to drought and harsh winters (*dzud)*. Possession of land is not the most important driving force of a society engaged in pastoral livestock production; rather, having access to pasture and to water and shelter resources necessary to permit optimal livestock production has been the focus of Mongolian pastoralism. Privatization of pasture is not conducive to maintaining the traditional, or even current, pastoral livestock system in Mongolia. However, ownership/possession of land often increases investment, as the land would be managed as a capital, in which investments must be made to promote sustainability and prevent land degradation. Therefore, cultivated pasture development would be feasible in the case in which the land tenure is legally certified. On the other hand, the measure is costly because it will require sufficient irrigation, good seeds, and application of fertilizers.

Increased vegetation cover of pasture by different varieties of perennials that are tolerant to drought is also a good adaptation option to increase pasture yield and restoration of degraded pasture. The feasibility of this measure depends on seed availability for such varieties of perennial pastures. The willingness of herders to bear the responsibility is also important.

Expansion and rehabilitation of pasture water supply are other promising measures for improved pasture utilization and stock survival, as well as ecosystem conservation and rural development. However, implementation of this measure would require high investment.

Traditionally Mongolian herders' lived in groups of two or more households called *khot ail*, which served a variety of functions, including informal regulation of pasture use by member *households that was effective at protecting paturelands and mitigating the imacts of* droughts and *dzud*. This can be taken as indigenous measures to cope with current climate extremes. Such current demonstrations of community-based adaptation, in which the community decides on how to share the limited common resource, shows this is a promising adaptation measure. Further strengthening of the collective actions among herders with involvement of livestock experts and feed preparatory groups in the community will certainly help to find the solution and implementation mechanisms/tools to encourage herders in adapting to climate change. The community's decision making is based on knowledge of livestock behavior and its needs. This includes knowledge of the set of physical and biological resources available to satisfy needs of the livestock in the environment, which is very important not only in the conservation of natural, pasture but also to enhance an adaptive capacity.

Herders need flexible access to credit for financing (e.g., to purchase feed for animals, equipment for improvement of pasture, the adoption of new technologies, and for investment in high-quality animals). Increased access to credit would greatly help increase their adaptive capacity and successful adaptation to climate change.

Research, training, strengthening, and building upon existing capacity might be the most important measure in strengthening the adaptive capacity and enhancing the quality of life, in general. It is also important that more feasible and workable instruments are devised to influence local habits and traditions for the successful implementation of adaptations. This can be reached by educating herdsmen and increasing their awareness with respect to environmental degradation and climate change. Research and training must be maintained and expanded at the herders' level.

Improvement of the forecasting and warning systems is also essential, although implementation could be deterred by institutional and communication infrastructure. Increased disaster forecasting, especially drought and *dzud*, would, however, help in preparing to meet potential dangers.

5. Barriers

There are also many barriers at national level for the implementation of adaptation measures, including financial, technical, and human resources, and institutional capacity, legislative framework, and public support. The most widely recognized barriers at national level are considered below.

Institutional: Problems in Mongolia seem more or less recognized at sectoral levels, and they are being addressed to a certain extent. However, there is no coordination of sectoral actions, and the responsibilities are not clearly distinguished between sectors. It is often found that certain mandates are not identified, or are not clearly allocated to a department; there are overlaps in competence, leading to interdepartmental conflicts; the management of the sector is therefore far from optimal.

Financial. Because of the economic difficulties in Mongolia—as the country is undergoing a transition period—the government is failing to resolve financing issues. Lack of financial resources for initial investments would limit the implementation of the measures.

Technical. Lack of modern machinery and equipments that could ease work like preparing hay, milking of animals, cutting of wool and cashmere, etc and *know-how* in processing, storing, packing of animal products that could compete global market are the most urgent technical problem.

Legislative. Adequate policies and strategies should be established both at the national and the local level. At the moment, the legal, regulatory and standardization framework for pasture use are inadequate to effectively implement some of the adaptation measures. Mongolia's herders have rights of access to natural resources that are critical to livestock production such as forage on natural pasture and water from rivers, streams, springs, lakes and wells). Because these resources are treated as common property, no one is willing to invest in their protection and improvement. If land use could be legally certified, ownership would create incentives to manage land as a capital good and to make investments that promote sustainability and prevent land degradation. However, as mentioned before, direct land ownership is not conducive to maintaining the traditional or current pastoral livestock system of Mongolia and herders opposed adaptation options that would institute private ownership widely. Yet herders indicated a willingness to have private ownership of small pasture areas near to the winter/spring camps for emergency use. Policy/decision makers as well as herder still need to find appropriate approach to applying solutions to this issue.

