Final Report for Year 1 & 2
CBA2009-12NMY-Togtohyn
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Dryland Development Paradigm Application for the Most Vulnerable to Climate and Land Use Change of Pastoral Systems in the Southern Khangai Mountains of Mongolia

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"Dryland Development Paradigm Application for the Most Vulnerable to Climate and Land Use Change of Pastoral Systems in the Southern Khangai Mountains of Mongolia" DDPPas project

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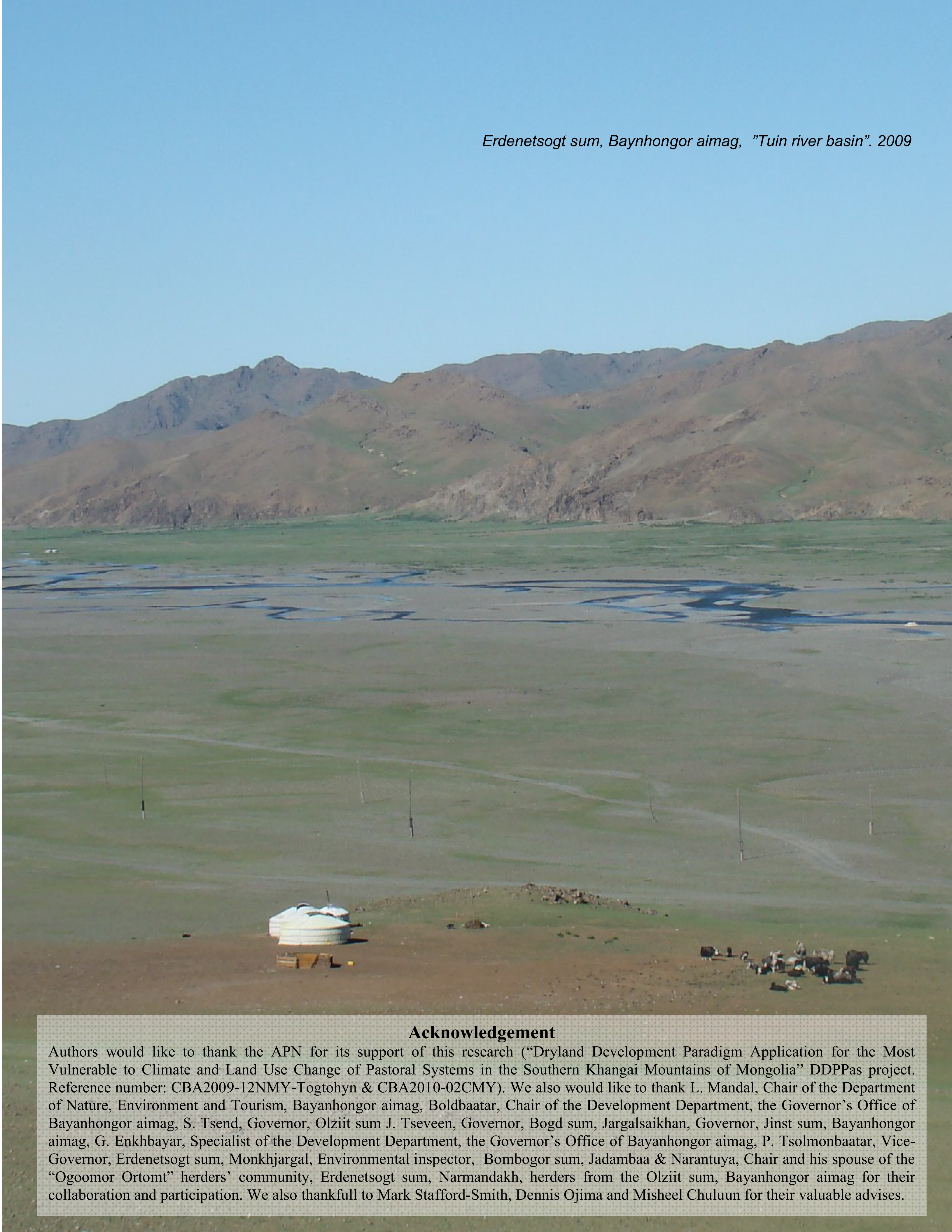
CHAPTER IV. SUSTAINABILITY STRATEGY



Erdenetsogt sum, Baynhongor aimag, "Tuin river basin". 2009

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Chapter I. Overview and Outcomes

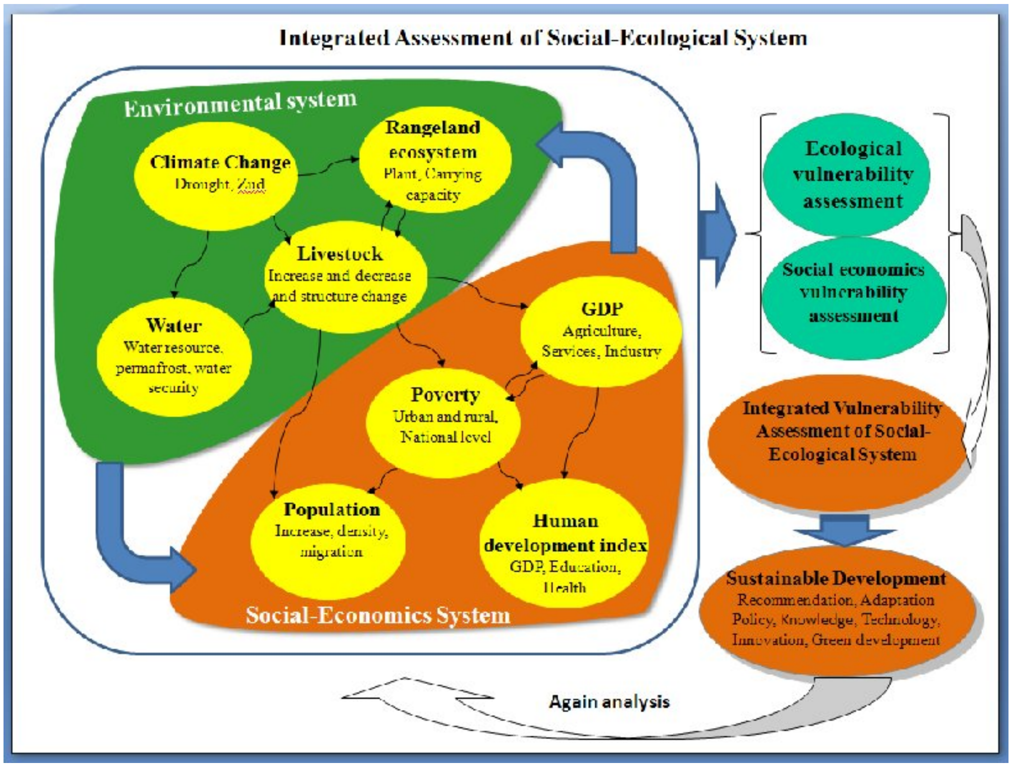
Project introduction

Pastoral social-ecological systems have been studied in the Tuin river and Baidrag river basins, located in the Southern Khangai Mountains. In these remote from the market areas, traditional pastoral communities in Mongolia are still in existence in informal ways, and they have better chance to utilize traditional cultural landscapes to cope with climate (seasonal) variability. The transition to a market economy two decades ago played own role increasing goat numbers for their cashmere values. Goat increase in livestock composition is contributing to increased rangeland degradation as many herders claim. However, cashmere price went down last year, hurting well-being of herders. This winter herders from our study area are experiencing *zud* disaster. It is likely many herders are going to have large livestock losses. On top of these political, social, and ecological perturbations, climate change, particularly, global warming and globalization are becoming critical slow variables. Global warming is increasing social-ecological vulnerability to climate change, gradually leading to decreased water resources and reduced forage for livestock. Water resource decrease due to global warming in the region already exceeded the threshold level, and led to drying out of the Orog lake, where the Tuin river flows into. In contrary, a globalization with technological innovation opportunities is holding positive hopes if it is enhancing climate change adaptive capacity. There is an informal hierarchy of informal traditional communities, which are nested. Local knowledge, enhanced with knowledge on climate change (trends, variability and extreme events) and its impact on socialecological vulnerability is essential for management and policy development. A body of up-to-date local knowledge should serve as a foundation for science based legal framework and good governance to achieve sustainable development in the Tuin and the Baidrag river basin.

Objectives

Our goal and objective is to develop **policy framework for sustainable development of drylands in the Tuin and the Baidrag river basins of Bayanhongor aimag, located in the Southern Khangai Mountains, in order to increase its adaptive capacity and resilience to climate change. Dryland development strategies for the Southern Khangai Mountains will be developed with participation of local stakeholders.** We have 3 main objectives in order reach our goal:

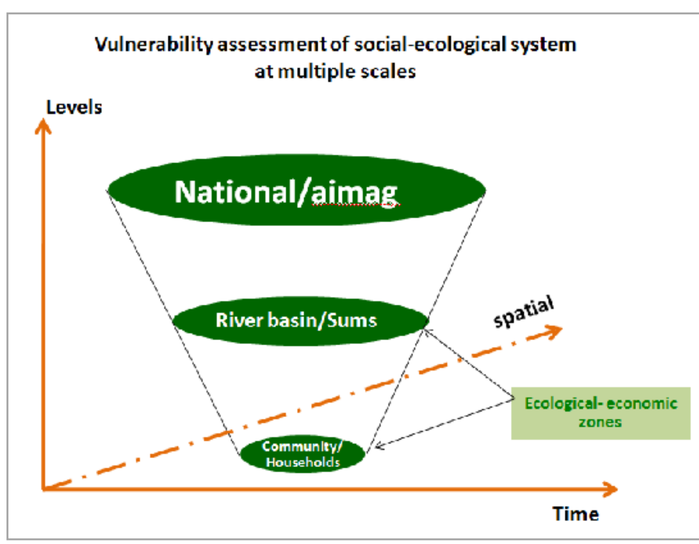
1. To conduct integrated assessment of the Tuin and the Baidrag river basins, riparian ecosystems and their services;
2. To raise awareness about vulnerability of the Tuin and the Baidrag rivers and riparian ecosystems to climate and land use changes;
3. To develop climate change adaptation and sustainable development strategies for the Southern Khangai Mountains with participation of local stakeholders.



Outcomes

This study initially focused in the Tuin River basin. During its first year, the project provided scientific knowledge on climate change, its impact on rangeland ecosystems, sustainable land-use, resilience reduction with land fragmentation in arid and semi-arid lands, and research findings in a suitable format for policymakers and resource users.

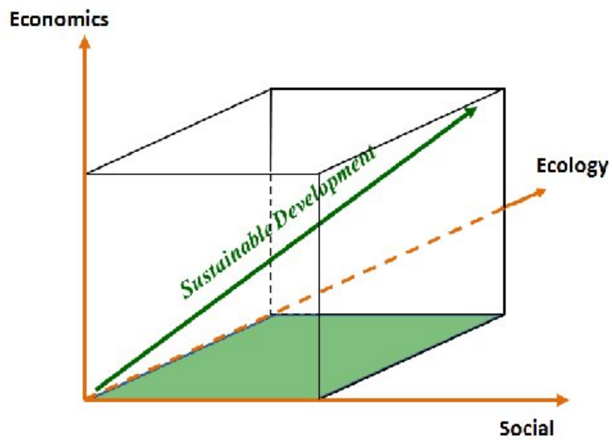
Integrated drought-*zud*, pasture use and ecological vulnerability indexes were calculated for Erdenetsogt (forest steppe), Olziit (dry steppe), Jinst (desert steppe) and Bogd (desert steppe) sums, using climate and livestock data (1986-2008). Relations between average values of ecological vulnerability during 1986-2008 for Erdenetsogt, Olziit, Jinst and Bogd sums were 1:1:1.1:1.5, which indicate that desert steppe region of the Tuin river basin is more vulnerable to climate and land use changes.



We studied examples of successful herder (a leader of *hot ail*), who is doing well with his traditional knowledge and management skills (Win-Win model), the Ortomt river community (traditional community model), herder with fenced pasture (rich herder model), and "tragedy of commons" for pastoral social-ecological systems . Many traditional pastoral communities

are still at bifurcation stage between sustainable livelihoods “Win-Win” (both “Win” ecologically and “Win” socially) and “Tragedy of Commons” collapse scenarios.
“Global warming became critical slow variable,already over-passing thresholds in terms of its negative impact on surface water and it is leading to collapse” according to the social survey in the Tuin river community. A prime example of it is that the Tuin river is not reaching the Orog lake and the Orog lake is dried out already for several years. Frequency and intensity of climatic disasters (drought, *zud*, dust and sand storms, and floods) increased as consequence of climate change.

Participating countries



Mongolia, USA and Australia. Mongolia is a place for project implementation. Dennis Ojima, USA and Mark Stafford Smith, Australia are voluntary advisers.

Overview paper

Dryland Development Paradigm Application for the Study of the Tuin and Baidrag River Basin Social-Ecological Systems in Mongolia

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Abstract:

Mongolia is a vast country comprised of mountains, rangelands, and desert landscapes with scarce water resources. As a consequence of socio-economic and climate changesduring last two decades, social-ecological vulnerability of Mongolia's pastoral social-ecological systems has increased. To study these dynamics, we have applied the Dryland Development Paradigm (DDP) (Reynolds et al. 2007) for analysis of pastoral social-ecological systems in the Tuin and Baidrag river basins, located in Bayanhongor aimag, Mongolia. The dynamics of a coupled human-environmental system is defined by primarily by two different variables factors, such as, in this case, market forces and climate disasters. Privatization of livestock in early 1990s has triggered an & interest in increasing private livestock numbers-especially in the number of goats due the value of their cashmere. However, a series of climate disasters, droughts followed by *zud (severe winter conditions),* caused massive livestock losses. Global warming is the most critical slow variable in the drylands, with amplified consequences than in other regions. For example, the decrease in water resources in the region already exceeded the threshold level observed by local residents. Only three out of the twenty-five rivers (based on a map 1969) were inflowing into the Tuin river during our field survey in summer of 2009. Orog lake was completely dry in summer of 2009, and depth of the Boontsagaan lake is decreasing rapidly (Davaa. 2010). The residents of the Tuin river basin concluded that global level regulation is more important, but residents of the Baidrag river basin was claiming that local regulation is the most critical. These differences can be explained by the level of water depletion of the Orog and Boon Tsagaan lakes. A body of up-to-date local knowledge is essential for management and policy development of pastoral human-environmental systems.

Ecological vulnerability (drought, stocking rate relative to carrying capacity) and social vulnerability (livestock number per capita, distance to the market, livestock loss during zud) assessment showed that social-ecological vulnerability has increased more rapidly in the desert steppe region compared to other ecological zones. This indicates that the desert-steppe region is becoming more vulnerable to climate and land use change.

Keywords: Dryland Development Paradigm, pastoral social-ecological systems of Mongolia

1. Introduction

Mongolia is a vast country composed of mountains, rangelands, and desert landscapes with scarce water resources. These environmental conditions have contributed to the development of pastoral-nomadic systems that take advantage of the seasonal availability of forage and water resources found in different landscapes. The Mongolian pastoral-nomadic cultures occur as an emergent feature of the variable ecosystem and climate dynamics of the arid and semi-arid systems (Chuluun 2000, Fernandez-Gimenez 2006). These pastoral systems have adapted to variable environmental conditions responding to variations in resource availability. The emergence of hierarchical pastoral networks or cooperative groups based on common location of grazing or family relationships, as a complex adaptive system, increases the resilience of these systems to climate variability (Ojima and Chuluun 2008). The Mongolian pastoral-nomadic system exhibits oscillatory movements in regions where the climate and rangeland production dynamics are less variable, and can accommodate the need to move only between summer and winter camps. The inhabitants of forest steppe areas illustrate typical instances of this kind of oscillatory pastoral movement. More frequent seasonal oscillatory movements with more than one movement during the summer season occur in the mountain steppe regions. In regions with relatively higher climate variability and increased uncertainty, such as the Gobi and dry steppe areas, pastoral movements tend to be more chaotic and follow more opportunistic strategies to secure forage. These movements are associated with drier parts of the steppe and the Gobi desert-steppe and desert areas where non-equilibrium ecosystem dynamics are observed (Ellis and Chuluun 1993 and Fernandez-Gimenez 1999). A loss of mobility leads to both rangeland degradation and reduced pastoral risk management.

During the past several decades, changes in climate, ecosystem dynamics and socio-economic factors are interacting in new ways that are altering nomadic land use systems in Mongolia. Livestock production systems have undergone dramatic changes due to movement patterns of the pastoral nomads, provisioning of supplemental aid following harsh conditions, and a shift in herd composition caused by a transition from meat production to cashmere products. These changes have resulted in a greater concentration of livestock along sensitive waterways and in reserve pasture areas once set aside for recovery from harsh conditions. In addition, socio-economic conditions have altered the landscape utilization resulting in degradation of pasture lands near village centers and water sources. These changes in livestock grazing patterns coupled with climate change have disrupted the historic livestock management strategies and are leading to greater vulnerability of the pastoral system. Traditional resilience of pastoral community-cultural landscape systems are being affected by socio-economic changes related to mining and goat-cashmere production activities which have led to a loss in resilience and are leading to further degradation of the rangelands, riparian areas, and water bodies and are considered to be an example of a “tragedy-of-the-commons.” Privatization of livestock in the early 1990s became a driver for goat increases, self-interest rather than community’s interests, and rangeland fragmentation (Ojima and Chuluun, 2008).

In terms of climate influences on pastoral systems, during the last seventy years the annual mean air temperature has increased by 2.14^0C in Mongolia (MARCC 2009) and this warming has intensified during the last two decades. Winter temperature has increased by 3.6^0C and spring-fall temperature by 1.5^0C. However, the summer temperature has decreased by 0.3^0C. Changes in warming are not spatially uniform; winter warming is more pronounced in the high mountains and mountain valleys, and less in the Gobi desert and the steppe. Decreases in snowfall, increased tree cutting, the melting of permafrost, intensifying drying trends, destruction of riparian zone shrubs and swamps, and overgrazing all interact in a non-linear way, resulting in the disappearance of water sources. Regional climate may also be affected due to the albedo change that comes with land and snow cover changes. Because the number of water points continues to decline from year to year, traditional nomadic pastoral pattern of seasonal grazing have been disrupted with the loss of these watering points. The increased grazing pressure around the remaining water points have resulted in overgrazing of pastures in those areas.

In addition to the anthropogenic grazing effects, a warmer and drier climate has created conditions promoting expansion of deserts. Forage availability, as determined by remote sensing data from 1982 through 2002 in the central parts of Mongolia, has been affected by these climate effects (Ojima et al. 2004). Ellis and others (Ellis et al. 2002) showed that the steppe area adjacent to the Gobi region is especially vulnerable to climate changes. Increased grazing pressures during the past decade have led to desertification. However, it is likely that the main ecological zones are not shifting, but southern areas with lower productivity within each ecological zone are expanding (Chuluun et al., 2010). Riparian ecosystems appear to have keystone values in coupled pastoral social-ecological systems. The collapse of these critical ecosystems' ability to provide water would greatly impact the pastoral community, as water is the most valuable resource for both people and animals in the drylands. These changes have led to temporal and spatial destabilizing conditions where pastoral movements are not able to keep pace with the changing availability of rangeland resources due to a combination of environmental, economic, and political factors.

As a consequence of these socio-economic and climatic changes, social-ecological vulnerability of pastoral social-ecological systems has increased. This is also impacting the growing urban population, as the traditional pastoral systems can no longer meet the increased demand for milk and meat. In this paper, we more formally examine the vulnerability of Mongolian rangelands and explore possible adaptation options.

2. Materials and Methods

2.1. Study Areas

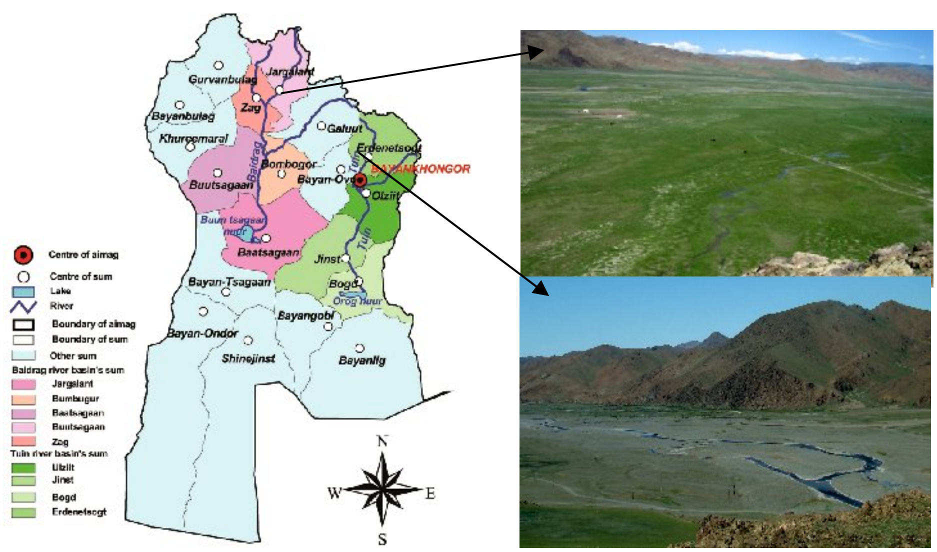

Figure 1. Map of the Tuin and Baidrag river basins in Bayanhongor aimag, Mongolia is shown on the Map.

Dryland Development Paradigm (DDP) (Reynolds et al. 2007) was used for analysis of pastoral social-ecological systems in the Tuin and Baidrag river basins, located in Bayanhongor aimag (province), Mongolia (Figure 1). These two rivers are major rivers located in the southern Khangai Mountains. The Tuin river flows into lake Orog, and the Baidrag – lake Boon Tsagaan. The study area covers different ecological zones: from forest steppe in high mountains, steppe in the middle, and desert-steppe in the southern part. These ecological systems were connected not only through natural processes like river flow, but by humans through livestock movements historically. Even historic administrative units included all ecological zones, taking into account cultural landscapes.