6. Responsibility for Adaptation

If we cannot adapt to current climate risks, it will be difficult, even impossible, to adapt to future risks associated with climate change. The time has already come to implement the adaptation measures obtained though assessment. Anticipatory adaptation can be undertaken at different levels with the individual herders and local community playing an important role in behavioral adaptations, which is a key factor in safeguarding the natural resource bases for adaptation activities. Planning of adaptation on the regional or national level should be justified when impacts and interventions cross the boundaries of mandated areas with economic and financial implications that go beyond the capacity of local communities.

The identified measures would involve a range of possible actors. Long-term concerns with respect to sustainable use of pasture resources are generally the responsibility of the national government, as the pasture is state owned. Hence, the implementation of adaptation measures should first be on national planning organizations. However, successful adaptation requires coordination between central and local levels of management. Adaptation to long-term changes will especially require a combination of measures at the local level as well. Participation of national and local governments, scientists, and herders is equally important in the implementation of any of the adaptation measures.

Implementation of most of the adaptation measures requires heavy investments. Mongolia has many other socio-economic problems and financial constraints. Therefore, it is important that at the national planning level, the available funds are more clearly prioritized and allocated according to the objective of the economic and technical criteria.

There are many regional and global programs related to the implementation of the United Nations Framework Convention on Climate Change targets. The Global Environment Facility (GEF) provides financial support to cover the incremental cost in developing countries and those with economies in transition to protect and manage the global environment, including climate change. Therefore, the other way to find financing in implementation of adaptation measures could be to develop adaptation projects under the GEF funding through its implementing agencies like the United Nations Development Programme, United Nations Environment Programme, and the World Bank. Also, Mongolia should participate in regional, subregional, and bilateral cooperations and initiatives on climate change-related issues, so that it could gather more experience and knowledge on adaptations to climate change.

7. Conclusions

The Mongolian pastoral livestock sector is highly sensitive to climate change impacts. Considering the livestock-based subsistence economy, and that almost half of the population is engaged in that sector, adaptations to climate change impacts are vital in achieving sustainable development. The key risks from climate change to livestock are increased incidence of drought and *dzud* (harsh winter).

Several adaptation measures have been recommended on the basis of findings from this study. The selected adaptation measures classified as measures to (1) conserve natural resources, (2) strengthen animal biocapacity, (3) enhance capacities and livelihood opportunities of rural communities, (4) increase food security and supply, and (5) improve understanding of climate extremes and forecasting. The interaction between forage condition and feed availability and timing of feed availability and animal body condition is basic to all pastoral livestock production. Adaptations for the purpose of improving the economic sustainability of livestock production and the ecological sustainability of natural resources used in livestock production is focused on improving feed availability to livestock during annual production cycles. Reduction of vulnerability of livestock to impacts of climate change through the suggested adaptation measures requires actions in a coordinated way and incorporation in long-term planning.

Many of the actions to remove or palliate barriers require administrative decisions or actions. This includes the definition and granting of grazing rights, probably emphasizing winter camps and hay lands in the first instance; a structure for the organization of the herding population, so that they could participate in the regulation of local land use, as well as pasture management, development, and maintenance, all of which must have users' participation; and monitoring of pasture condition and regulation of its use. This will also require the participation of herders' associations, as well as the establishment of guidelines on the use of grazing land.

The suggested adaptations measures are useful in coping with climate change. However, it may make sense to start with existing adaptations that people have already made to deal with climate variability and extreme events.

References

Batima, P. 2003. Climate change: pasture-livestock. Synthesis report. Potential impacts of climate change and vulnerability and adaptation assessment for grassland ecosystem and livestock sector in Mongolia. Ulaanbaatar, Mongolia: Admon, 119 pp.