2.2. Methods

Social surveys, climate change, land use and cover change, social-economic assessments, and integrated social-ecological assessments were used for this study. For social surveys, we have used the Dryland Development Paradigm as framework for understanding key slow variables and thresholds of river basin social-ecological systems. Questions for the social surveys were finalized after preliminary surveys and visits to study sites. Climate change analysis included the warming trend, drought and *zud* indexes calculation. Livestock dynamics and composition change were also included to study land use and cover change. Social-economic study included HDI and social vulnerability assessments.

Rangelands in Mongolia were studied at community, river basin and country scales. The Dryland Development Paradigm, DDP, (Reynolds et al. 2007) was used to analyze pastoral social-ecological systems in the Tuin and Baidrag river basins, located in the Southern Khangai Mountains of Mongolia (Chuluun et al., 2010). The DDP was also used to frame discussions with key stakeholders to understand the main drivers of system dynamics, critical slow variables and thresholds already crossed in pastoral social-ecological systems in our study area. The social survey results were then integrated with socio-economic and climate data analysis.

The rangeland ecosystem vulnerability index is a combination of a drought index and a rangeland use index (Figure2). The index is high in response to increasing drought and declining plant biomass due to overgrazing.

$$EV = D + \Delta N \quad [1]$$

EV Rangeland Ecosystem Vulnerability index; D - Drought index; ΔN -stocking rate index.

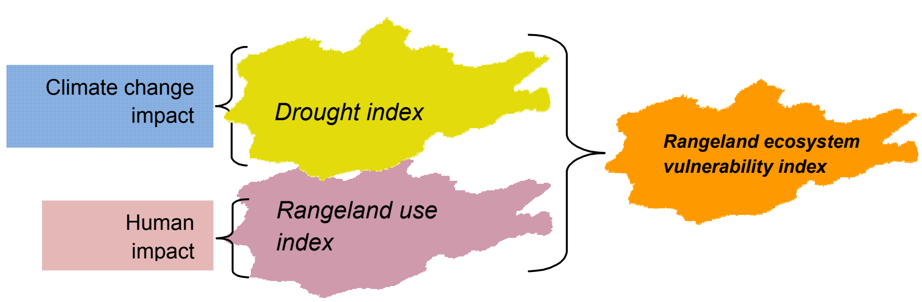

Figure 2. Methodology for rangeland vulnerability assessment

Drought index

The summer drought index was calculated using Ped index-difference normalized temperature and normalized precipitation indices as:

$$D = \sum_{t=1}^{n}\left(\frac{T-\overline{T}}{\sigma_T}\right) - \sum_{t=1}^{n}\left(\frac{R-\overline{R}}{\sigma_R}\right) \qquad [2]$$

where D-drought index; T_i and R_i - temperature and precipitation for particular months at the "i" station; T_i and R_i – an average temperature and precipitation for particular months at the "i" station; σ_T and σ_R – fluctuation of temperature and precipitation for particular months at the "i" station, defined with the following formula:

$$\sigma = \sqrt{\frac{1}{n-1}\cdot\sum_{i=1}^{n}(x_i - \langle x\rangle)^2}$$

Where x_i is the "i"-the value of x and <x> is arithmetic average.

Rangeland use index

Rangeland use index was calculated using the formula:

$$\Delta N = \alpha\left(\frac{N-N_o}{N_o}\right) \qquad [3]$$

where ΔN - is the stocking rate index; N-livestock density, sheep unit/ha; N_0-carrying capacity, sheep unit/ha (Mongolian National Atlas. 1990, 2009 and Tserendash. 2006); α - pasture management coefficient was included to take into account other human factors influencing on vulnerability, but it was taken as equal to 1.

Information on seasonal and spatial patterns of these variables was evaluated across Mongolia to assess the multi-scale changes in environmental and socio-economic patterns.

3. Illustration of results

3.1. Dryland Development Paradigm Application

The following findings, related to 5 principles of the DDP, were based on local key stakeholder's opinion and data analysis (Chuluun and Smith, 2011) : DDP1: Dynamics of coupled human-environmental system is defined by primarily by climatic disasters such as drought and zud; DDP2: Climate change, particularly, global warming became critical slow variable. Indeed, temperature increased by more than 2^0C since 1940 in our study site. Global warming is increasing social-ecological vulnerability to climate change, gradually leading to decreased water and forage resources; DDP3: Water resource decrease due to global warming in the region already exceeded the threshold level. Only 3 rivers out of 25 (based on a map 1969) were inflowing into the Tuin river during our field survey in summer of 2009; DDP4: "Both global and local regulation are critical" as key stakeholders concluded; DDP5: A traditional knowledge for adaptation to climate variability and extremes is still valuable. However, a body of up-to-date knowledge, enhanced with knowledge on climate change (trends, variability and extreme events), and its impact on social-ecological vulnerability, is essential for management and policy development of pastoral human-environmental systems. Main points of the DDP application to our study area are summarized in the Table 1.

Table 1. Dryland Development Paradigm Application for the Tuin and Baidrag river basin social-ecological systems

Principle	Pastoral social-ecological systems in Mongolia	Key implications for research, management and policy
P1: H-E systems are coupled, dynamic, and co-adapting, so that their structure, function, and interrelationships change over time.	During last 2 decades of critical transition to democracy and market economy: ~ Pastoral SESs became more dynamic with goat number increase (due to income from cashmere) and zud impact on livestock loss, which have trade-offs for human or ecosystem well-being; ~ Any mobility and/or no cooperation on common rangelands make the pastoral H-E system dysfunctional; and, ~ Institutions became weaker compared with pre-negdel period, when traditional informal institutions were in place, or socialist period when both lands and livestock were common property.	ki-1: Additional comprehensive research is needed for understanding changes (trends and variability) in resilience and adaptive capacity of pastoral social-ecological systems to interacting climate change and market forcing; ki-2: Management of pastoral social-ecological systems require strategies to cope with both trends, and variability; ki-3: A "win-win" policy, that strengthens both social and ecological resilience is necessary;
P2: A limited suite of 'slow' variables are critical determinants of H-E system dynamics.	~ Global warming is reducing forage and water resources overall and seasonally; and, ~ Overgrazing increased with privatization of livestock.	ki-4: Water resource decrease due to global warming became key slow variable. Research, management and policy are necessary to cope with it; ki-5: Spring is becoming a bottleneck in short-grass steppe areas both due to drying and overgrazing. Without pro-active policy in these areas, desertification will advance;
P3: Thresholds in key slow variables define different states of H-E systems, often with different controlling processes;may change over time.	Water resources decrease has crossed threshold level and leading to collapse according to a survey among local stakeholders in the Tuin river basin in summer of 2009. ~ The Orog lake was dried out in summer of 2009, but it was half filled in 2010; and, ~ Only 3 out of 25 (marked in old map) rivers and streams were flowing in 2009.	ki-6: Continued drying of many streams and lake water reduction indicate crossing of thresholds at different levels. Improved management in the remaining river basins and strengthening of "one-river" pastoral communities along these rivers are key ways to reduce vulnerability;
P4: Coupled H-E systems are hierarchical, nested, and networked across multiple scales.	River basin is great example of this: ~ Coupled hot ails embedded in stream community, small river community, or coastal community,are all embedded in the Tuin river community. The communities along	ki-7: Integrated river basin social-ecological system management plans must be developed, which incorporate not only lower scales of coupled H-E systems, but aimag social-ecological systems;

	the three remaining inflowing rivers could each be considered as key “neg golynhon” or one-river communities.	
P5: The maintenance of a body of up-to-date LEK is key to functional co-adaptation of H-E systems.	LEK, both traditional and scientific knowledge, is critical for adaptation. Many development projects may be mal-adaptive because of ignorance of traditional informal institutions, knowledge on rangeland management, and culture.	ki-8: The identified gaps: ~ Vulnerability increase due to feedbacks between interacting climatic and human factors; ~ Forecasting ability of pastoral SES; ~ Monitoring of SESs; ~ Prime examples of the best SESs based on hybrid scientific and traditional knowledge, technology and innovation; and, ki-9: Finally, it is necessary to have diverse adaptive policies for different ecological-economic zones of Mongolia.

3.2. Climate and Land Use Changes

Interestingly, the proportion of goats (goat fraction) in the total livestock numbers was very stable, hovering right around 30%, during the socialist period between 1970 and 1990. The goat fraction increased up to 45% by 1999 and 60% by 2010 since the privatization of livestock in early 1990s (Figure 4). The goat fraction did not change during drought-zud events in 1999-2002 and 2009-2010, despite massive livestock losses. The biggest increase in goat fraction over 30% occurred in our study areas, particularly in Bogd, Buutsagaan and Bombogor sums (Figure 5).

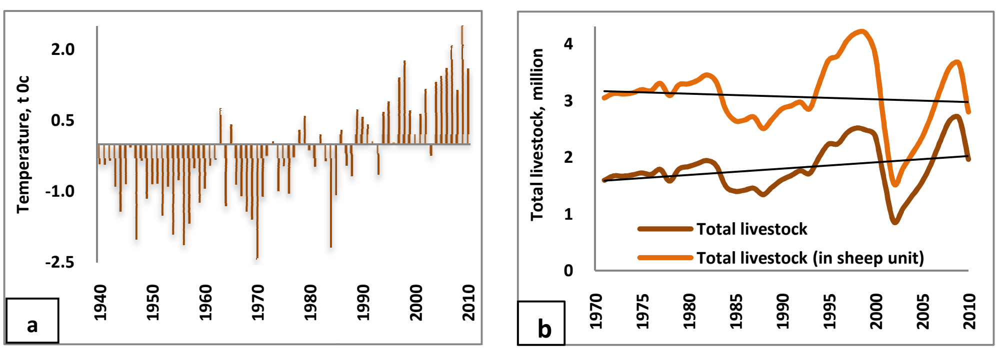

Figure 3. a. Annual temperature in Bayanhongor.b. Livestock dynamics in Bayanhongor aimag

Long-term temperature trend since 1940 shows a clear warming trend by more than 2^{0}C in our study area. An intense warming (Figure 3a) and transition to a market economy coincided during last two decades.

Livestock numbers became more dynamic during last two decades (Figure 3b). Livestock number increased by about 30% during early 1990s after privatization of livestock certainly contributed for overgrazing of rangelands. Drought summers and zuds of 1999-2002 caused huge livestock losses. The recovery of livestock took five to six years. However, summer drought in 2009 followed by *zud* in winter of 2010 resulted in more than 300,000 livestock loss in Bayanhongor aimag (Statistical office of Bayankhongor aimag). Therefore, both climatic and market factors play important role for livestock dynamics.

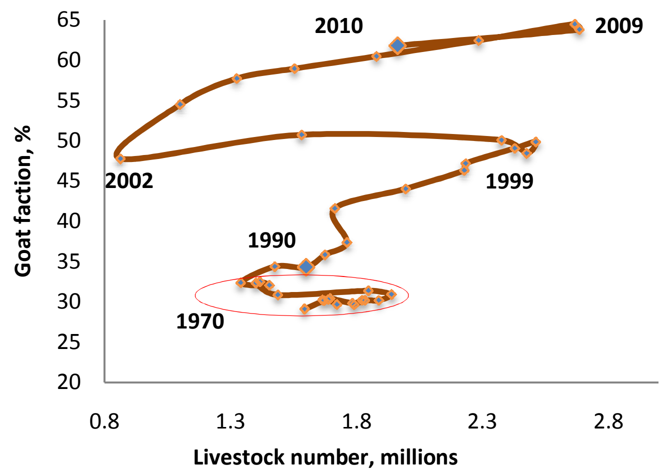

Figure 4. Regime shift since transition to market economy early 1990.

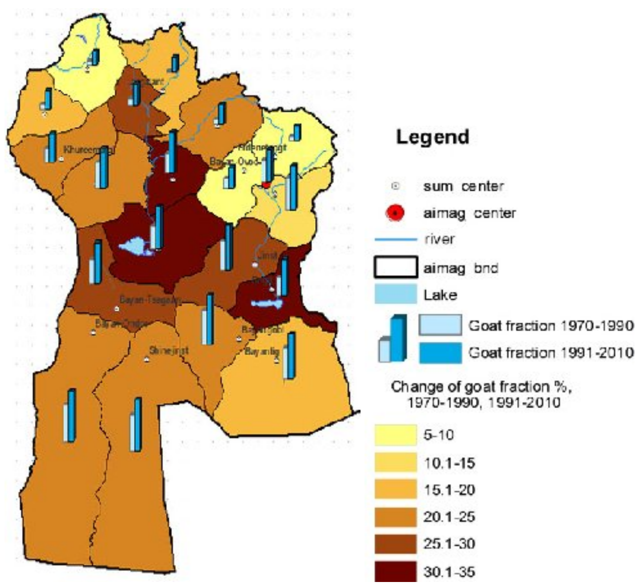

Figure 5. Change of goat fraction in the total livestock

Droughts occur more often in desert-steppe region compared to forest steppe and steppe regions (Figure 6a). Ecological vulnerability, which accounts both drought and stocking rate relative to carrying capacity, is greater in desert-steppe region relative to forest steppe and steppe regions (Figure 6b & 7a).

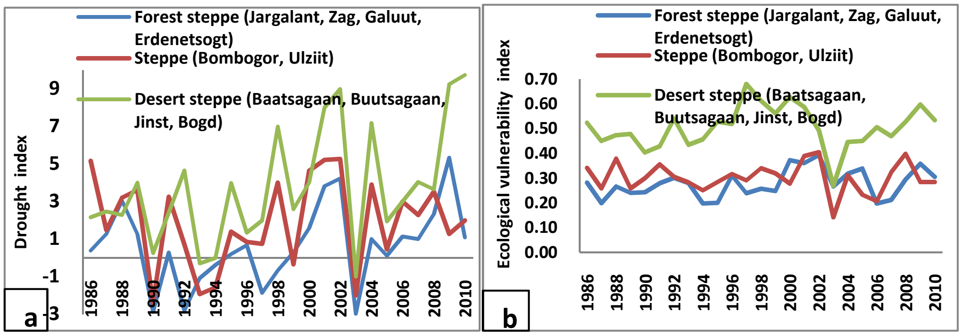

Figure 6. Drought (a) and ecological vulnerability (b) assessment in the Tuin and Baidrag river basins by ecosystem type (1986-2010).

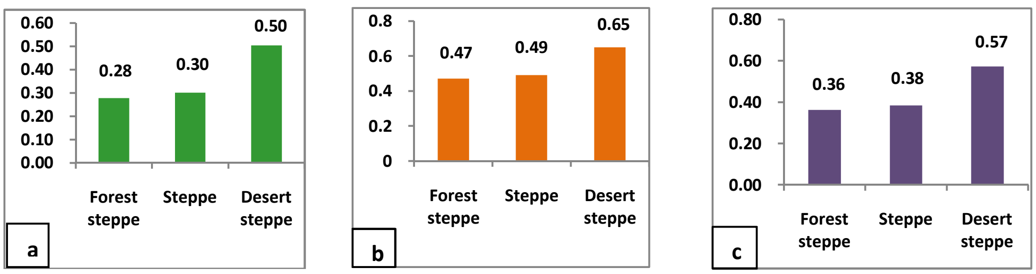

Figure 7. Ecological (a), social (b) and social-ecological vulnerability (b) assessments in Tuin and Baidrag river basins by ecosystem type (1986-2010) (Forest steppe: Jargalant, Zag, Galuut, Erdenetsogt; Steppe: Bombogor, Ulziit; Desert steppe: Baatsagaan, Buutsagaan, Jinst, Bogd)

Social vulnerability of sums (districts) was calculated based on wealth (livestock number per capita), robustness (livestock loss during zud events of 1999-2002 and 2009-2010) and distance to the Bayanhongor aimag center (Figure 7b). Social vulnerability is high when wealth and robustness are low, and distance to the market is long. Sums located in desert-steppe zone have higher social vulnerability relative to sums located in forest-steppe and steppe zones. Vulnerability of social-ecological systems in desert-steppe zone is higher than vulnerability in steppe and forest-steppe zones (Figure 7c).

4. Discussion and Conclusions

In coping with greater socio-ecological vunerability due to both climate disasters and market forces in Mongolia, there is a greater need for adaptive regulation and innovative solutions. Continued research and assessments are needed to track the growing complexity and interchange of variables including the effects of global warming.

Ecological vulnerability (drought, stocking rate relative to carrying capacity) and social vulnerability (livestock number per capita, distance to the market, livestock loss during the zud) assessment trends showed that social-ecological vulnerability have increased in desert steppe region compared to other ecological zones. This indicates that the desert-steppe region is becoming more vulnerable from climate change, land use change and transition to market economy.

Eight key implications for research, management and policy for the Tuin and Baidrag river basin social-ecological systems were summarized in the table 1.

1. Interaction of climate change and goat number increase in different ecological zones was not understood well;
2. We do not have any adaptation policy yet to respond for gradual climate change;
3. We do not have any research or policy to strengthen social-ecological resilience;
4. Water resource depletion is very serious issue. Adaptive options may be costly. For example we may have to build dams to restore water from snow melting and flooding;
5. Proactive policy is needed during spring period, especially in short grass zones;
6. Conservation and strengthening of surviving traditional institutions is important, especially along the remaining rivers;
7. Integrated river basin social-ecological system management is key issue for dryland sustainability; and,
8. It is necessary to have diverse adaptation policies in different ecological-economic zones of Mongolia. There is no panacea.

These research findings and recommendations were used for creating a Tuin river basin sustainable management plan, developed in collaboration with the Tuin River Basin Consul.

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Introduction

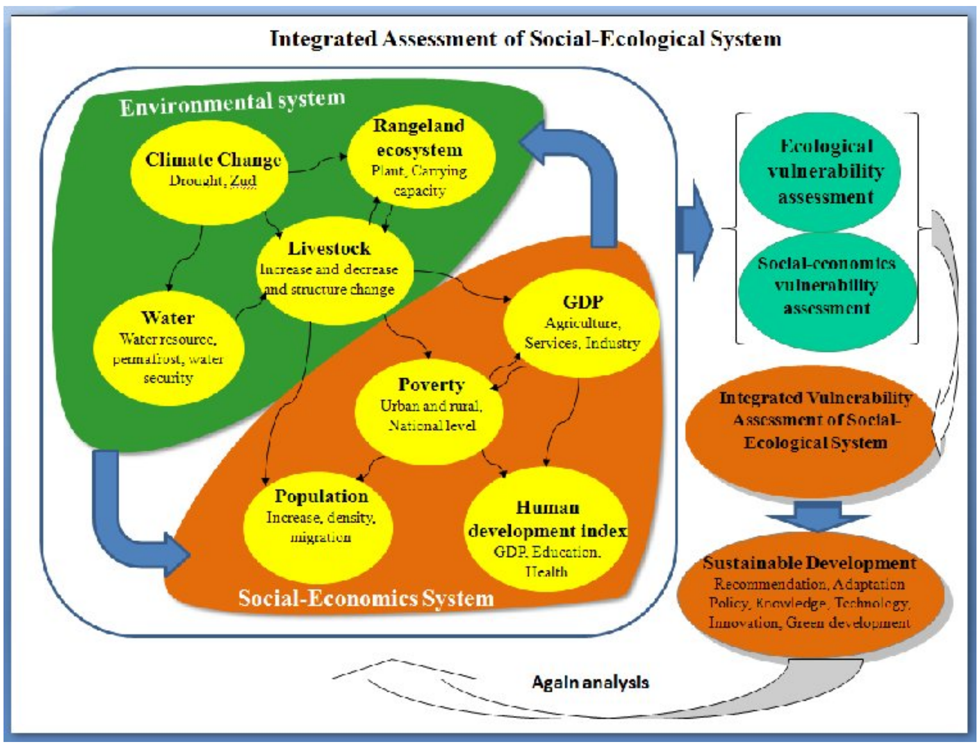
Project introduction

We studied pastoral social-ecological systems in the Tuin River Valley, located in the Southern Khangai Mountains to assess factors in vulnerabilities in the human-environmental systems in these regions with hopes of developing possible policy framework by applying Dryland Development Paradigm (DDP). In these areas remote from the market, Mongolian traditional pastoral communities still function, because traditional coping methods manage climate (seasonal) variability using the customary cultural landscapes. The transition to a market economy two decades ago indirectly influenced the increase in the number of goats because of their cashmere values. The increase in the number of goats in livestock composition is contributing to increased rangeland degradation, as many herders acknowledge. Yet this increasing dependence on the value of cashmere means when cashmere price went down last year, it hurt the well-being of herders. This winter, herders from our study area experienced *zud* disaster. It is likely many herders suffered large livestock losses. On top of these political, social, and ecological perturbations, climate change--particularly--global warming and globalization, are becoming critical slow variables. Global warming is increasing social-ecological vulnerability to climate change and variability, gradually leading to decreased water resources and reduced forage for livestock. Water resource decrease due to global warming in the region already exceeded the threshold level, and led to drying out of the Orog Lake, into which the Tuin River flows. On the other hand, a globalization with technological innovation and opportunities promises positive hopesof enhancing adaptive capacity to climate change. There is an unofficial hierarchy in these informal traditional communities. This nested local knowledge, enhanced with knowledge of climate change (trends, variability and extreme events) and its impact on socialecological vulnerability, is essential for management and policy development. A body of up-to-date local knowledge should serve as a foundation for sciencebased frameworks for legal support, policy, and good governance to achieve sustainable development in the Tuin and the Baidrag River Basin

Objectives

Our goal and objective is to help develop an effective, adaptive **policy framework for sustainable development of drylands in the Tuin and the Baidrag River Basins of Bayanhongor Aimag, located in the Southern Khangai Mountains, to increase its adaptive capacity and resilience to climate change. Dryland development strategies for the Southern Khangai Mountains are being developed with participation of local stakeholders.** We have 3 main objectives in order reach our goal:

1. To conduct integrated assessment of the Tuin and the Baidrag River Basins, riparian ecosystems and their services;
2. To raise awareness about vulnerability of the Tuin and the Baidrag Rivers and riparian ecosystems to climate and land use changes;
3. To develop climate change adaptation and sustainable development strategies for the Southern Khangai Mountains with participation of local stakeholders.



Outcomes

This study was focused in the Tuin and the Baidrag Rivers Basin. During its first year, the project provided scientific knowledge on climate change, its impact on rangeland ecosystems, sustainable land-use, resilience reduction with land fragmentation in arid and semi-arid lands, and research findings in a suitable format for policymakers and resource users.

Integrated drought-*zud*, pasture use and ecological vulnerability indexes were calculated for Erdenetsogt (forest steppe), Olziit (dry steppe), Jinst (desert steppe) and Bogd (desert steppe) soums, using climate and livestock data (1986-2008). Relations between average values of ecological vulnerability during 1986-2008 for Erdenetsogt, Olziit, Jinst and Bogd soums were respectively, 1:1:1.1:1.5, which indicate that desert steppe regions of both the Tuin and Baidrag Rivers Basin is more vulnerable to climate and land use changes.

We studied examples of a successful herder (a leader of *hot ail*), who is doing well with his traditional knowledge and management skills (Win-Win model), the Ortomt River community (traditional community model), herder with fenced pasture (rich herder model), and "tragedy of commons" for pastoral social-ecological systems . Many traditional pastoral communities are at the junction between a sustainable livelihood at a "Win-Win" situation (both "Win" ecologically and "Win" socially) and a "Tragedy of Commons" collapse scenario.

Global warming has become a critical slow variable, already passing thresholds in depletion of surface water, "leading to a collapse" according to the social survey in the Tuin River community. That Tuin River is not reaching the Orog Lake and the Orog Lake is dried out already for several years are prime examples. Frequency and intensity of climate disasters (drought, *zud*, dust and sand storms, and floods) increased as consequence of climate change, revealing increased environmental vulnerability.

Participating countries

Mongolia, USA and Australia. Mongolia is a place for project implementation. Dennis Ojima, USA and Mark Stafford Smith, Australia are voluntary advisers.

Study area

(1) ***The Tuin river basin:*** Forest steppe (Erdenezogt), steppe (Bayankhongor, Olziit), desert steppe (Jinst, Bogd)- 5 soums.

(2)The Baidrag river basin: Forest steppe (Galuut, Zag, Jargalant), Steppe (Bombogor), desert steppe (Baatsagaan, Buutsagaan)- 6 soums.

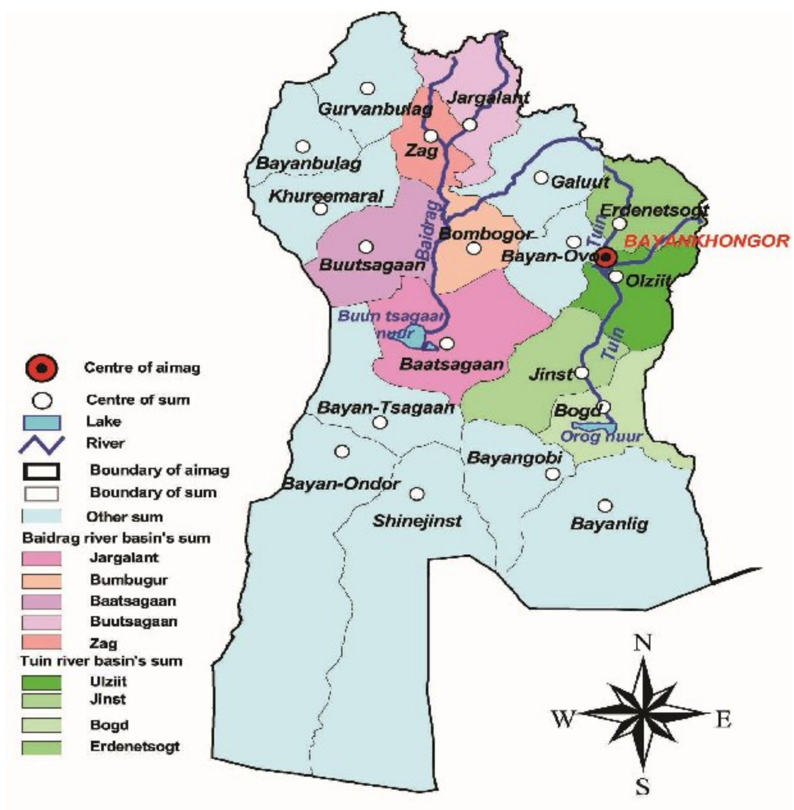


Figure 1 Study area: The Tuin and The Baidrag river basins in Bayankhongor aimag

1. About The Tuin River Basin

The Tuin river originates from the Khangai mountains, and flows into the Orog lake. The Tuin river proceeds through soums Erdenetsogt, Olziit, Jinst and Bogd of Bayanhongor Aimag (Figure 3). The Shargaljuut River, Biiriin River, and Hujirt River all flow into the Tuin River (243 km long).

Long-term average flow of the Tuin River is 3.15 m3/s near the Bayanhongor City and 1.91 m3/s near the Bogd Soum (Davaa 2001). Preliminary calculation showed that we need to increase the Tuin River flow by 51% in order to stop the Orog Lake from shrinking (Davaa 1993). It means the Tuin River flow at the Bogd station must increase from 1.91 m3/s to 2.88m3/s. Mean annual precipitation is 234mm in Erdenetsogt Soum, 214 mm - in Bayanhongor City, 150 mm – in Olziit Soum and 70 mm - in Bogd Soum.

Since 1940, the temperature at Bayanhongor City has increased by about 20C with more intense warming occurring during the last two decades. Annual precipitation has a decreasing trend, with the most decrease in rainfall during the growing season.

Meanwhile, land use intensity, especially since 1996, has increased dramatically with mining increase, livestock density increase, and loss of traditional mobility. Almost 40,000 people, or 50% of Bayanhongor Aimag's population, currently live in the Tuin River Basin. Population of Bayanhongor city is 27,000.

During 1999-2001 *zuds* following droughts, almost 60% of livestock was lost and the livestock (in sheep units) has not recovered yet. In Erdenetsogt Soum, 60% of livestock are yak and horse, but in Bogd and Jinst Soums, 80% of livestock are goats.

We studied the complex social-ecological systems in Tuin River Basin's Soums. Tuin River Basin's ecosystem is the keyto living sustainably for the local people and ensuring biodiversity in the long-term. Not only does it support half of Bayanhongor Aimag's population, but also 670 thousand livestock.

Erdenetsogt Soum. This soum is located in southern part of a forest steppe zone of Khangai Mountains. Erdenetsogt is 4100 km2. Tuin Riverhead flows down from Erdenetsogt Soum. The soum is 26 km from the aimag center and has 4206 people. Seventy-seven percent of inhabitants are herders, raising livestock in countryside, and the rest live in the soum center. Erdenetsogt boasts the most number of animals and the most number of people in the aimag.

Ulziit Soum. This soum is situated nearest to the aimag center at a distance of 17 km, in mountain steppe zone of Tuin River Basin. According to 2008 statistical data, Ulziit Soum had 3477 population and 177405 animals. Goats and sheep comprise majority of the livestock. Around 80 percent of the total population, live in countryside raising livestock and 20 percent in the soum center.

Jinst Soum. This soum is located 93 km from aimag center and covers 53 thousand km of land. Jinst Soum's ecological zone is desert steppe and has the smallest population, numbering 1958 local residents. According to the 2008 census, Jinst Soum's herders own 119361 animals. Goats and sheep dominate, with 81 percent being goats.

Bogd Soum. Bogd Soum is 122 km from aimag center and in desert steppe zone of Tuin River Basin. The population is 2902. Seventy-eight percent of the total population live in the countryside raising livestock. The rest live in the soum center. Tuin River's mouth and Orog Lake are in Bogd Soum. According to 2008 statistical data, 159500 animals were counted.

Tuin River. Tuin River flows from the riverhead in Erdenetsogt Soum in Khangai mountain, and through Ulziit and Jinst Soum, pours to Orog Lake in Bogd Soum. Area to accumulate water is 9410 км2 and total length is 243 km and Shargaljuut, Biir and Hujirt River empty to Tuin River. Annual average flow of Tuin River is 3.15 m3/s in Bayanhongor Soum and 1.91 m3/s in Bogd Soum (B.Myagmarjav, G.Davaa, 1999). Now Tuin River gets in underground in Jinst Soum (N45 31.811 E100 35.562, July 02, 2009) and then flows on the ground in Bogd Soum. It is calculated that should increase by 51% in order to reach Tuin River to Orog Lake (G.Davaa, 1993).

Orog Lake. This lake is located at 1217 m above sea level in the back Great Bogd mountains. It has tectonics derivation. Tuin River Basin's ecosystem is very vulnerable to climate change. Tuin River sinked and so that Orog Lake dried up after 1999-2002 drought and zud disasters. But this lake have not still been had water after filling up water in 2005. (Personal communication with environmental officer of Bogd Soum, Lhagvasuren, 2009). One of the water sources of the lake was swamps around it. To conclude, it is true to say that the lake, which provides water people and animals, was a keystone to keep sustainability of social-ecological systems

Orog lake had water several years ago

Dried bottom of Orog lake. 2009.

2. Baidrag River Basin

Baidrag River. Baidrag River starts at confluence of Buga River, Nariinteel River and Mandal River in the southern Khangai mountain, and the river's delta flows into the largest lake Boontsagaan in the southern Mongolia. Moreover, the river reaches at Adgiin Tsagaan Lake when it has large water, and dries up when it has less water. Water conductivity was 7.40 at Baidrag River bridge and delta area to Boontsagaan Lake was 0.48 m3/s in 1988. Most water of Baidrag River flows into Boontsagaan Lake through under ground stream.

Boontsagaan Lake. Boontsagaan Lake is the biggest lake in the southern part of Mongolia. Boon Tsaagan Lake is a large saltwater lake located at the end of the Baidrig River. The lake is protected under the Ramsar convention as a wildlife destination and is the most famous lake in Bayankhongor's "Valley of Lakes". The lake is famous for the varied wildlife present, including breeding relic gulls. The lake is located about 17km west of the Baatsagaan Soum center and nearly 90km southwest of the Bayankhongor Aimag center. Despite the lake's proximity to the Gobi Desert, it oftens rains here in the summer.

Large permanent lakes. Gently or very low mineralised waters. Smaller lakes with variable water permanence. Slightly or moderately mineralised waters. Water turbidity not due to inorganic suspended particles. Very mineralised or saline waters (not hyper saline waters). Shallow lakes and lagoons both with permanent or temporary waters. Slightly or highly mineralised waters. High water turbidity due to inorganic suspended particles. Hyper saline lakes and lagoons.). Its surface area is 28617 hectar.

"Buuntsagaan lake",Baatsagaan sum, Baynhongor. 2009.08.08

The river basin sums

Galuut Soum. It is located at a distance of 95 km from aimag center and in the forest steppe mountain zone or in northern part of the river basin. The soum is one of the leading soums by livestock number and human population number in the aimag. It has population number of 3862 and livestock number of 142 thousands (231 thousand by sheep unit).

Jargalant Soum. The soum is located at a distance of 163 km from aimag center and in the forest steppe mountain zone or in northern part of the river basin. The soum is source area of Baidrag River. It has population number of 2917and livestock number of 79 thousands (152 thousands by sheep unit).

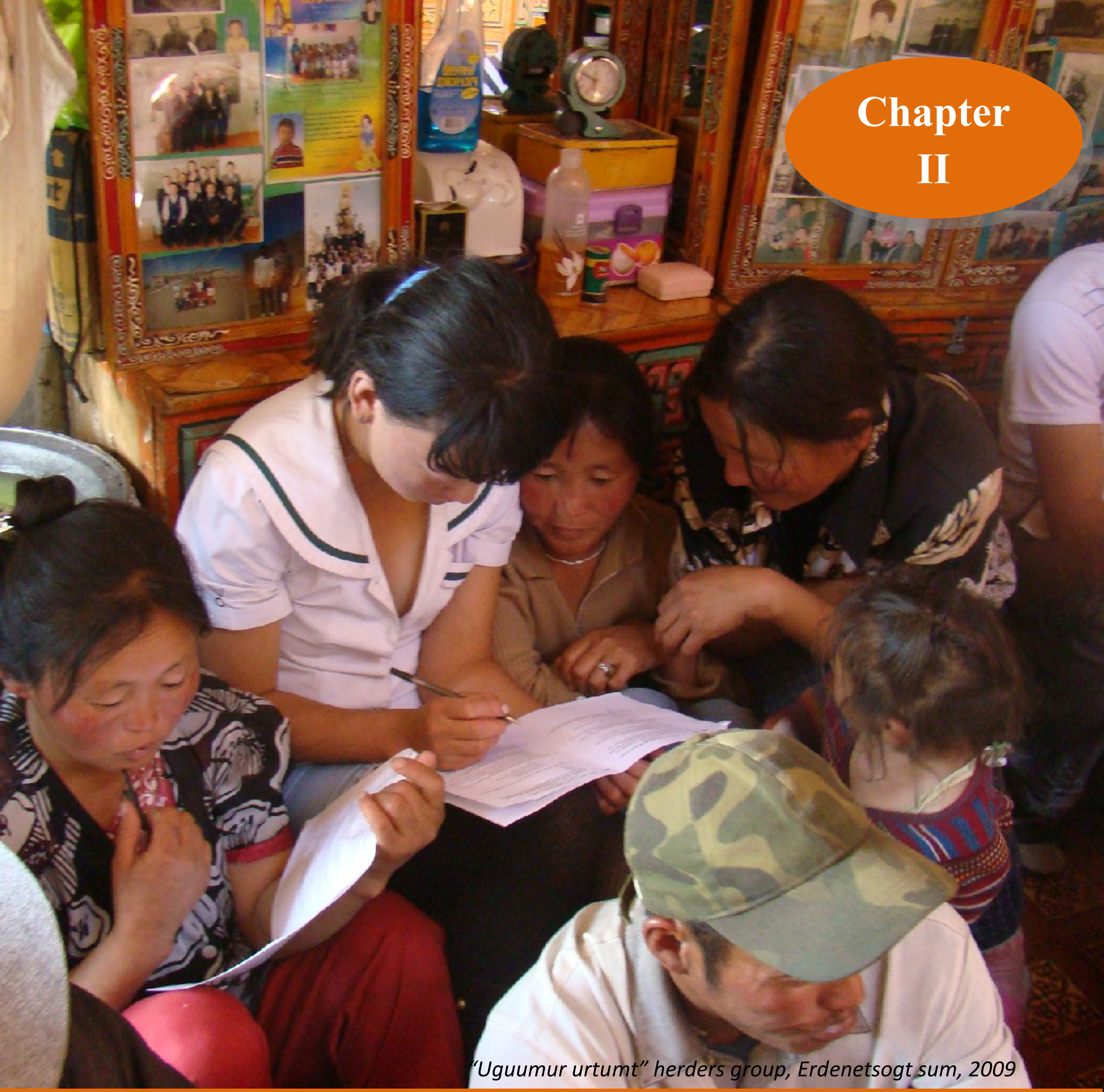
Zag Soum. The soum is located at a distance of 188 km from aimag center and in the forest steppe mountain zone or in northern part of the river basin. The Baidrag River flows through middle part of Zag Soum. It has population number of 2016 and livestock number of 68 thousands (96 thousands by sheep unit).

Bombogor Soum. It is located at a distance of 95 km from aimag center and in the steppe zone. Baidrag River flows through western part of the soum. The soum has population number of 2767 and livestock number of 102 thousands (115 thousand by sheep unit).

Buutsagaan Soum. The soum is located at a distance of 174 km from aimag center and in the desert steppe zone. Baidrag River flows through eastern part of Buutsagaan Soum. It has population number of 3435 and livestock number of 140 thousands (165 thousand by sheep unit).

Baatsagaan Soum. It is located at a distance of 143 km from aimag center and desert steppe zone or in the southest part of the river basin. Baidrag River flows into Boontsagaan Lake in the middle part of the soum. The soum has population number of 3243 and livestock number of 130 thousands (154 thousand by sheep unit)

Chapter II



"Uguumur urtumt" herders group, Erdenetsogt sum, 2009

PARTICIPATORY STUDY

- **Social survey**
- **Participatory workshops**
- **Scenarios of pastoral social-ecological systems**

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Social Survey related to "Dryland Development Paradigm" (DDP)

The social survey among the stakeholders in the Tuin and Baidrag river basin yielded interesting results for understanding of coupled social-ecological systems in the Tuin river basin from the dryland development paradigm's point of view. The following statements are the main outputs of this study in the Tuin river basin:

Figure 2. *The Fractured "Tuin gol", Dried "Orog lake"*

1. Dynamics of social-ecological systems is defined primarily by climatic disaster events such as drought, *zud*, flood and dust storms;
2. Global warming is a critical determinant of social-ecological systems;
3. Surface water shortage is already crossed the threshold level and its leading to collapse of social-ecological systems;
4. Global (44%) and country (31%) level regulations are more important than local government (16%) or community level regulations (9%);
5. Level of policy, which combines up-to-date modern science and traditional knowledge, is fair.

Global warming impacts on surface water decrease. Nowadays only 3 rivers (Shargaljuut, Ortomt and Ovgon Jargalant) out of 99 rivers are still flowing into the Tuin river. A prime example of it is that the Tuin river is not reaching the Orog lake and the Orog lake is dried out already for several years (Fig 2).

Actions are needed in order to improve resilience of human-environmental-systems, combining modern scientific knowledge with traditional knowledge. Climate change also impacts on increased (in frequency and intensity) climate disasters such as drought, *zud*, sand and dust storms, and flood. Thus it was logical to expect global regulation has the highest importance for sustainability of social-ecological systems in the Tuin river basin.

The survey showed high level of environmental awareness, and needs for actions with knowledge based on up-to-date modern science. However, actions without up-to-date body of "hybrid" environmental knowledge, that integrates local management and policy experience with science-based knowledge, may become mal-adaptation to climate change.

Social Survey Discussion of Rangeland Degradation

The social survey among the stakeholders in the Tuin river basin yielded interesting results for understanding of rangeland degradation and policy to reduce it. The following statements are the main outputs of this study in the Tuin river basin:

1. Meteorological factor, particular precipitation decrease (50%), was a number one factor impacting on rangeland degradation. Human factors such as goat number increase (25%) and total livestock number increase (16%) were secondary for rangeland degradation.
2. The role of goats relative to other animals in rangeland degradation was the highest (84%), according to stakeholders' view.
3. A majority (34%) of the participants responded that the Government should implement pasture use tax for animals in order to reduce their numbers, and higher tax for goats for their damage for rangeland degradation. Other regulations by the Government were to give pastures for ownership of herders' groups (31%), and to restore degraded rangelands (19%).
4. A majority (75%) responded that pasture ownership is the way to stop rangeland degradation.

60% of the participants were positive, and 34% - negative in role of herders groups' pasture use in collective and rotational way on rangeland productivity and nutrient quality.

People living in the Tuin river view the meteorological factor, particularly precipitation decrease, as a dominant factor for rangeland degradation. However, land use factor was another important aspect for land degradation. The goat was without doubt main animal relative to other domestic animals in terms of causing damage to rangelands. Taxing animals in order to reduce its number, especially goats, and giving pastures for collective ownership of herders' groups were the highest priority measures by the Government. Pasture ownership was the way to reduce rangeland degradation, and a majority of the survey participants think that pasture use by the herders' groups in rotational manner will conserve rangeland productivity and quality (nutrient quality for livestock).

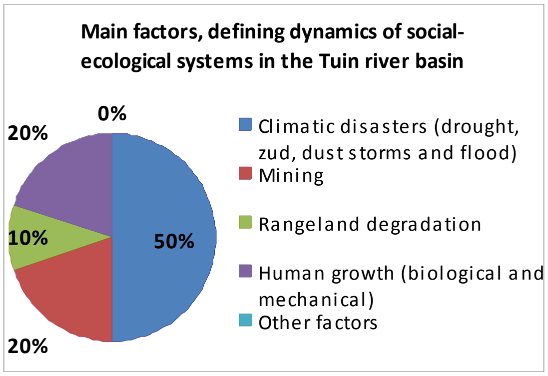
There were many other suggestions such as:

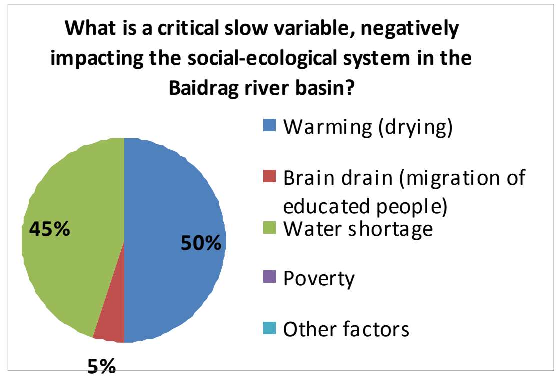
- To produce legal acts for pasture resting, and protection of winter and spring pastures;
- To develop livestock raw materials processing industry;
- Support herders for four seasonal and *otor* movements, making regulations for otor movements and investing for herders' mobility;
- Improve livestock quality and build wells in order to improve pasture use;
- To improve ecological education and invest in nature protection.