Bayarbaatar, B. and Tuvaansuren, G. 2002. Current climate change impacts on livestock. Annual report. *Potential impacts of climate change and vulnerability and adaptation assessment for grassland ecosystem and livestock sector in Mongolia.* 26 pp.

Bolortsetseg, B. and Gantsetseg, B. 2003. Climate change impacts on pasture. Vulnerability and Adaptation Assessment for Grassland Ecosystem and Livestock Sector in Mongolia project. AIACC annual report. Ulaanbaatar. 32 pp.

Bizya, , 2003. Climate change and livestock. Vulnerability and Adaptation Assessment for Grassland Ecosystem and Livestock Sector in Mongolia project. AIACC annual report. Ulaanbaatar.18 pp.

Enkh-Amgalan, 2002. Strengthening herder's communities as key to achieving greater resistance to vulnerability. Vulnerability and Adaptation Assessment for Grassland Ecosystem and Livestock Sector in Mongolia project. AIACC annual report. Ulaanbaatar.

IPCC. 2000. Emissions Scenarios. N. Nakicenovic, and R. Swart, eds. Cambridge University Press, Cambridge, UK.

Natsagdorj, L. 2003. Climate change impacts on extremes Vulnerability and Adaptation Assessment for Grassland Ecosystem and Livestock Sector in Mongolia project. AIACC annual report. Ulaanbaatar.56 pp.

Shiirev-Adya, S. 2004. Traditional herding practice. Vulnerability and Adaptation Assessment for Grassland Ecosystem and Livestock Sector in Mongolia project. AIACC annual report. Ulaanbaatar.16 pp.

Tserendorj, Ts. 2004. Some adaptations to climate change. Vulnerability and Adaptation Assessment for Grassland Ecosystem and Livestock Sector in Mongolia project. AIACC annual report. Ulaanbaatar.24 pp.

Tuvaansuren, G., Sh.Bayasgalan, B. Bolortsetseg, B. Dorj, and L. Natsagdorj. 2000. Impacts on agriculture. In: *Climate change and its impacts in Mongolia*, edited by P. Batima and D. Dagvadorj. Ulaanbaatar, Mongolia: National Agency for Meteorology, Hydrology and Environment Management , pp. 95-200.

Tuvaansuren, G., and B. Bayarbaatar. 2003. Future climate change impacts on livestock. Vulnerability and Adaptation Assessment for Grassland Ecosystem and Livestock Sector in Mongolia project. AIACC annual report. Ulaanbaatar.19 pp.

US Country Studies 1996. Vulnerability and Adaptation Assessment. 1996. Mongolia's Country Studies Report on Climate Change. Ulaanbaatar.

Figure 1. Geographic elevation map of Mongolia.

Table 1. *Aboveground Biomass Change*

		Temperature Changes			
		T + 0	T + 1	T + 3	T + 5
Precipitation changes, %	*Forest Steppe*				
	P +0%	0.0	–6.3	–23.9	–44.1
	P –10%	–11.9	–18.1	–35.5	–53.9
	P +10%	12.1	5.3	–12.7	–33.8
	P +20%	22.9	16.5	–2.3	–24.8
	Steppe				
	P +0%	0.0	–5.5	–20.8	–37.7
	P –10%	–12.7	–18.4	–32.0	–47.8
	P +10%	12.3	6.9	–9.4	–27.5

	P +20%	24.1	18.8	2.1	–17.1
	Altai Mountains				
	P +0%	0.0	–4.0	–11.4	–19.9
	P –10%	–15.8	–19.4	–25.6	–33.4
	P +10%	17.7	13.6	5.1	–4.0
	P + 20	34.9	30.7	21.8	11.5
	Gobi Desert				
	P +0%	0.0	–1.6	–7.4	–14.9
	P –10%	–21.3	–18.8	–23.9	–30.5
	P +10%	20.2	16.8	9.6	1.4
	P +20%	39.0	35.1	26.5	17.5

Aboveground biomass changes are given in percent.

Table 2. *Estimated Changes of Ewe Weight Gain for HadCM3 projections of future climate*

Natural zone	Pasture land as per cent of national total	**A2**			**B2**		
		2020	2050	2080	2020	2050	2080
Forest steppe	22.9	–10.68	–34.40	–57.75	–26.97	–38.33	–53.99
Steppe	28.0	–12.85	–31.67	–39.50	–15.86	–24.10	–34.37
High mountain	4.5	–2.92	–3.05	–9.03	–2.76	–3.64	–3.77
Desert steppe	44.6	2.02	3.87	–0.18	2.18	0.96	–0.36

Estimated changes of ewe weight gain by HadCM3 are given as percentage from current level.