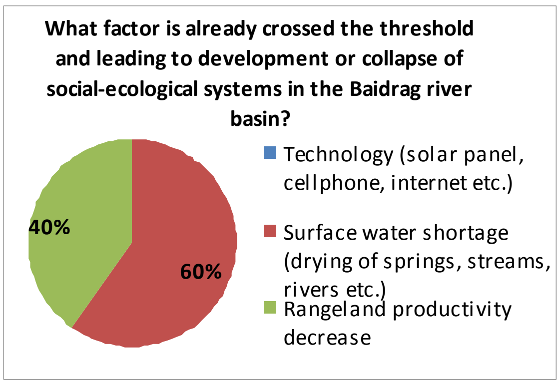
"Global warming became critical slow variable, already over-passing thresholds in terms of its negative impact on surface water and it is leading to collapse" as the Tuin river community thinks.

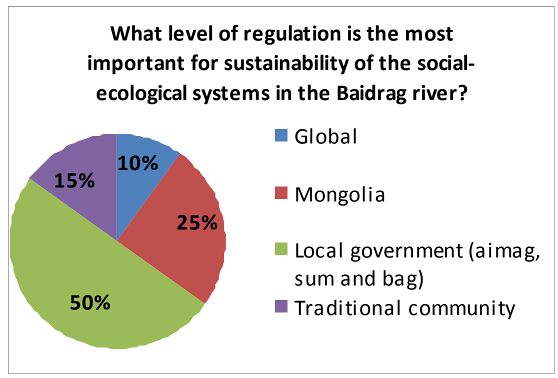
This social survey among the herders and policy makers living in the Tuin river basin was useful to understand social-ecological systems and rangeland degradation from the point of view of the Dryland Development Paradigm and policy development to reduce human-environmental system degradation not only in the Tuin river basin, but at aimag and country levels too.

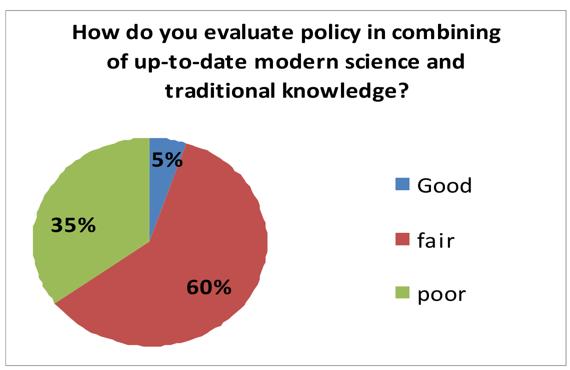
The results of social survey related to "Dryland Development Paradigm



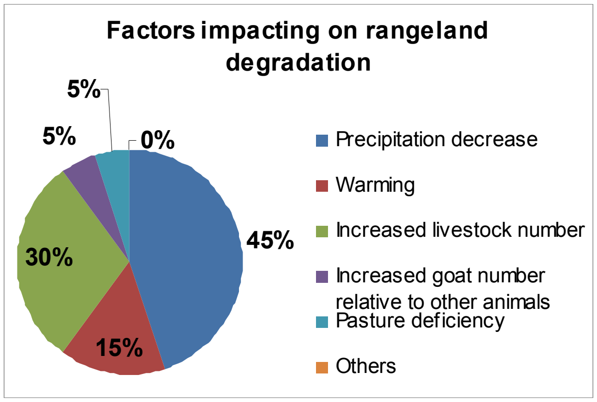


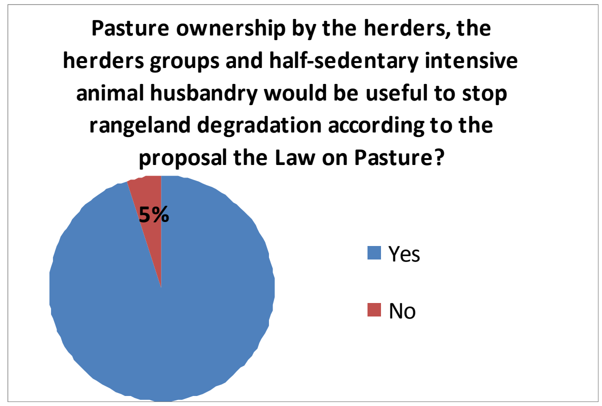






1. Rangeland degradation and policy for its reduction





Dryland Development Paradigm Application

Following findings, related to 5 principles of the DDP, were based on local key stakeholder's opinion and data analysis: DDP1: Dynamics of coupled human-environmental system is defined by primarily by climatic disasters such as drought and *zud*; DDP2: Climate change, particularly, global warming became critical slow variable. Indeed, temperature increased by more than 2^0C since 1940 in our study site. Global warming is increasing social-ecological vulnerability to climate change, gradually leading to decreased water and forage resources; DDP3: Water resource decrease due to global warming in the region already exceeded the threshold level. Only 3 rivers out of 25 (based on a map 1969) were inflowing into the Tuin river during our filed survey in summer of 2009; DDP4: "Both global and local regulation are critical" as key stakeholders concluded; DDP5: A traditional knowledge for adaptation to climate variability and extremes is still valuable. However, a body of up-to-date knowledge, enhanced with knowledge on climate change (trends, variability and extreme events), and its impact on social-ecological vulnerability, is essential for management and policy development of pastoral human-environmental systems. Main points of the DDP application to our study area are summarized in the Table 1.

Table 1. Dryland Development Paradigm Application for the Tuin and Baidrag river basin social-ecological systems

Principle	Pastoral social-ecological systems in Mongolia	Key implications for research, management and policy
P1: H-E systems are coupled, dynamic, and co-adapting, so that their structure, function, and interrelationships change over time.	During last 2 decades of critical transition to democracy and market economy: ~ Pastoral SESs became more dynamic with goat number increase (due to income from cashmere) and zud impact on livestock loss, which have trade-off for human or ecosystem well-being; ~ Any mobility and/or no cooperation on common rangelands make the pastoral H-E system dysfunctional; ~ Institutions became weaker compared with pre-negdel period, when traditional informal institutions were in place, or socialist period when both lands and livestock were common property.	ki-1: Additional comprehensive research is needed for understanding changes (trends and variability) in resilience and adaptive capacity of pastoral social-ecological systems to interacting climate change and market forcing; ki-2: Management of pastoral social-ecological systems require strategies to cope both trends and variability; ki-3: "Win-Win" policy, which strengthens both social and ecological resilience is necessary;
P2: A limited suite of 'slow' variables are critical determinants of H-E system dynamics.	~ Global warming is reducing forage and water resources overall and seasonally; ~ Overgrazing increased with privatization of livestock.	ki-4: Water resource decrease due to global warming became key slow variable. Research, management and policy is necessary to cope with it; ki-5: Spring is becoming bottleneck in short-grass steppe areas both due to drying and overgrazing. Without pro-active policy in these areas, desertification will advance;
P3: Thresholds in key slow variables define different states of H-E systems, often with different controlling processes; thresholds may change over time.	Water resources decrease is crossed threshold level and leading to collapse according to survey among local stakeholders in the Tuin river basin in summer of 2009. ~ The Orog lake was dried out in summer of 2009, but it was half filled in 2010; ~ Indeed only 3 rivers out of 25 (marked in old map) rivers and streams were flowing in 2009.	ki-6: Still drying out of many streams and lake water reduction indicates thresholds at different levels. Improved management in the remaining river basins and strengthening of "one-river" pastoral communities along these rivers are key issues.
P4: Coupled H-E systems are hierarchical, nested, and networked across multiple scales.	River basin is great example of it. Coupled hot ails embedded in stream community, small river community or coastal community, which embedded in the Tuin river community. We think that communities along 3 remaining inflowing rivers could be considered as key "neg golynhon"-one river communities.	ki-7: Integrated river basin social-ecological system management plans must be developed, which incorporate not only lover scales of coupled H-E systems, but aimag social-ecological systems.

P5: The maintenance of a body of up-to-date LEK is key to functional co-adaptation of H-E systems.	LEK, both traditional and scientific knowledge, is critical for adaptation. Many development projects may be mal-adaptive because of ignorance of traditional informal institutions, knowledge on rangeland management, culture and spirit.	ki-8: The identified gaps: ~ Vulnerability increase due to feedbacks between interacting climatic and human factors; ~ Forecasting ability of pastoral SES; ~ Monitoring of SESs; ~ Prime examples of the best SESs based on hybrid scientific and traditional knowledge, technology and innovation; ki-9: Finally, it is necessary to have diverse adaptation policies in different ecological-economic zones of Mongolia.

9 key implications for research, management and policy for the Tuin and Baidrag river basin social-ecological systems were summarized in the table 1.

1. Interaction of climate change and goat number increase in different ecological zones was not understood well;
2. We don’t have any adaptation policy yet to respond for gradual climate change;
3. We don’t have any research or policy to strengthen social-ecological resilience;
4. Water resource decrease is very serious issue. An adaptation options may cost a lot, for example we may have to build dams to restore water from snow melting and flooding;
5. Proactive policy is needed during spring period, especially in short grass zones;
6. Conservation and strengthening of surviving traditional institutions is important, especially along the remaining rivers;
7. Integrated river basin social-ecological system management is key issue for dryland sustainability;
8. It is necessary to have diverse adaptation policies in different ecological-economic zones of Mongolia. There is no panacea.

Participatory Workshops

- Tuin river basin and Kick-Off workshop in the Bayanhongor city
- Sum level workshop in the Ulziit sum
- Pastoral community workshop of “Uguumur urtumt” herders group
- Regional level workshop in the Bayanhongor city

1. ***Kick-off and Tuin river basin level workshop of the APN project in Bayankhongor aimag on 22 June, 2009.***

The Council members of Tuin river, Bayanhongor aimag’s policy makers, environmental agency’s staffs and herders participated in the Tuin river basin level and Kick-off workshop in Ecology and Education Center in Bayanhongor aimag.

Figure 3. Tuin river basin level and Kick-off workshop in Bayanhongor, 22 June 2009

2. Participatory and Sum level workshop in the Olziit sum on 01 August, 2009

The Tuin river basin Council members participated in the workshop in Olziit sum. The Tuin river Council's the first meeting was convened after our APN workshop in Olziit and it made decision that our Institute and the Tuin river basin Council will work jointly on the Tuin river basin management plan.

Figure 4. Sum level and Participatory workshop Olziit sum. 03 Aug 2009

3. Participatory and herder community level workshop in the "Ogoomor Ortomt" community in Erdenetsogt sum on 30 July, 2009.

The Ortomt river was one of few remaining streams, inflowing into the Tuin river. This pastoral community, living along the Otromt river, was going to have an official NGO status.
Herders of traditional one river community (*neg golynhon*), living along the river Ortomt of Erdenetsogt sum, Bayanhongor aimag, have formed an official herders' group a year ago. 26 households self-organized into the group not artificially as happened in many parts of Mongolia to take an advantage of international project's benefit. This community lives in the southern slopes of the Khangai mountains.

Figure 5. Community level workshop at the "Ogoomor ortomt" pastoral community in Erdentsogt sum. 30 Aug

4. Regional workshop of the APN project in Bayankhongor aimag on 12 May, 2010.

The Council members of Tuin and Baidrag rivers, Bayanhongor aimag's policy makers, environmental agency's staffs and herders participated in the Tuin river basin level and Baidrag river Kick-off workshop in Ecology and Education Center in Bayanhongor aimag.

Figure 6. Regional workshop in Bayanhongor. 12 May 2010

Scenarios of Pastoral Social-Ecological Systems

- Traditional pastoral system- “Ogoomor Ortomt”-one river community
- WIN-WIN model- Narmandah - Young “National champion” herder
- Rich herder- Lhamhuu – herder with fenced pasture
- Tragedy of commons
- Conclusion

Four types of pastoral social-ecological systems (Fig.7) can be summarized for Mongolia (Chuluun 2008). Examples of different pastoral social-ecological systems were shown in the Tuin and Baidrag river basin, Bayanhongor aimag.

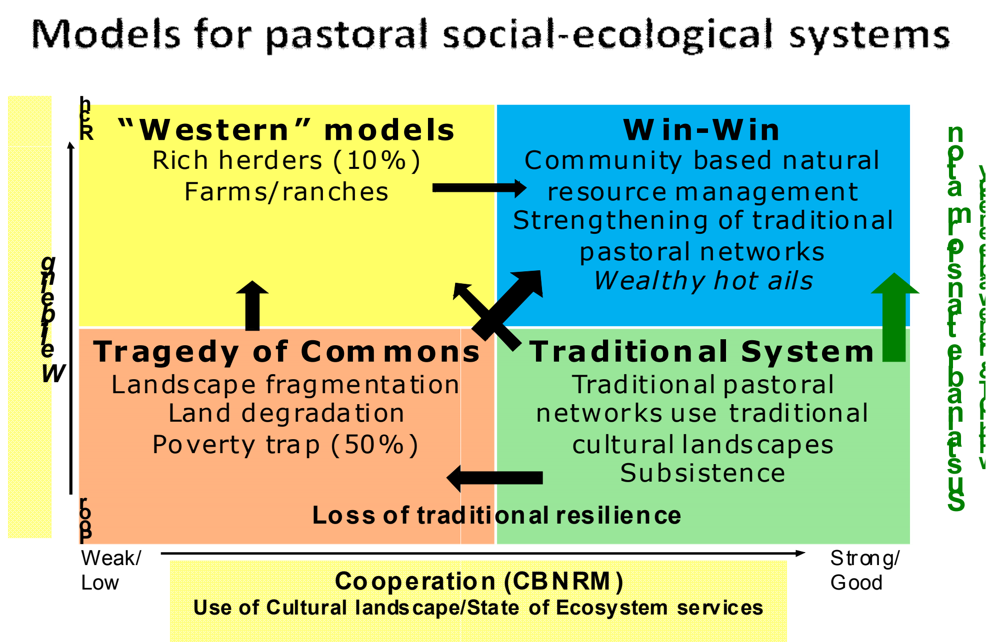


Figure 7. Models of pastoral social-ecological systems.

Traditional system. Cooperation within traditional pastoral networks serves as a mechanism enhancing resilience to climatic disasters. Communal disaster relief mechanisms, assisting the most affected herders in many different ways, were in place. Traditional pastoral communities used cultural landscapes to cope with climate variability and climatic extremes. Due to proper management, rangeland ecosystems used for traditional grazing and ecosystem services were in good condition.

Tragedy of the commons. The rangelands are still State owned in Mongolia although livestock has been privatised. This has been the main reason for the increased overgrazing and ecosystem degradation near both settlements and water sources under capitalism. Poor herders especially have tended to become less mobile, living near towns, infrastructures and water sources as a result causing dryland fragmentation. Generally, herders have not cooperated and have competed more for resources in this scenario. Many herders in this model have lost their traditional resilience mechanisms to cope with climate variability and extremes, and potentially 50% of herders live in poverty. Deterioration of the social-ecological system with ecosystem degradation and increasing poverty happens in this model.

"Western models". Only 5-10% of herders became wealthier through the transition to a market economy. Generally, these rich herders don't cooperate with a larger pastoral community. They often take advantage of the current State ownership of pasture, often causing more damage to ecosystem services. Some of herders have small communities and use traditional cultural landscapes. Thus, some of the traditional networks that use cultural landscapes in sustainable ways can be included in the win-win model, with social and ecological benefits. This group of herders needs to be encouraged through proper pasture and culture landscape ownership mechanisms.

***Win-win model**.* A majority of herders must be transformed into this Win-Win scenario: win ecologically and win socially. The most desirable pathway for pastoral systems would be direct transformation from a traditional system to a win-win state, strengthening traditional pastoral communities with modern technologies such as renewable energy and communication information technology. High levels of literacy among the Mongolian herders (98%) and the suitability of the nomadic culture in concert with wireless communication make such a sustainable transformation very attractive. There is a great opportunity to conserve natural, cultural and social capital in order to maintain the adaptive capacity and resilience of Mongolian pastoral social-ecological systems to climate change and globalization. Teaching sustainable farming techniques to herders living near settlements and water points would be another pathway to reach a *win-win* situation and escape the *tragedy of the commons* state. A reform of administrative-territorial divisions that restores cultural landscapes appears to be the best, most cost effective adaptation option in order to promote the sustainability of coupled social-ecological systems with increased adaptive capacity and resilience to climate change at supra-pastoral community scales.

Case study of different pastoral social-ecological system scenarios was studied shown in the Tuin river basin, Bayanhongor aimag.

Traditional pastoral system- "Ogoomor Ortomt"-one river community

Herders of traditional one river community, living along the river Ortomt of Erdenetsogt sum, Bayanhongor aimag, have formed an official herders' group a year ago. 26 households self-organized into the group not artificially as happened in many parts of Mongolia to take an advantage of international project's benefit. This community lives in the southern slopes of the Khangai mountains. Yaks take a major proportion of livestock, because the herders live in high altitudes. A major income source comes from sale of yak milk and milk products. However, goat numbers are increasing since 2000. Half of herders's households were in age, younger than 40. A leader of the herders' group is Jadamba, 27 years old, graduate from high school.

They have been doing the following activities:

- *They have got ownership of their pasture from the sum government;*
- *After not grazing in 2008 plant biomass in the pasture was improved and it became possible to fatten their animals;*
- *Women have attended the training classes and learned to make sweet and fruit curds and cheese. Their income increased with sale of these products in the aimag center or through salespeople;*
- *They keep traditional religious believes to protect nature, and clean the Ortomt river and river basin every month;*

They have credit-savings pool, which is used for loans. Originally this fund was set as an insurance to

They are planning to find the ways to sale yak meat (the Erdenetsogt sum government was going to export 2,000 yaks to Russia), especially to increase their income through sale of dried yak meat. It was obvious that this community can reach the Win-Win model, if they continue to protect pasture, water and nature, and improve their living standards.

Figure 8. "Ogoomor Ortomt" community's members.

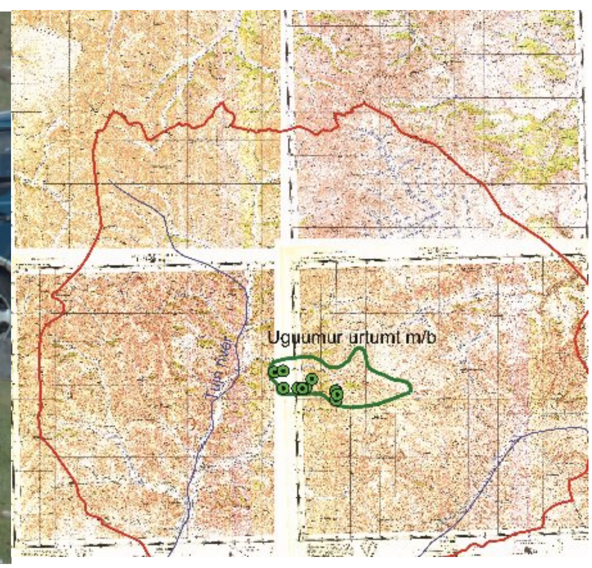


Figure 9. Boundary of pasture, owned by the reduce impact of disasters.

WIN-WIN model- Narmandah - Young "National champion" herder

<u>Family life:</u> Narmandah is 31 years old. He graduated from the high school. He married at age of 17 and has 3 children with ages between 6 and 14. The children study in Bayanhongor aimag center. The children come home in summer time and assist the parents in herding. He lives in Nuramt Har of Olziit sum of Bayanhongor aimag (in boundary area of dry steppe and desert-

steppe). He was living with his grandfather from 6 to 18 years old, learning traditional pastoral management system. Thus he has 20 years experience of herding. He keeps good contacts with his relatives, living in the same area. However, he has to move far from them because of big number of livestock and carrying capacity of pastures.

The household over 70 horses, about 30 cattle, 250 sheep, and over 2,000 goats. His annual income is 24 million togrog. His wife is a hard working woman. She milks 180 goats everyday, makes curd and cheese, and sales in Bayanhongor center. They make more income through sales of their dairy products in summer, instead of keeping whole fall and winter. They also produce the Mongolian vodka every week, but never sale it.

<u>Movement pattern:</u> He moves 8-10 times during a year, and moves for *otor* pasture for 20-80 km. He plans his moving place and duration well because has good knowledge on plants, specifically about their quality, phenology, and suitability for kind of livestock (Fig.11). For instance, he thinks that grazing in on area longer than one month during growing season is main reason of overgrazing and sand movement. That's why he doesn't stay at *otor* longer than one month. It is good for pasture not to be overgrazed and for its quick recover from one hand, and also good for animals for gaining weight and increased productivity. It is important to know what plants are good during what time of year in order to gain weight and increase livestock productivity. For example, grazing of sheep and goats in fall pasture with budargana (*Salsola* sp. and *Reaumurea* sp.) and wild onion (*Allium* sp.), located in the desert-steppe zones, is critical for gaining weight and fat for winter survival.

Figure 10. Herder Narmandakh

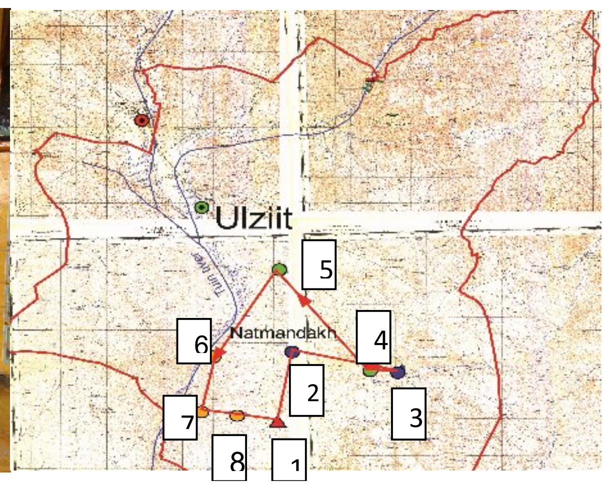


Figure 11. Narmandah's seasonal movement

Disaster management policy

Narmandah left out with 94 goats out of over 200 livestock after 2002 *zud*. After this event Narmandah fully understood that disaster management policy based on both scientific and traditional knowledge is essential for prevention from potential disasters.

Table 2. Moving season, duration and places

№	Season	Duration	Name of place
1	Winter	12/12-2/20	Nuramt har
2	Spring	2/21-4/20	Dund hashaat
3	Spring	4/21-6/10	Nurangiin eh
4	Summer	6/10-7/10	Ulaadgain adag
5	Summer	7/11-8/20	Baruun hargana
6	Summer/Fall	8/21-9/20	Tsagaan ders
7	Fall	9/21-11/20	Gashuuny eh
8	Fall	11/21-12/11	Ovoot hanan

His main policy for disaster management policy are:

- *To keep a number of livestock constant (for instance, if you are expecting 500 kids, then to sale the same number of goats);*
- *To loan money with interest rate 3-5% for people who have needs in money;*
- *To make otor movements often and fatten animals well in order to get more cashmere with better quality;*
- *To prepare hay enough not to keep animal weights;*
  - *To clean winter shelters well in order to keep animals warmer;*

To sale animals in wholesale before they not lost their weight in order to prevent from loss during potential zud, if they had drought in summer

He spends the income, saved from disaster prevention, buying housing, machinery and equipments, and also invests in education.

We visited to Narmandah family after 2009-2010 *zud* on May, 2010. He successfully managed the zud that winter, losing only few animals during the disaster. His *zud* management actions were:

- **40 percent of total animals were killed in fall and the meat was sold in the spring during the "Tsagaan Sar"-a new year by the lunar calendar;**
- **He bought hay and fodder in time when their prices were cheap;**

He also well managed a mating of animals depending on their weight gain

Rich herder- Lhamhuu – herder with fenced pasture

Lhamhuu lives in three river meeting place of the Shargaljuut river of Olziit sum (in the forest steppe zone). He is an old single man and lives with his nephew's family. He has a house, which is located near of his fenced pasture. He owns 42,000 ha fenced pasture since 1990. He doesn't face any pasture degradation or livestock loss during *zud* and droughts. He also made water channel through his pasture from the river, creating wetlands and protecting them. It is unusual to have a fenced pasture, that's why he can be considered as a rich herder because of his fenced pasture. According to current legislation, any herder can't own such fenced pasture.

Fenced pastures have many good benefits:

- *Rangeland ecosystem inside of the fences has diversity of plants with over 50 plant sp. (Carex sp. and Leymus Chinensis are dominant plant sp., many annual plants and forbs). This plant diversity contributes for gaining weight for animals;*
- *He doesn't worry about drought or zud because his fenced pasture has always enough forage for his livestock, serving as the best disaster management method;*
- *The newly-born animals gain weight faster in the fenced pasture;*
- *He also makes hay from his fenced pasture;*
- *He doesn't need to move for otor pastures for long distances, saving expenses from otor movements and labor;*
- *Fenced pasture is the best for protection and recovery of rangeland ecosystems. We even have marmots inside of the fences, while they are absent in surrounding lands.*

Livestock composition and pasture management

He has about 300 small ruminants keeps sheep:goat ratio equil. He also has about 50 cattle and about 10 horses mainly as winter food source. His strategy is to keep livestock number constant, however, he slaughters more animals if summer was dry (Figure 12).

Annual income is 3 million togrog. He has everything what he needs such as car, motorcycle, TV, solar panel et. He is satisfied with his life. He pasy 23,000 togrog as a pasture fee. His nephew lives with his wife and children. All his relatives of school age come to fix his fences and winter shelter during their summer vacation.

Figure 12. Lhamhuu is outside of his house

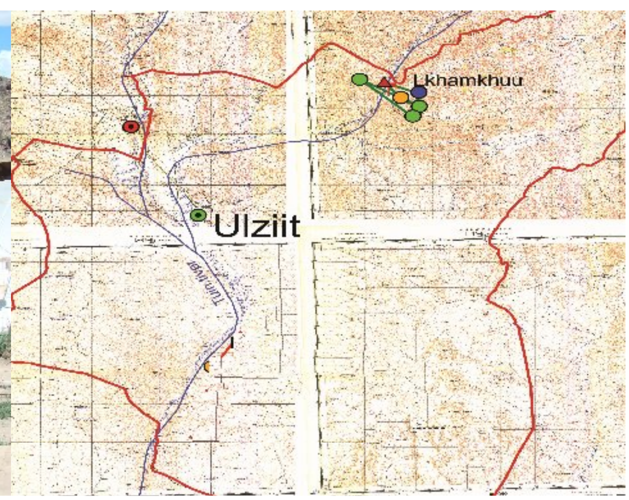


Figure 13. Lkhamhuu's seasonal movement

He thinks that improper and intensive use of water basins during the socialist period is one of main reasons of water flow reduction and drying out. He protects wetlands with fencing. He uses surrounding mountain pastures seasonally. He uses fenced pasture with following schedule:

grazing sheep and goats in spring from March through May 20, then – cattle during May and October (Fig. 13).

We also have learned that this family did well during the zud event of 2009-2010.

Tragedy of commons

One family was introduced as an example of this model by local government officers. This family lives in the southern part of Ovoot Mountain in Olziit sum. This household doesn't move seasonally, live in one place a year around. They survive milking of few animals. Household head was died many years ago, thus woman was head of the family and living with her 3 daughters and 1 son. She used to be the state champion in milking, and the life of family was used to be very good. However, she got few livestock during privatization and her children were not able to raise animals, thus they became poor. She became older and she is surviving on pensions. They have lost contacts with relatives, who could help them. They are not only poor, but they degraded their surrounding lands, digging for gold and making many holes.

Conclusion

We introduced examples of successful herder (a leader of hot ail), who is doing well with his traditional knowledge and management skills (Win-Win model), Ortomt river community (traditional community), herder with fenced pasture (rich herder), and "tragedy of commons" for pastoral social-ecological systems. 2008 Noble prize winner in economics Elinor Ostrom (2008 Resilience Conference, Stockholm) showed that no cooperation (among herders in our case) is the most important condition for the "tragedy of commons", using agent based modeling. Many traditional pastoral communities are still at the stage of bifurcation between sustainable livelihoods "Win-Win" (both "Win" ecologically and "Win" socially) and "Tragedy of Commons" collapse scenarios since it is impossible for all herders to become rich. We need the Government policy, which will lead traditional pastoral communities to "Win-Win" scenario, but not to "Tragedy of Commons" scenario. Many multi-million dollar fragmented projects, aimed only for poverty reduction or only nature conservation based on community approach, are not yielding enough results. "Win-Win" should serve as criteria for projects because only social and ecological double benefits are key for success in development of pastoral social-ecological systems. We need to develop **"Strategy for Commons"** to get out from "Tragedy of Commons", fighting against poverty-desertification at community level, against air pollution in Ulaanbaatar at country level, and against greenhouse gas emission at global level. We need to develop **"Strategy for commons"** to get out from **"Tragedy of commons",** which will be explored in the final chapter on policy recommendations.

The opportunity of using the existing cultural landscape at community and cross-administrative boundary scales in Mongolia appears to be the most cost-effective resilience option for climate change adaptation in pastoral communities. Strengthening traditional pastoral networks with modern technologies to enhance social wellbeing as well as legal framework development for cultural landscapes at community and administrative unit scales for ecosystem service conservation are required to promote sustainability in pastoral social-ecological systems. The traditional coping mechanisms enhancing the resilience of pastoral communities in the face of climate variability will be lost in Mongolia as in the surrounding countries of Central Asia, China and Russia unless alternative development agendas are taken.

Bogd sum, Baynhongor. 2010

VULNERABILITY ASSESSMENT

- Climate change analysis
- Land use and cover change
- Riparian ecosystem
- Social vulnerability
- Sociol-ecological vulnerability

VULNERABILITY ASSESSMENT

- **Methodology**
- **Climate change analysis**
- **Land use and cover change**
- **Riparian ecosystem**
- **Social vulnerability**

Methodology

Social surveys, climate change, land use and cover change, social-economic assessments, and integrated social-ecological assessments were used for this study. For social surveys, we have used the Dryland Development Paradigm as framework for understanding key slow variables and thresholds of river basin social-ecological systems. Questions for the social surveys were finalized after preliminary surveys and visits to study sites. Climate change analysis included the warming trend, drought and *zud* indexes calculation. Livestock dynamics and composition change were also included to study land use and cover change. Social-economic study included HDI and social vulnerability assessments.

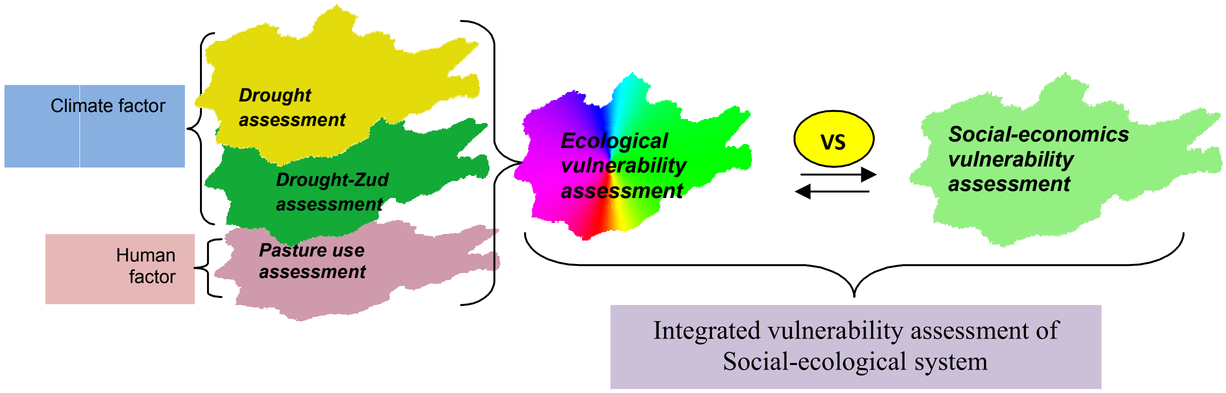


Figure 14. Methodolical scheme

Rangelands in Mongolia were studied at community, river basin and country scales. The Dryland Development Paradigm, DDP, (Reynolds et al. 2007) was used to analyze pastoral social-ecological systems in the Tuin and Baidrag river basins, located in the Southern Khangai Mountains of Mongolia (Chuluun et al., 2010). The DDP was also used to frame discussions with key stakeholders to understand the main drivers of system dynamics, critical slow variables and thresholds already crossed in pastoral social-ecological systems in our study area. The social survey results were then integrated with socio-economic and climate data analysis.
The rangeland ecosystem vulnerability index is a combination of a drought index and a rangeland use index (Fig. 14). The index is high in response to increasing drought and declining plant biomass due to overgrazing.

$$EV = D + \Delta N \qquad [1]$$

EV Rangeland Ecosystem Vulnerability index; D - Drought index; ΔN -stocking rate index.

Drought index

The summer drought index was calculated using Ped index-difference normalized temperature and normalized precipitation indices as:

$$D = \sum_{t=1}^{n}\left(\frac{T-\overline{T}}{\sigma_T}\right) - \sum_{t=1}^{n}\left(\frac{R-\overline{R}}{\sigma_R}\right) \qquad [2]$$

where D-drought index; T_i and R_i - temperature and precipitation for particular months at the “i” station; T_i and R_i – an average temperature and precipitation for particular months at the “i” station; σ_T and σ_R – fluctuation of temperature and precipitation for particular months at the “i” station, defined with the following formula:

$$\sigma = \sqrt{\frac{1}{n-1}\cdot\sum_{i=1}^{n}(x_i - \langle x\rangle)^2}$$

Where x_i is the “i”-the value of x and <x> is arithmetic average.

Rangeland use index

Rangeland use index was calculated using the formula:

$$\Delta N = \alpha\left(\frac{N - N_o}{N_o}\right) \qquad [3]$$

where ΔN - is the stocking rate index; N-livestock density, sheep unit/ha; N_0-carrying capacity, sheep unit/ha (Mongolian National Atlas. 1990, 2009 and Tserendash. 2006); α - pasture management coefficient was included to take into account other human factors influencing on vulnerability, but it was taken as equal to 1.

Information on seasonal and spatial patterns of these variables was evaluated across Mongolia to assess the multi-scale changes in environmental and socio-economic patterns.

Climate change analysis in study area

Air temperature. Climate change analysis was done based on Bayanhongor sum’s climate data (1940-2008) and Erdenezogt, Jinst and Bogd sum’s climate data (1981-2008). As seen from next figure showed annual air temperature trend, we can see that annual air temperature has warmed by 2.1^{0}C in Bayanhongor sum and by averagely 4.3^{0}C in Bayanhongor aimag during 1940-2008.

This warming rate is twice as much as than Mongolian average rate (2.14^{0}C, MARCC, 2009) and fourfold as much as than global warming rate for past 100 years.

As seen from our detailed analysis, annual air temperature has warmed by 2.4^{0}C in Erdenezogt sum, by 2.3^{0}C in Jinst sum and by 1.4^{0}C in Bogd sum during 1981-2008. To conclude it, warming has been appeared more in steppe zone than desert steppe. Annual air temperatures of sums in Tuin River are: Bogd sum in desert steppe – the highest (4.07^{0}C), Jinst sum (3.38^{0}C), Bayanhongor and Ulziit sum in mountain steppe (-0.32^{0}C), Erdenezogt sum in forest steppe – the lowest (-1.21^{0}C).

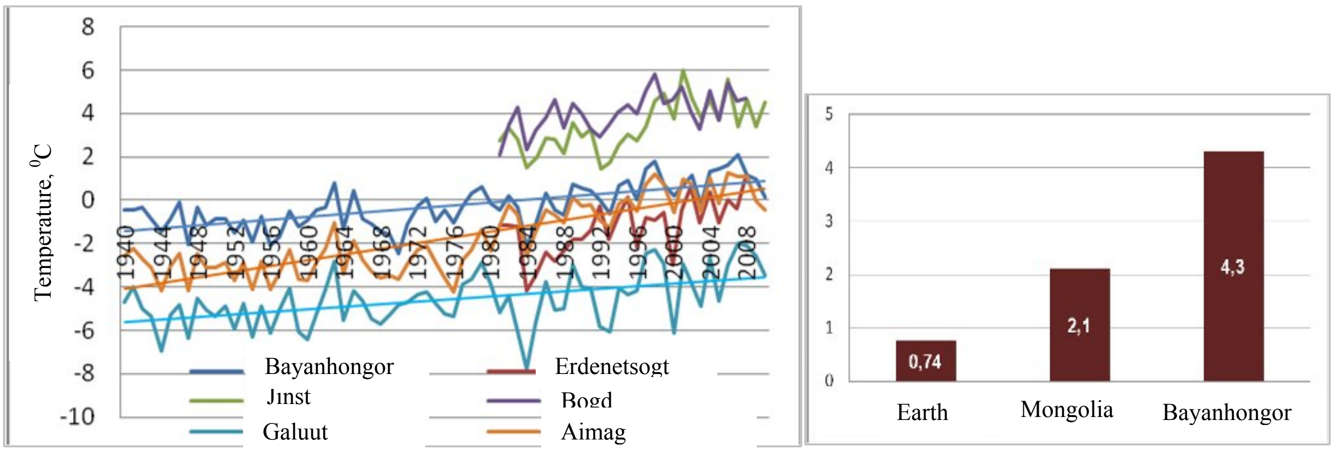


Figure 15. Air annual temperature trend, (trend for 1940-2010 and average)

Precipitation. Analysis were done based on precipitation data measured at meteorological stations of Erdenezogt, Jinst, Bogd sum (1985-2008) and Bayanhongor sum (aimag center, 1950-2008). Annual precipitation size is 201.5 mm in Erdenezogt, 212.2 mm in Bayanhongor, 75.5 mm in Jinst, and 77.4 mm in Bogd sum.

As seen from the figure next to, we can see annual precipitation change of sums in Tuin river in the past years. Annual precipitation has decreased by 60 mm in Bayanhongor sum during 1950-2008. But we can say that there is no any change in Erdenezogt, Jinst and Bogd sum in 1985-2008

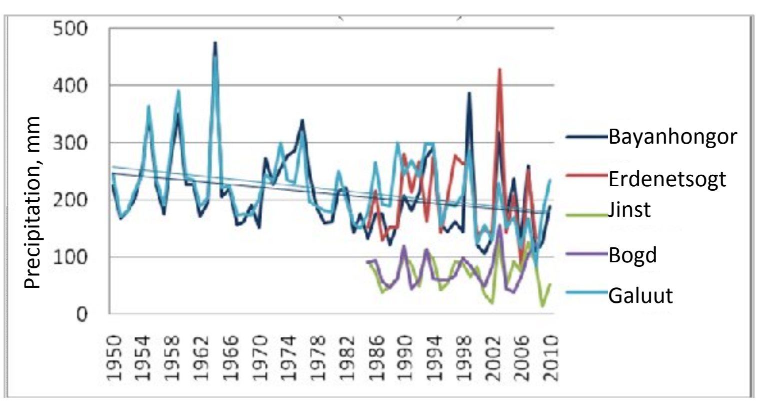


Figure 16. Precipitation trend, (1986-2010)

Future Scenarios of Climate Change in Study Area

IPCC developed global climate change trends by A1, A2, B1, B2 scenarios using global social economic development, population growth, technological transformation and carbon dioxide emission models (IPCC, 2007). According to IPCC Assessment report, freshwater sufficiency will be decreased in south, central, east and south-east regions of Asia. It is clear that climate change will have been pressured more at sustainable development of developing countries.
Likewise, Tuin River basin's ecosystem is one or the most vulnerable rivers to climate change. We calculated air temperature change trend by A1, A2, B1, B2 scenarios using IPCC SRES (BCCRBCM2) model and FAWSIM software (Tab 3). It is appeared more warming along ecological zones from north to south.

Table 3. Future trend of annual air temperature and precipitation in Tuin river basin, 2020-2100 (temeprature-^{0}C, precipitation-mm)

№	Location (sum & ecological zone)	Координат	**Temperature/precipitation	A2			B1		
				2020	2050	2100	2020	2050	2100
1	Erdenezogt, mountain forest-steppe	N46.419445 E100.826111	-1.42 260	-0.88 260	-0.10 261	2.53 263	-0.87 260	-0.28 261	0.30 261
2	Ulziit, mountain steppe and dry steppe	N 46.075554 E100.833054	0.28 216	0.89 216	1.60 217	4.22 220	0.89 216	1.49 217	1.99 218
3	Jinst, desert steppe	N 45.401669 E 100.580833	2.37 138	2.92 138	3.38 139	6.25 124	2.93 138	3.52 139	4.37 140
4	Bogd, desert steppe	N 45.185833 E 100.781387	3.34 124	3.93 124	4.85 125	7.38 127	3.94 124	4.20 125	5.25 125
5	Orog Lake	N 45.024723 E 100.863609	3.84 114	4.41 114	5.29 115	7.66 117	4.42 114	5.02 115	5.68 115

*Source: IPCC model using FAWSIM programme**
***Meteorological station's data analysis of sums*

As seen from Table 3, for A2 scenario, annual air temperature will have been changed by -0.88^{0}C, -0.10^{0}C, 2.53^{0}C in Erdenezogt sum, 0.89^{0}C, 1.60^{0}C, 4.22^{0}C in Ulziit sum, 3.93^{0}C, 4.85^{0}C, 7.38^{0}C in Bogd sum in 2020, 2050, 2100 respectively. But annual precipitation size may increase a little in the same period

The change of Biomass

We prepared to compare the change of biomass between 2002 and 2009 based on the dryness index as well as precipitation and temperature in those years 2002 and 2009. Due to drought and Dzud occurred in 1999 to 2002, 2009 to 2010, the dryness index of those years was 1.0, 1.4 which is lower than the preannual dryness index of 2.4 (Fig. 17).