Table 3. *Selected Adaptation Options*

Vulnerability	Mass death of livestock, increased poverty in rural area and overall decline in national economy of Mongolia						
Climate drivers	Drought, harsh winter (locally known as dzud) extremely low temperature, high snowfall, snowstorms						
		Evaluation criteria					
Adaptation objective	Adaptation measures	current adaptive capacity	Importance of climate as driver of outcomes	effectiveness	benefits	cost	barrier
Improved integrated pasture management	Improve grazing management	M	H	H	H	L	S& I
	Introduce cultivated pasture	L	M	H	H	H	F
	Improve pasture yield	L	M	M	H	H	T&F
	Improve pasture water supply	L	H	H	H	H	T&F
	Legislate possession of pasture	M	M	M	M	L	S& I
	Introduce taxation of pasture	L	M	M	M	L	S
	Livestock population control according to the pasture capacity	M	M	M	M	H	S
Increased strengthening of animal bio-capacity	Improve shelter for animals	M	H	H	M	M	F
	Increased supplementary feed	M	H	H	H	M	R&F
	Improve per animal productivity	L	H	H	H	H	T&F
	Introduce genetic engineering	L	H	H	H	M	T&F
	Improve veterinary services	M	H	H	H	H	T&F
	Introduce high productive cross breeds	L	H	H	H	H	T&F
Enhanced livelihood of rural community	Promote collective communities	M	H	M	H	M	S& I
	Develop/transfer new technologies	M	H	H	H	H	T&F
	Expand access to credit and generate alternative income	L	H	M	H	H	I&F
	Expand the supply of renewable energy applications to herders	M	H	H	H	M	T&F
	Promote and support the establishment of different kind of enterprises	L	M	M	H	H	T&F
	Establish insurance system of animals	L	M	M	M	H	T&F

	Establish risk fund	L	H	M	H	H	F&I
	Prepare educated herders	L	M	M	H	M	F
	Training of young herders	H	H	M	H	M	F
Increased food security and supply	Expand dairy and meat farms close to big cities to meet the demand of milk and other dairy products	M	H	H	H	H	T&F
	Promote and expand other food supply farms / egg, vegetables /	M	H	H	H	H	T&F
Climate Change study	Establish climate change monitoring stations	H	H	H	H	H	T&F
	Improve forecasting system of extreme events	H	H	H	H	H	T&F
Note: H-high, M-medium, L-low, F-financial, T-technical, S-social, I-Institutional, R-Resource							

Table 4. Ewe weight decline in extended grazing time (HADCM3)

HADCM3						
Natural zone	Grazing time					
	0	2	4	6	8	10
2020						
Forest steppe	-1.71	-1.06	-0.36	0.24		
Steppe	-2.19	-1.18	-0.30	0.43		
High mountain	-0.20	0.34	0.71	1.12		
Gobi-desert	0.43	0.52	0.62	1.05		
2050						
Forest steppe	-5.50	-3.68	-2.25	-1.16	-0.33	
Steppe	-5.27	-3.53	-2.48	-1.21	-0.26	

High mountain	-1.17	-0.63	-0.19	0.20	0.58	
Gobi-desert	0.25	0.55	0.69	0.80	0.92	
2080						
Forest steppe	-8.11	-6.22	-4.39	-2.56	-1.65	-0.50
Steppe	-6.38	-4.61	-2.99	-1.54	-0.56	0.06
High mountain	-1.60	-0.99	-0.54	0.03	0.32	0.69
Gobi-desert	-0.14	0.00	0.17	0.28	0.42	0.61

Table 5. *Estimated Supplemental Feed Required to Compensate the Projected Decrease of Animal Weight*

Natural zones	**Time period**		
	2020	**2050**	**2080**
Forest-steppe	3.0	3.4	3.6
Steppe	3.3	4.2	4.6
High mountain	1.9	2.3	2.8
Gobi Desert	–	–	2.1