We did comparison on the change of biomass in 2002 and 2009 by using report from NDVI

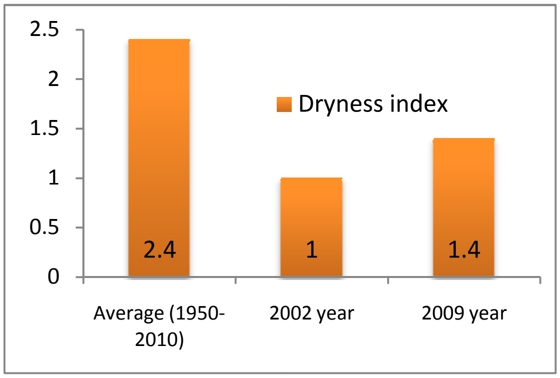


Figure 17. Dryness index, Bayanhongor aimag - 2002, 2009

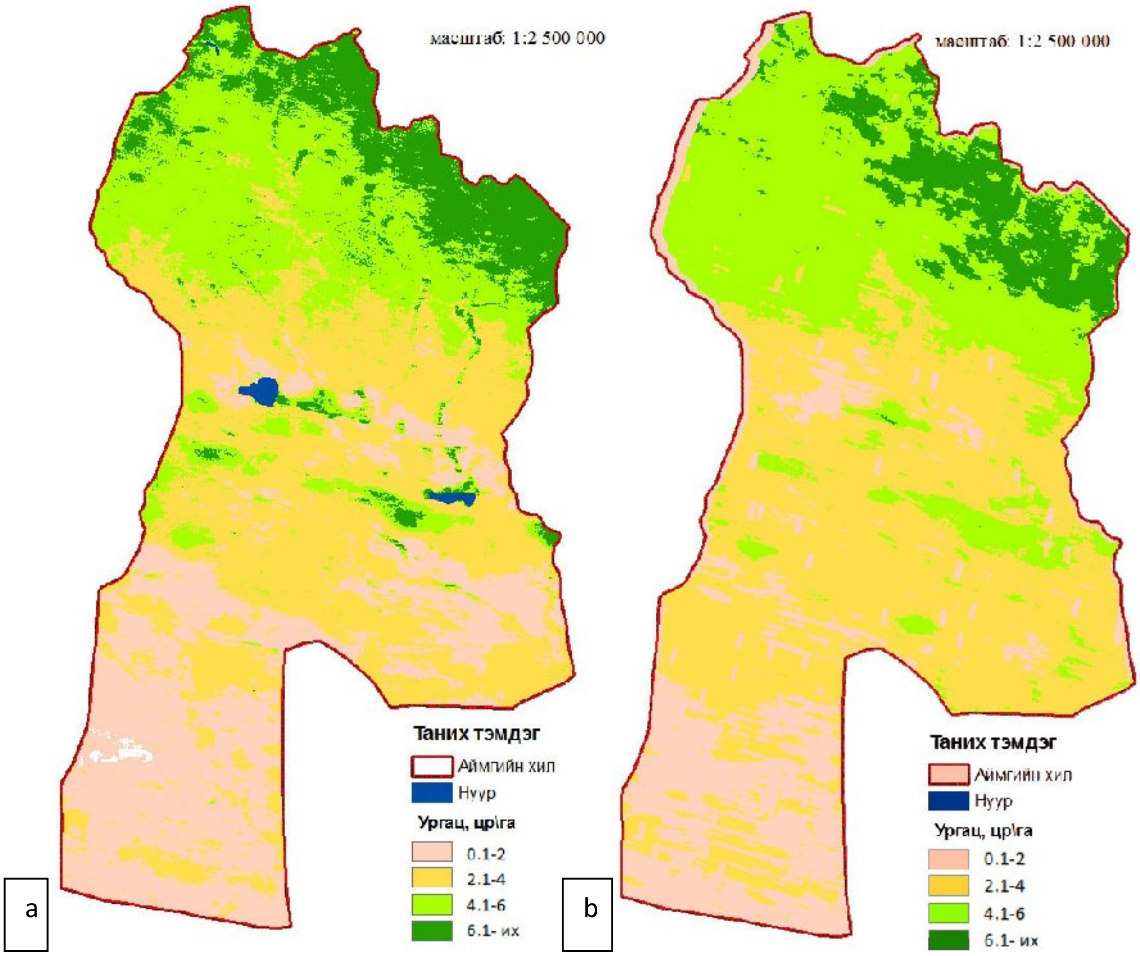


Figure 18 a. Annual average biomass, 2002 b. Annual average biomass, 2009

Research B.Tserenchunt et. al (2010) studied the vegetation trends analysis in Mongolia, using long-term remotely sensed vegetation index NDVI (1982-2008). Expansion of southern parts within ecological zones means that plant productivity trend to decrease due to climate and land use changes (Figure. 21a, 21b) showed that main ecological zone boundaries didn’t shift. Particularly, northern part of the desert steppe shrunk by 4.7%. Any kinds of evolution of ecosystem in nature is generally conducted in hundreds or thousands of years. Since the ecological sub zones have shrunk within 27 years is definetely one thing that we have to consider it as upcoming danger to the nature.

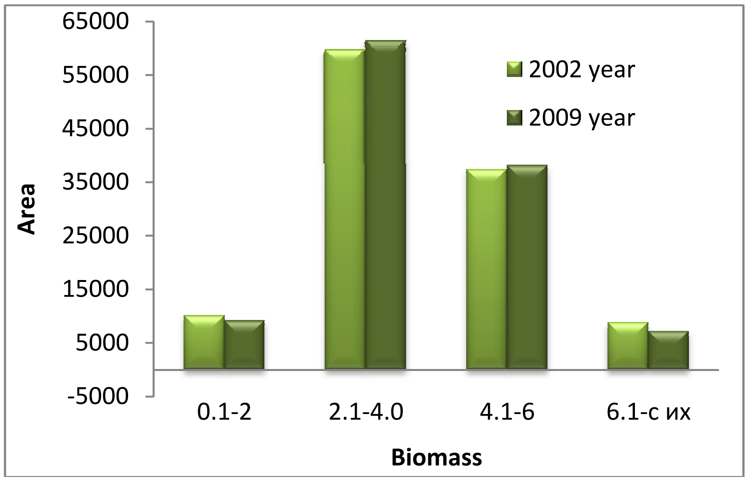


Figure 19. The change of pastoral biomass, Bayanhongor-2002 & 2009

In figure 22 showed that area with 0.1-2c/ha and 6.1-more c/ha biomass decreased by 9.8% and 22.2%. The area with 2.1-4 and 4.1-6 c//ha biomass increased by 2.8% and 2 (Fig 19, Tab 4).

Table 4. Biomass change

Biomass, c/ha	0.1-2	2.1-4.0	4.1-6	6.1-more
2002 year	10100	59700	37400	8800
2009 year	9200	61450	38150	7200
Change, km^2	-900	1750	750	-1600
Change (%)	-9.8	2.8	2.0	-22.2

Livestock number and composition change

Almost 60% of livestock was lost during 1999-2001 *zud* following drought and livestock (in sheep unit) didn't recover yet. 60% of livestock in the Erdenetsogt sum are yak and horse, but 80% of livestock in Bogd and Jinst sums are only goats.

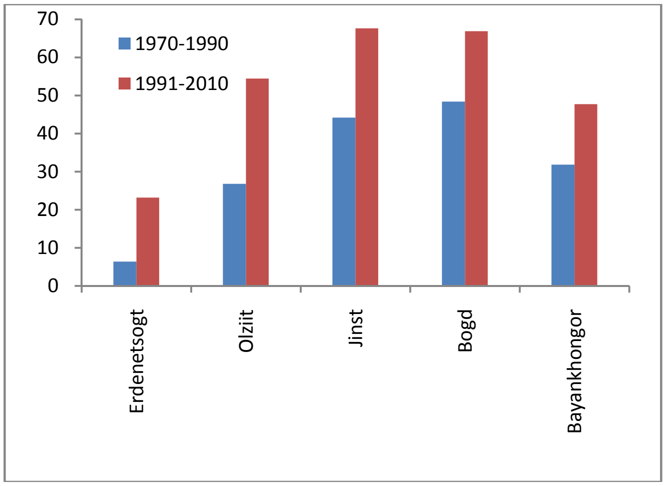


Figure 20. Goat fraction %, in the Tuin river basin, 1970-1990, 1991-2010

Table 5. Goat fraction change in the Tuin river basin

		Erdenetsogt	Olziit	Jinst	Bogd	Bayanhongor
1970-1990 year	Total livestock	1890637	2173075	1986285	1824358	205730
	Sheep unit	5720650	4885733	3894610	4101976	465822
	Goat fraction %	6	27	44	48	32
1991-2010 year	Total livestock	1387778	2172092	1825240	2220297	1557485
	Sheep unit	3496320	3487261	2355085	3405660	2622658
	Goat fraction %	23	54	68	67	48
Change	Total livestock	-502859	-983	-161045	395939	1351755
	Sheep unit	-2224329	-1398472	-1539525	-696316	2156837
	Goat fraction %	17	28	23	19	16

Total livestock number and Sheep unit in the Tuin river basin decreased during 1970-2010 in Erdentsogt, Olziit and Jinst. However, Goat fraction in the Tin river basin increased by 17-23% during 1991-2010 relative to 1970-1990 (Fig 20, Tab 5).

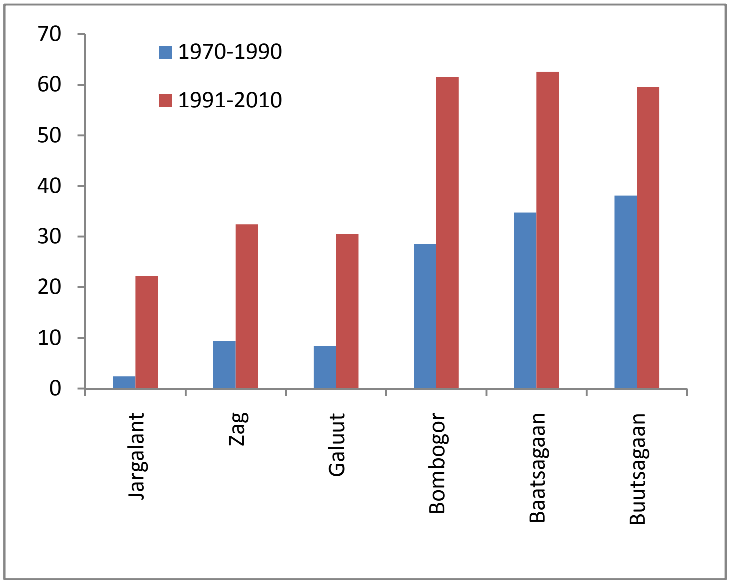


Figure 21. Goat fraction %, in the Bairdag river basin, 1970-1990, 1991-2010

Table 6. The change of livestock number, sheep unit andgoat fraction %, in the Baidrag river basin, 1970-1990, 1991-2010

		Jargalant	Zag	Galuut	Bombogor	Baatsagaan	Buutsagaan
1970-1990 year	Total livestock	1643894	1435889	2224887	1617274	2794045	2866505
	Sheep unit	3076617	3251200	6181499	3695939	5273803	5189170
	Goat fraction %	2	9	8	28	35	38
1991-2010 year	Total livestock	1763750	1520171	2256884	1560076	2840102	3234192
	Sheep unit	3832770	2798180	4612077	2206790	3727917	4447995
	Goat fraction %	22	32	31	61	63	60
Change	Total livestock	119856	84282	31997	-57198	46057	367687
	Sheep unit	756154	-453020	-1569422	-1489149	-1545886	-741176
	Goat fraction %	20	23	22	33	28	21

Total livestock number in the Baidrag river basin increased during 1970-2010. However, livestock number in sheep units decreased in 1991-2010 in Zag, Galuut, Bombogor, Baatsagaan and Buutsagaan sums relative to 1970-1991. Goat fraction in the Bairdag river basin increased by 20-33% during 1991-2010 relative to 1970-1990 (Fig 21, Tab 6).

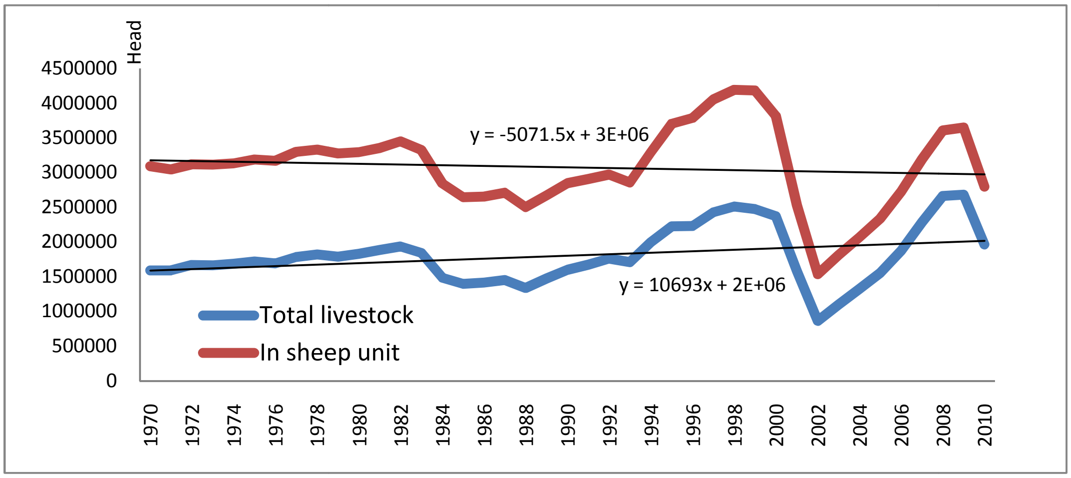


Figure 22. Dynamic of livestock number of Bayankhongor aimag

Livestock numbers became more dynamic during last two decades (Figure 22). Livestock number increase by about 30% during early 1990s after privatization of livestock certainly contributed for overgrazing of rangelands. Drought summers and zuds of 1999-2002 caused huge livestock loss. Recovery of livestock took 5-6 years. However, summer drought in 2009 followed by *zud* in winter of 2010 resulted in more than 300,000 livestock loss in Bayanhongor aimag (Statistical office of Bayankhongor aimag). Therefore, both climatic and market factors play important role for livestock dynamics.

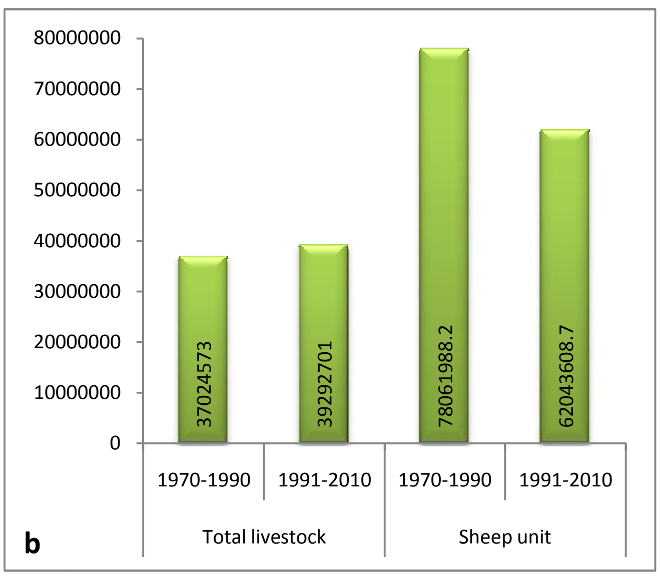


Figure 23. Livestock number and Sheep unit of Bayankhongor aimag, 1970-1990, 1991-2010

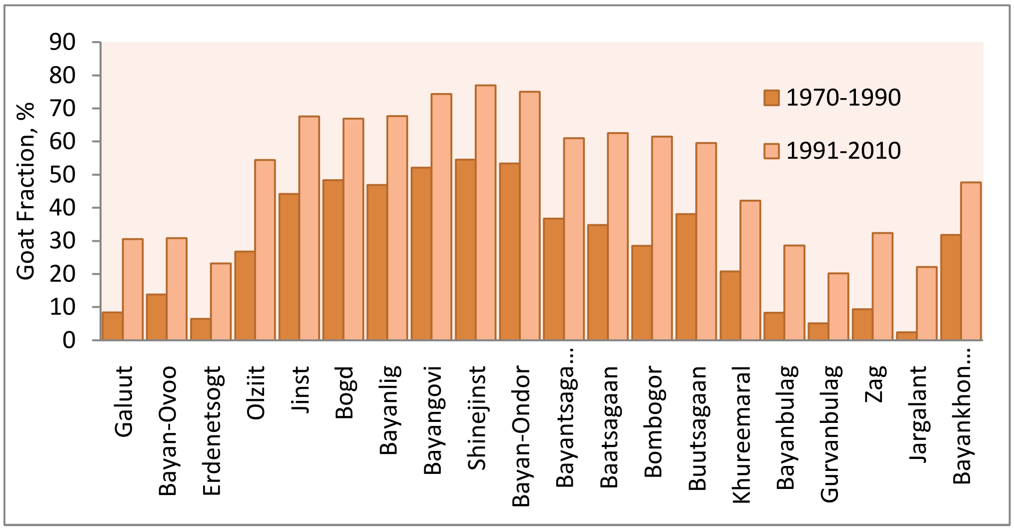


Figure 24. The goat fraction in total livestock after 20 years

Goat percentage in total livestock composition increased up to 81.8% and 79.2% in Jinst and Bogd sums (Fig 24).

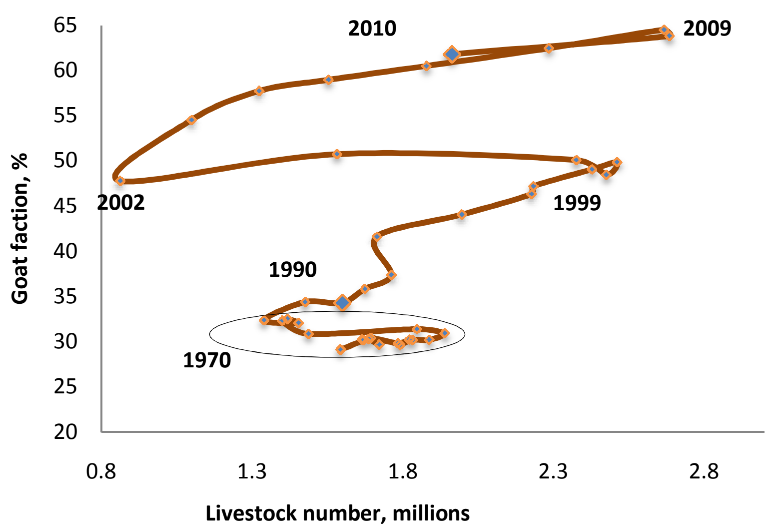


Figure 25. *Regime shift since transition to market economy early 1990*

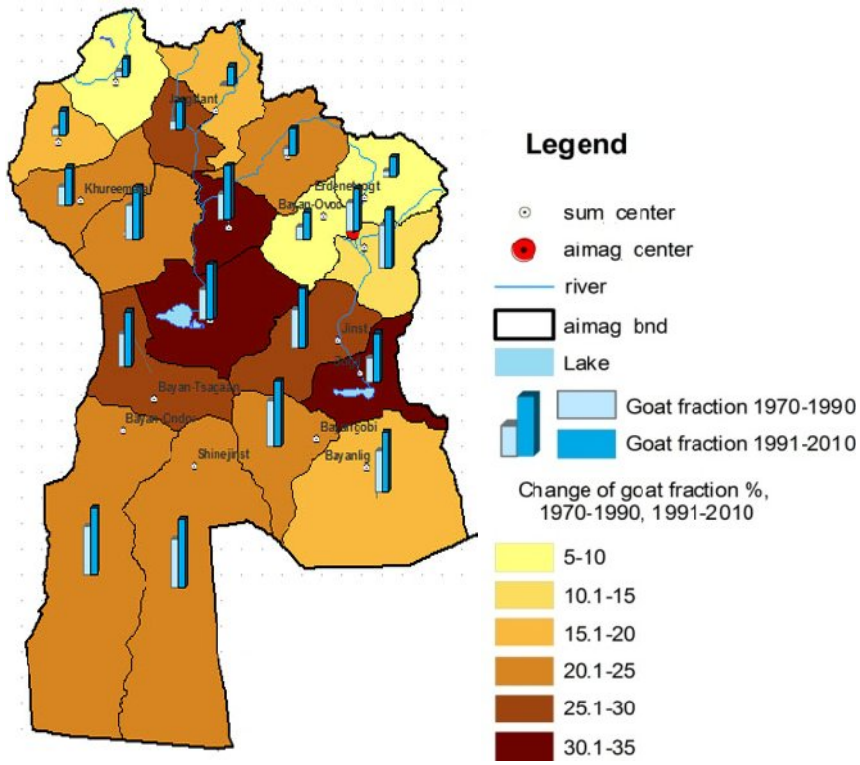


Figure 26. The goat fraction map of Bayankhongor aimag

Interestingly, goat fraction in total livestock numbers was very stable around 30% during the socialist period between 1970 and 1990. Goat fraction increased up to 45% by 1999 and 60% by 2010 since privatization of livestock since early 1990s (Fig 25). Goat fraction didn't change during drought-zud events in 1999-2002 and 2009-2010, despite of big livestock losses. The biggest increase of goat fraction over 30% occurred in our study areas, particularly in Bogd, Buutsagaan and Bombogor sums (Fig 26).

TUIN AND BAIDRAG RIVER BASIN

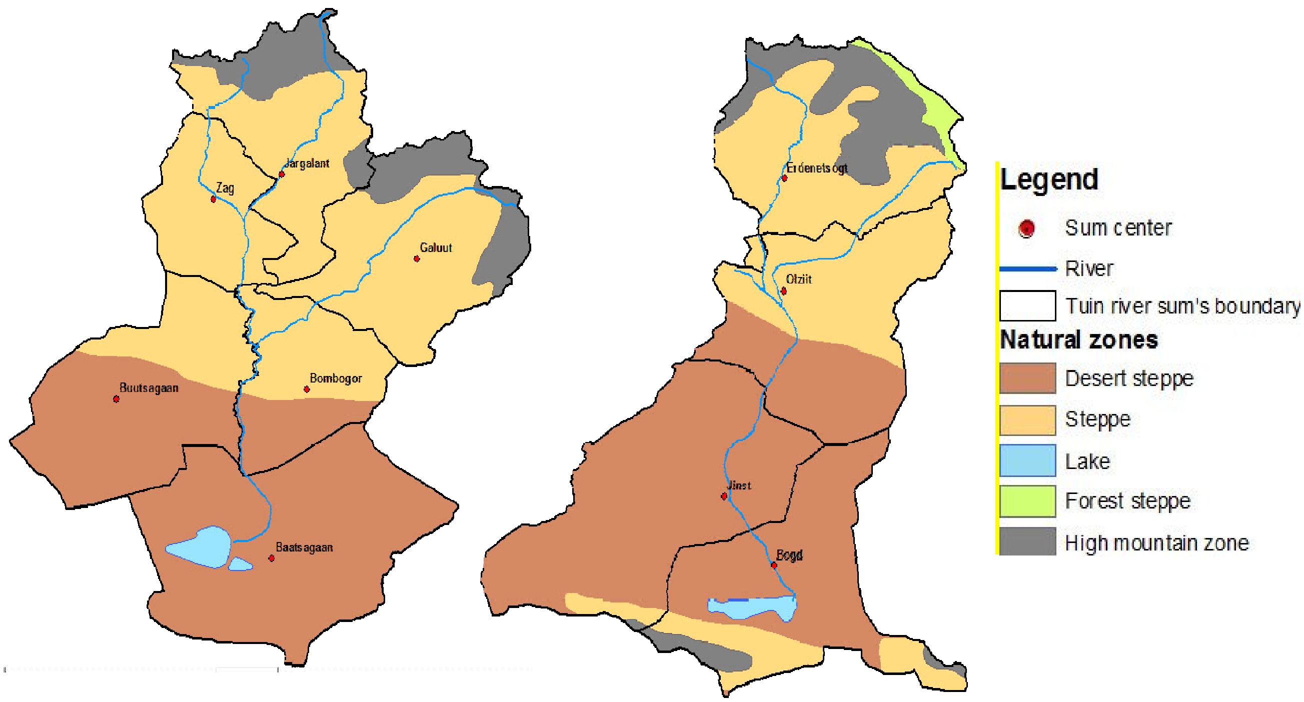
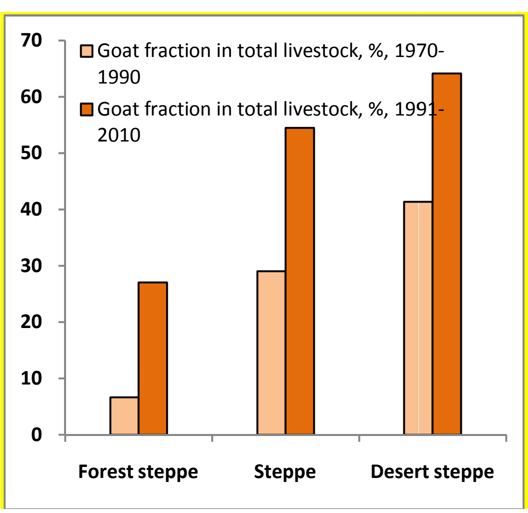


Figure 27. The natural zone of Baidrag and Tuin river basin

Forest steppe: Galuut, Jargalant, Zag and Erdenetsogt
Steppe: Bayanhongor, Olziit, Bombogor
Desert steppe: Baatsagaan, Buutsagaan, Jinst and Bogd



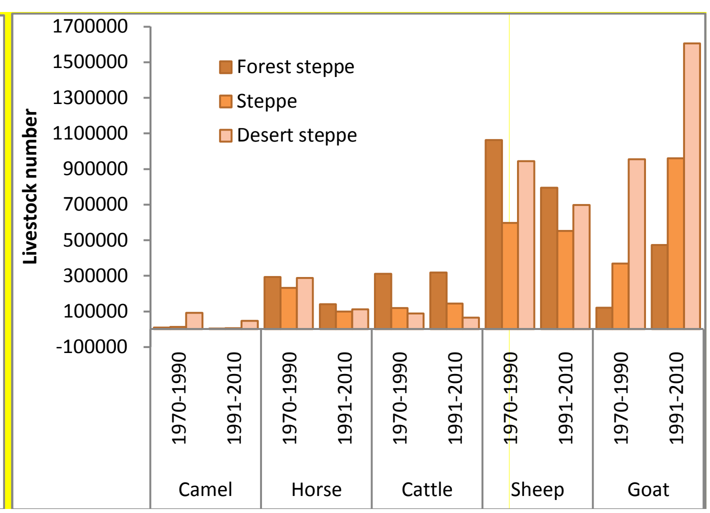


Figure 28-a. The change of goat fraction in the natural zone, Tuin and Baidrag river basin, 1970-1990, 1991-2010
Figure 28-b. The change of each animals in the natural zone, Tuin and Baidrag river basin, 1970-1990, 1991-2010

Example of land use change (traditional cultural landscape use change) in the Tuin river basin

The Mongolian nomadic pastoral system exhibit oscillatory movements in regions where the climate and rangeland production dynamics are relatively more predictable, and can accommodate the need to move only between summer and winter camps.

More frequent seasonal oscillatory movements with more than one movement during the summer season occur in the mountain steppe regions. In regions with relatively higher climate variability and increased uncertainty, such as the Gobi and dry steppe, pastoral movements tend to be more chaotic and follow more opportunistic strategies to secure forage. These movements are associated with drier parts of the steppe and the Gobi desert-steppe and desert areas where non-equilibrium ecosystem dynamics are observed (Ellis and Chuluun 1993, Fernandez-Gimenez 1999, Chuluun 2000 and Bedunah and Schmidt 2004). The herders from these regions move to places where better rangeland conditions exist—especially during the summer season.

However, pastoral systems have been under pressure of political, economic and climatic changes, taking place during the socialism, globalization and global warming. Currently, herders' movements are constrained to administrative boundaries, rather than to the ecological extent of suitable rangelands. However, the herders still use pastures located in other administrative units, but it causes pasture conflicts. With privatization of livestock and talk of land privatization (GISL 1997, Fernandez-Gimenez 2006), it is becoming more difficult to move livestock across the landscape to access water and forage.

Many herders of the Olziit sum started to move only twice currently, although traditionally they used to move seasonally. Decreased mobility is leading to overgrazing (Fig 29).

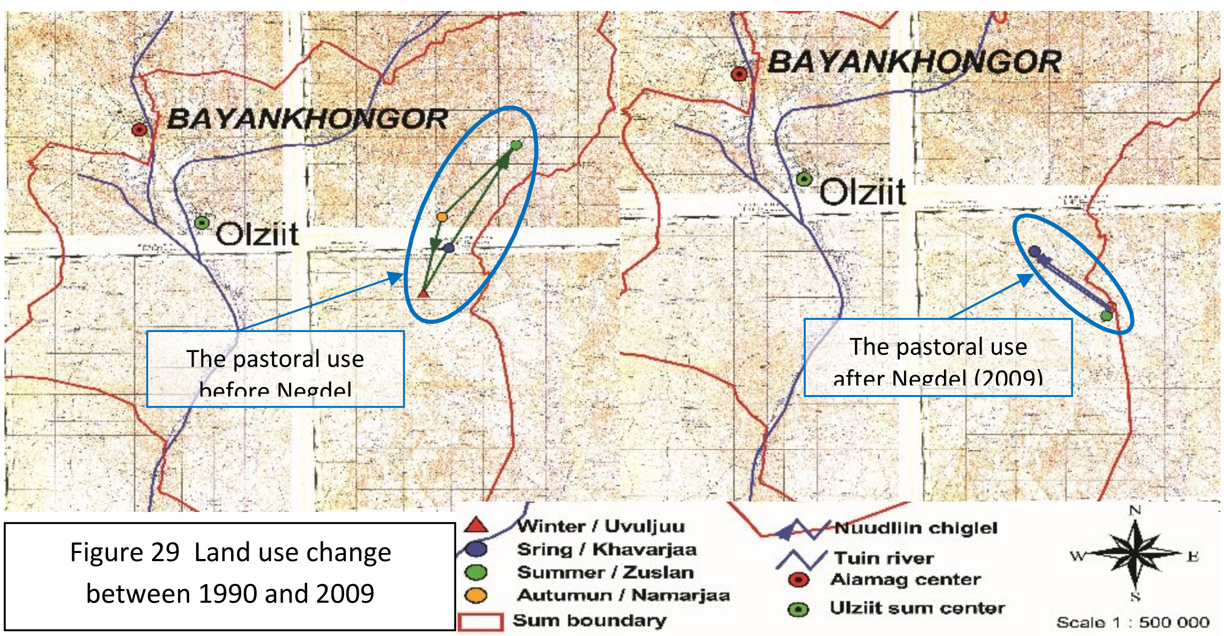


Figure 29 Land use change between 1990 and 2009

Droughts occur more often in desert-steppe region compared to forest steppe and steppe regions (Fig 30a). Ecological vulnerability, which accounts both drought and stocking rate relative to carrying capacity, is greater in desert-steppe region relative to forest steppe and steppe regions (Fig 30b).

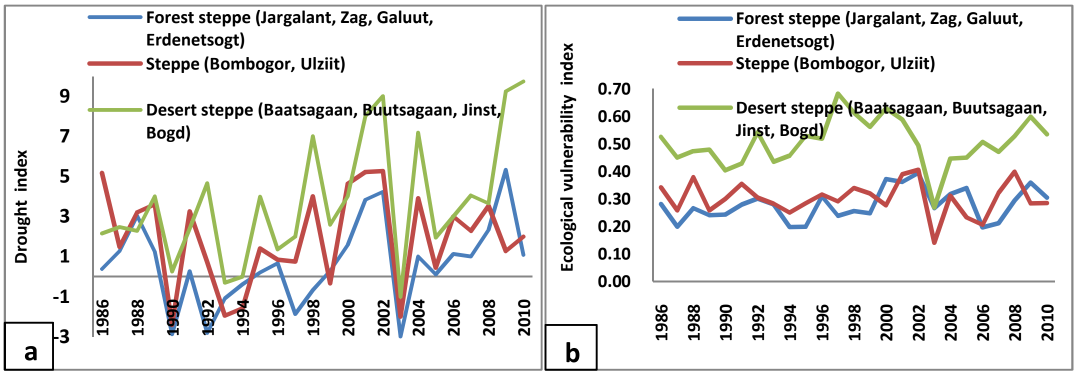


Figure 30. drought (a) and ecological vulnerability (b) assessment in the Tuin and Baidrag river basins by ecosystem type (1986-2010).

Riparian ecosystem

- **Pasture use assessment**
- **Mining footprint assessment**

Pasture use (stocking rate) assessment

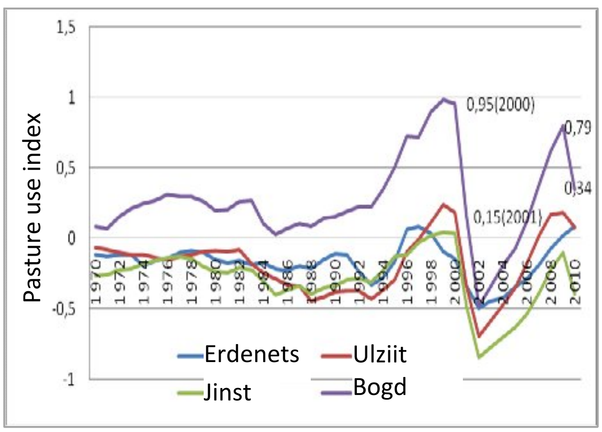


Figure 31. Pasture use assessment in the Tuin river

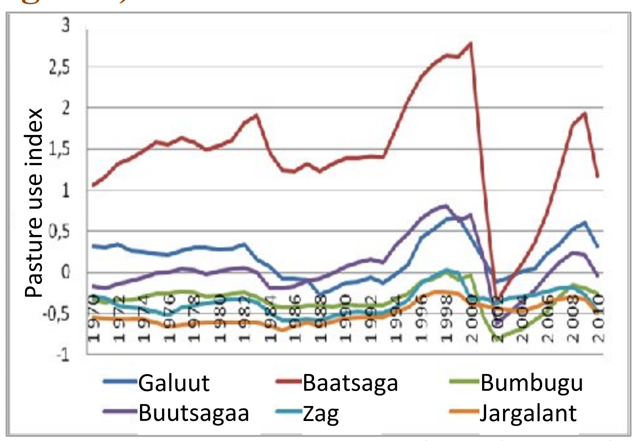


Figure 32. Pasture use assessment in the Baidrag river by sums (1970-2010)

Pasture use and vulnerability indexes were calculated for Erdenetsogt (forest steppe), Olziit (dry steppe), Jinst (desert steppe) and Bogd (desert steppe) sums, using climate and livestock data (1986-2010).

Pasture use intensity was the highest in Bogd sum, but pasture use intensity didn't reach yet 1999 level in all sums. Pasture use index is higher in Bogd sum than other sums. However, Jinst sum's pasture use index is the lowest in Tuin river basin. It is related to population and livestock number and land area's size. Sums' pasture use index has decreased by 2 times because of 1998-2002's drought and zud after regularly increase since 1986. And then pasture use reached at disaster level in 2010 since 2004's regularly increase. Likewise Tuin river basin, pasture use is more in desert steppe zone (Baatsagaan and Buutsagaan sums) than in forest steppe (Fig 32).

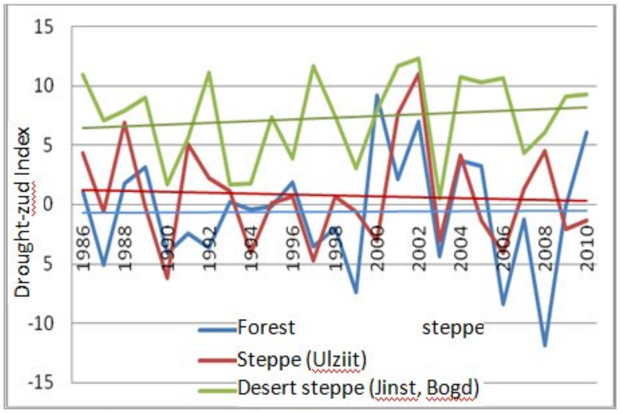


Figure 33. Integrated drought-zud assessment in the Tuin river basin by ecosystem type, (1986-2010)

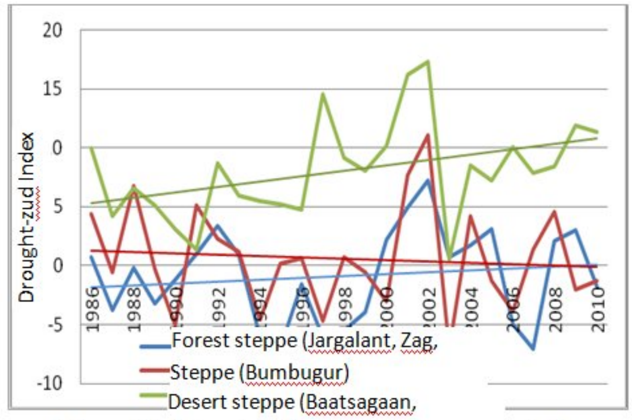
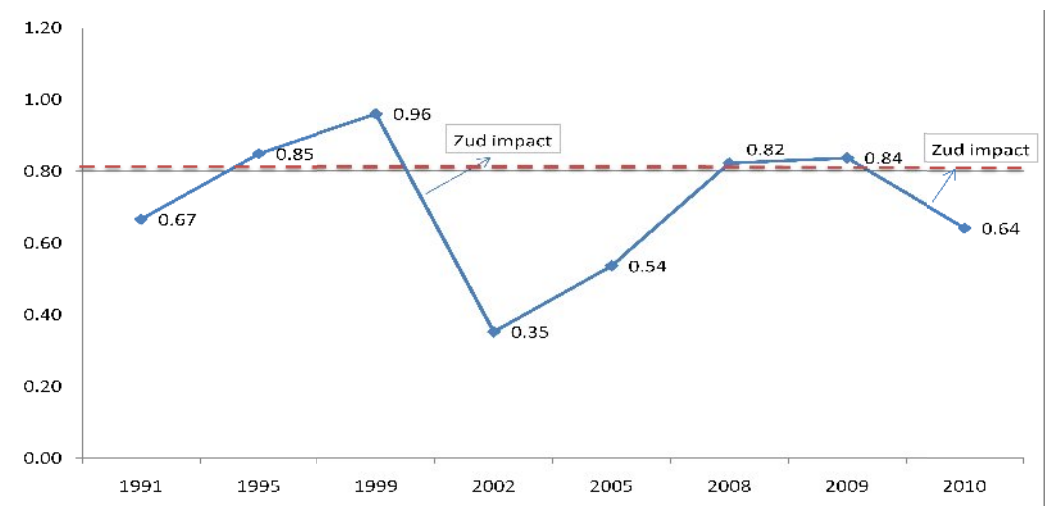


Figure 34. Integrated drought-zud assessment in the Baidrag river basin by ecosystem type, (1986-2010)

Figure 35. Bayankhongor's livestock number per 1 hectar pasture and carrying capacity threshold line(brown), at winter-spring, by sheep unit



Interestingly, after exceeding of carrying capacity threshold happened natural disasters zud (Fig 35).

Vulnerability to natural disaster zud

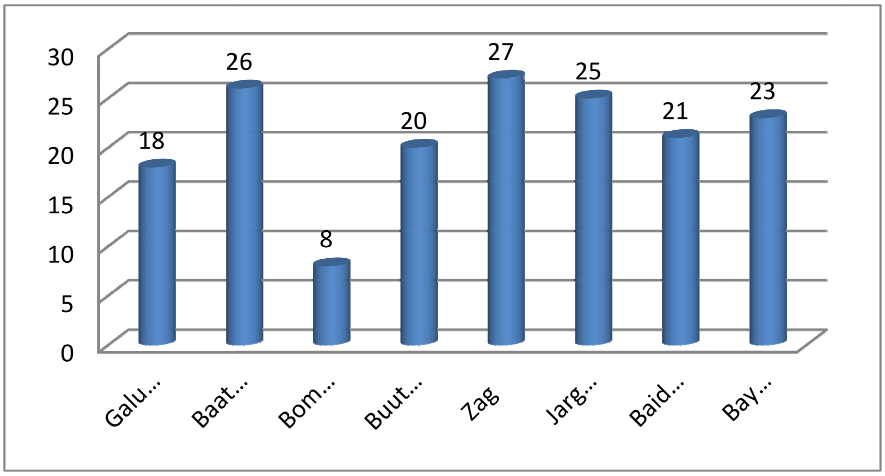


Figure 36. Livestock loss percent in 2009-2010 zud disaster

Higher percent of total livestock of Zag, Jargalant and Baatsagaan sum lossed from 2009-2010 zud disaster (Fig 36).

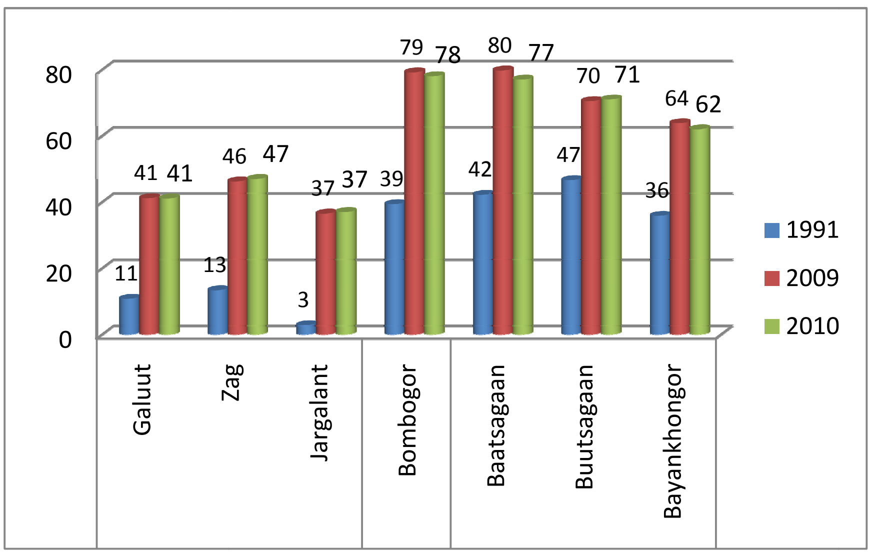


Figure 37. Goat share change in total livestock, 1991-2010

Goat share in total livestock has increased by 30-40 percent 1991-2010 in all sums.

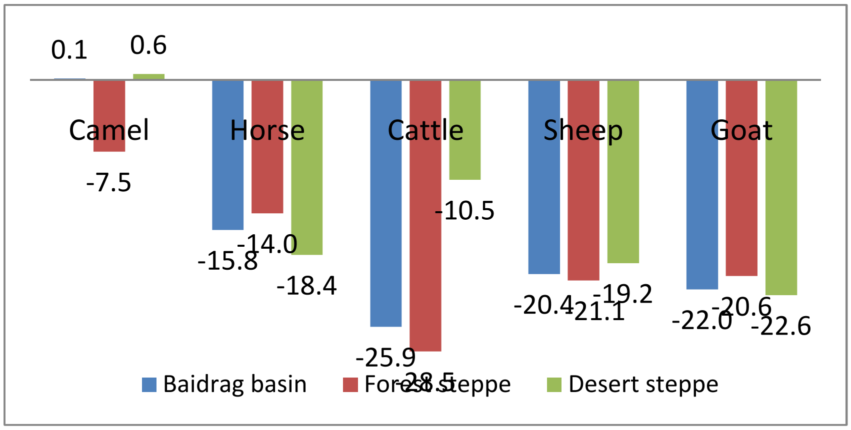


Figure 38. Livestock number change percent after 2009-2010 zud disaster

After 2009-2010 zud, cattle herd has decreased mostly by 28.5% in forest steppe zone.

Mining footprint assessment

Table 7. Mining footprint assessment on pastoral ecosystem of Baidrag and Tuin river basin, Bayankhongor aimag

Sums with artisanal miners and mining companies	Mining sites number used by companies with mining licence			Degraded pastoral area after mining	Shrinked springs and small rivers because of mining activities	Mining negative affect on Baidrag and Tuin river basins
	To mine	To search	Total mining-licensed area's share in Bayanhongor and Baidrag-Tuin river basin			
<u>Baidrag basin</u> – Jargalant, Galuut, Baatsagaan, Zag, Bombogor, Buutsagaan <u>Tuin river basin</u> - Bayan-Ovoo, Jinst, Olziit Total artisanal miners: 2100-2300	64	204	**<u>15 % of total Bayankhongor aimag,</u>** 30-35% of Baidrag and Tuin river basin area	**<u>Total 709 hectar:</u>** Of which: 333 hec – artisanal miners 376 hectar – mining companies	30	- Worsening drinking-water quality and supplying for local people and animals - River water resource decreasing due to river bed breaking - Water ecosystem degradation, desertification and deforestation

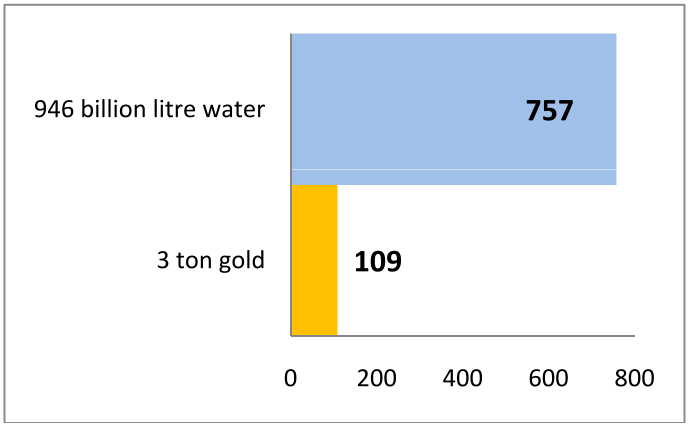


Figure 39. Cost comparison between Baidrag river annual flows water and 3 ton gold price, by million US$

We assessed total water size of Baidrag river per one year to economic price - 757 millions of US$. Its cost is 7 more times than 3 ton gold (half gold of Mongolia in 2010) (Fig 39). So, local herder households, mining companies and artisanal miners should use water resource sustainably and should recover water ecosystem.

Figure 40."The Odod Gold co.LTD" operates right on the Olziit river bank in Bombogor sum

Figure 41. Restored and unrestored sites along the Baidrag river, June 2010

River basins of Baidrag and Tuin are very rich in gold mineral resources. So, number of mining companies and artisanal miners has been increasing in these areas for last few years. The NGO "Calling of Mountains and Rivers" are a social movements that were started in response to the environmental degradation and visible decline of the Baidrag and Tuin river basin. So stakeholders such as local people's initiative, government, mining companies and river movements are needed to protect themselves ancestral traditions as well as our native places and rivers, to evaluate and protect the ecological equilibrium of the region, to provide environmental and legal education to local people, and to rehabilitate the fields destroyed by irresponsible human activities in order to pass on our native land to future generations.

First of all, it is urgently needed to prohibit any mining activities in the zone of river sourses of Baidrag and Tuin.

Social vulnerability

- **Demographic and migration analysis**
- **Human development**
- **Socio-economic vulnerability**
- **Social-ecological system's web analysis for sustainable livelihood**

Demographic and migration analysis

According to 2010, total population number has been decreased during 1990-2008 because of out migration. For example, population number has decreased from 19356 in 1990 to 18240 in 2008.

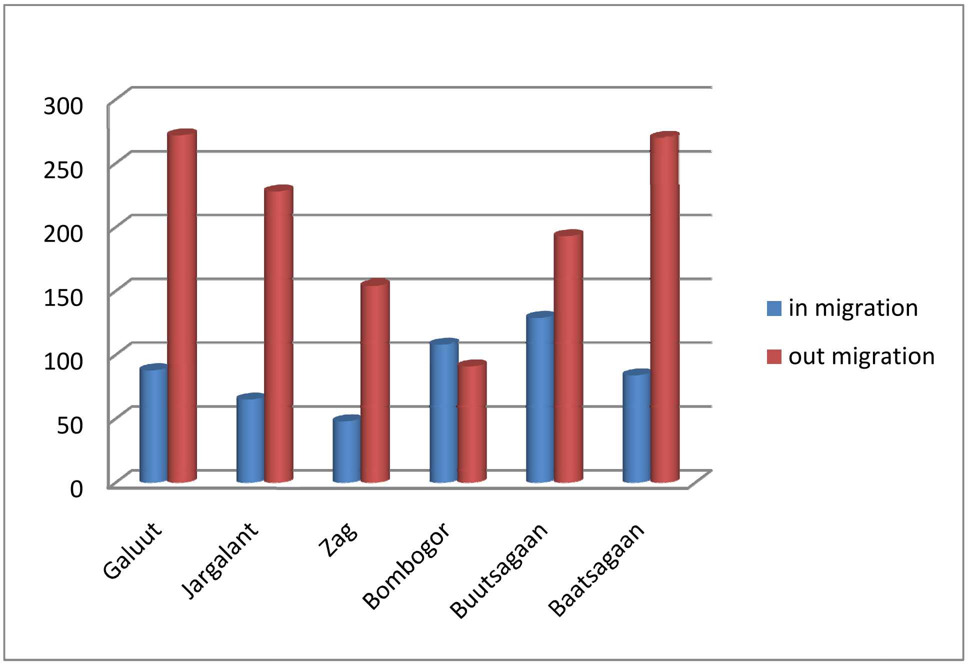


Figure 42. Population migration in Baidrag river basin, 2006-2008 (Source: Bayankhongor aimag's statistical yearbook-2009)

Population number of 1100 has migrated out of Baidrag basin during 2006-2008. Particularly, out- migration is higher in Galuut, Jargalant and Baatsagaan sums, and in-migration is high in Bombogor sum related to artisananl gold mining. Many herder households migrated out of Baidrag and Tuin river basins after zud disasters of 1999-2001 and 2009-2010 because they lost their animals from zud.

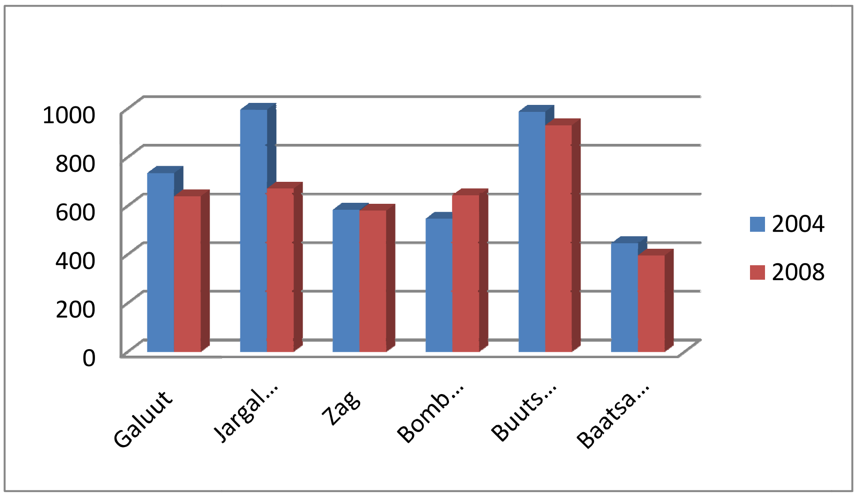


Figure 43. Sum center's population change, 2004-2008 (Source: Bayankhongor aimag's statistical yearbook-2009)

Population number in all sum centers has decreased during 2004-2008 excepting Bombogor sum. It is related to low level of market size and population number to develop small and medium enterprises in sums.

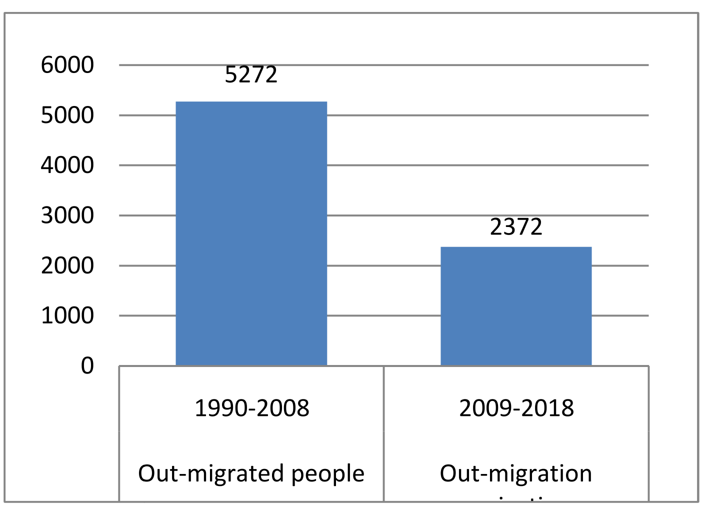


Figure 44. Out-migration during 1990-2008, and out-migration projection during 2009-2018

Population number of 2400 should migrate out of Baidrag river basin 2009-2018 based on migration analysis. Out-migration is one of the adaptation options and preparedness to out-migration is important. So it is needed to develop education and accumulate their financial capital.

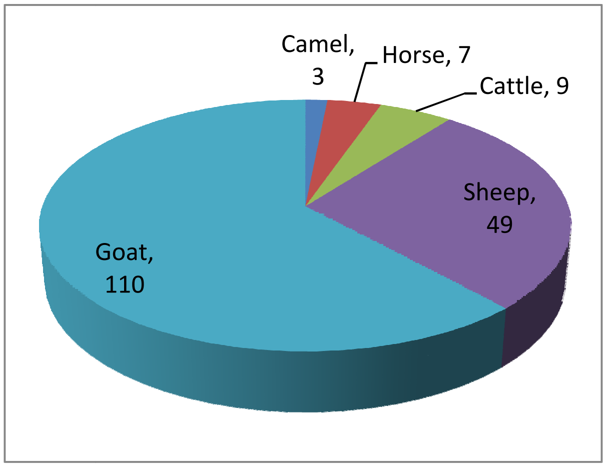


Figure 45. Livestock structure of middle-class herder household

As seen from figure, traditional livestock structure adapted to natural zones has lost. Number of goat is 110, sheep is 49, cattle 9, horse 7 and camel 3 respectively in middle class herder household's livestock structure.

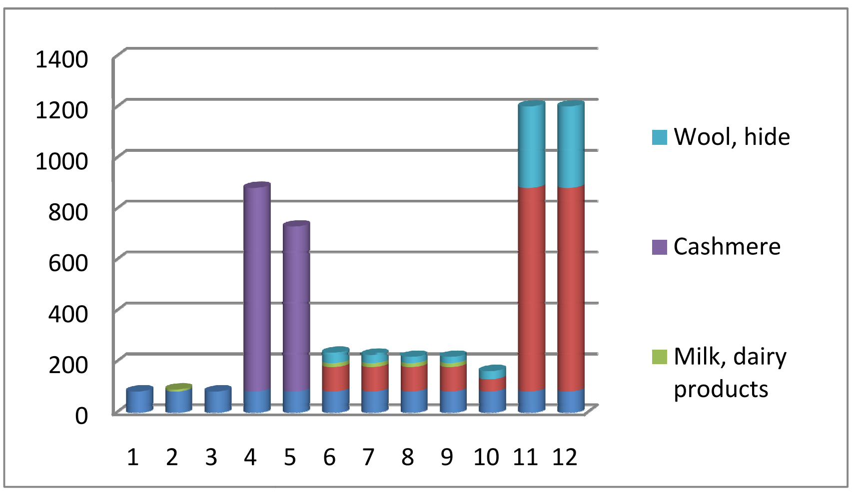


Figure 46. Middle-class Herder household's average income, by months, US $

As seen from figure 51, main months of income for herder households are april and may from cashmere, and november and december from meat sales. Annual total income is 5372 US$. Interestingly, income from meat sales is more than cashmere income. So herder households should focus on building money accumulation instead of getting bank loan. Also they need to increase diversification of products in order to increase income.

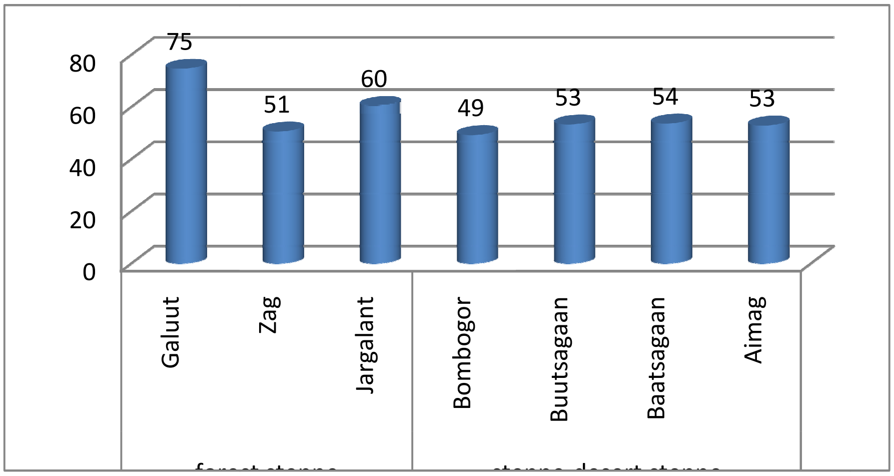


Figure 47. Livestock number per capita of Baidrag river basin by sheep unit, 2010

Sum with highest livestock number per capita is Galuut sum (75 per capita). And livestock number per capita is low at sums of steppe and desert steppe zone.

Socio-economic vulnerability analysis

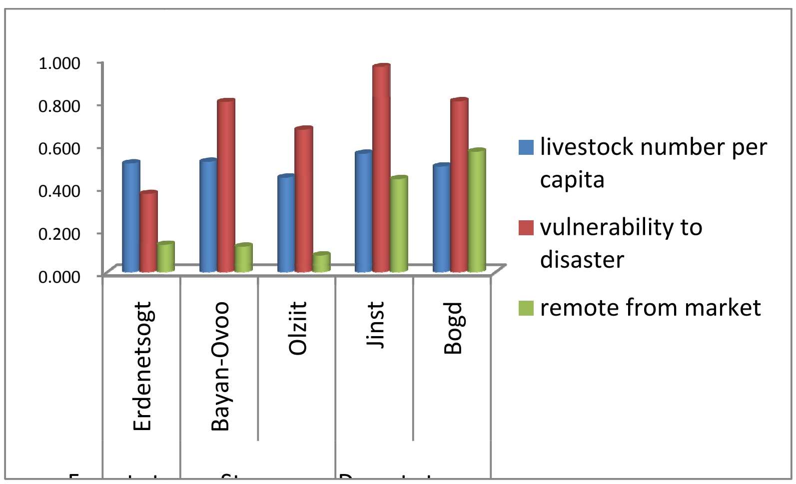


figure 48. Socio-economic vulnerability sub indexes of Tuin river basin sums

For Tuin river basin, forest steppe – Erdenetsogt sum's vulnerability to disaster zud is low, and desert steppe – Jinst and Bogd sums' vulnerability to disaster zud and remote from market is higher than other sums. (Fig 48).

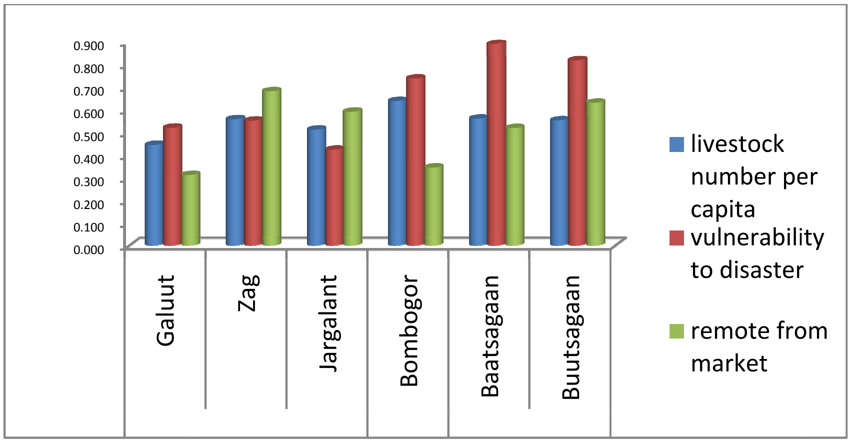


Figure 49. Socio-economic vulnerability sub indexes of Baidrag river basin sums

Likewise, for Baidrag river basin, forest steppe zone's Galuut, Zag and Jargalant sums' socio-economic vulnerability is low because their vulnerability to disaster zud is low livestock number per capita is higher. (Fig 49).

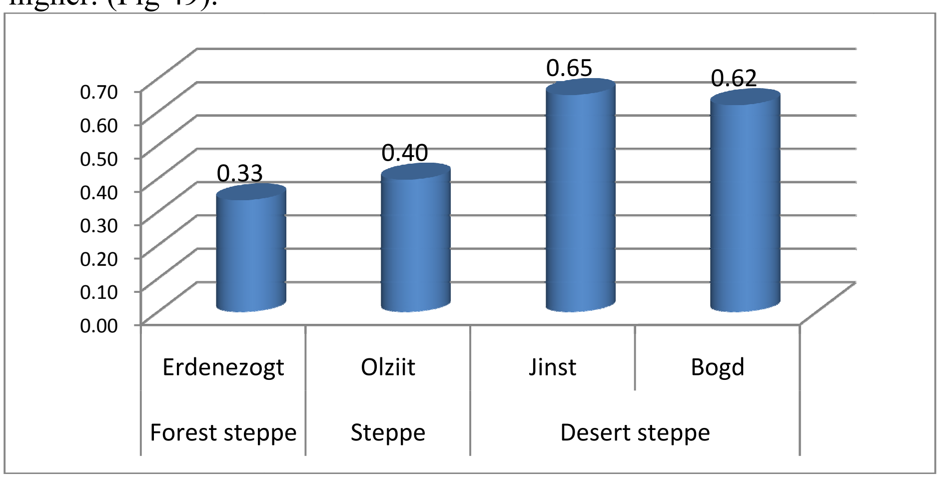


Figure 50 . Socio-economic vulnerability composite index of Tuin river basin's sums

Composite index of socio-economic vulnerabilities of desert steppe – Jinstr and Bogd sum are higher in Tuin river basin's sums.

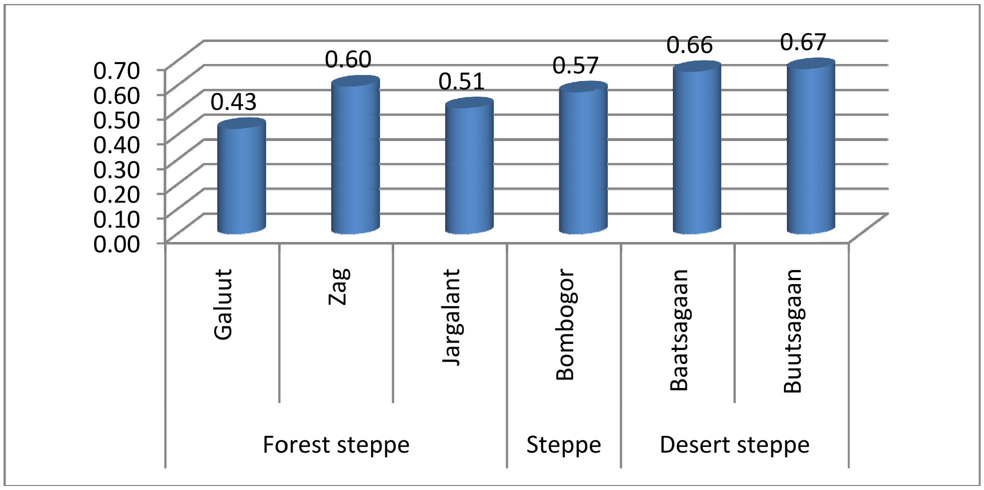


Figure 51**.** Socio-economic vulnerability composite index of Baidrag river basin's soums

Likewise Tuin river basin, composite indexes of socio-economic vulnerability of desert steppe – Baatsagaan and Buutsagaan sums are higher in Baidrag river basin (Fig 51). To calculate composite index, we used arifmetic mean by three indicators including livestock number per capita, vulnerability to disasters and remote from market.

Social-Ecological Assessments

Assessments of social-ecological systems in the Tuin river basin

- Drought and *zud* (white and black) assessment
- Pasture use (stocking rate) assessment
- Environmental vulnerability assessment
- Human development assessment
- Integrated assessment of human-environment system

We made integrated assessment of social-ecological systems by integrating **ecological vulnerability index,** which includes drought and *zud* indexes, pasture use assessment (stocking rate relative to carrying capacity) and **human development index** (including GPP per capita, education and average life expectancy). If sums are affected by drought and zud disasters, and overstocking, then ecological vulnerability index is high. Likewise it, social-ecological vulnerability is a high if human development index is low and ecological vulnerability index is high.

The main disasters in Mongolia are drought and *zud*. According to drought study (Bayaraa, N and P.Damdin, 2006), droughts occurred 12 times (1941, 1944, 1946, 1951, 1972, 1999-2004) during 1941-2004 in 50-70 percent of total land areas of Mongolia. Drought frequency is 1-2 times in forest steppe, 3-4 times in steppe and 5 times in desert steppe and desert zones for 10 years (Natsagdorj, L, B.Tsatsral and J.Dulamsuren, 2002).

Interestingly, in Bayanhongor aimag, our study site, droughts likely occurred more frequently, 22 times since 1941.

Drought and *zud* (white and black) assessment

First of all, the state of ecosystems in the Tuin river basin was assessed from existing information and knowledge (The State of The Nation's Ecosystems 2002 and MA 2005).

Assessment of the rangelands to climate and land use changes will be done using vulnerability index, developed by Chuluun and Altanbagana (2004). This index calculates zud index, accounting previous year's summer drought (Natsagdorj & Sarantuya 2004) and land use index relative to carrying capacity. This index is based on climate and land use intensity information, but it needs to be developed further to include water resources.

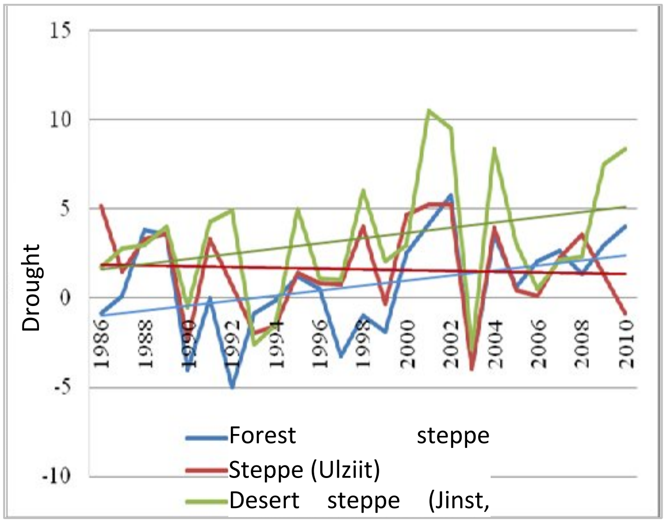


Figure 52. Drought assessment in the Tuin river basin by ecosystem type, (1986-2010)

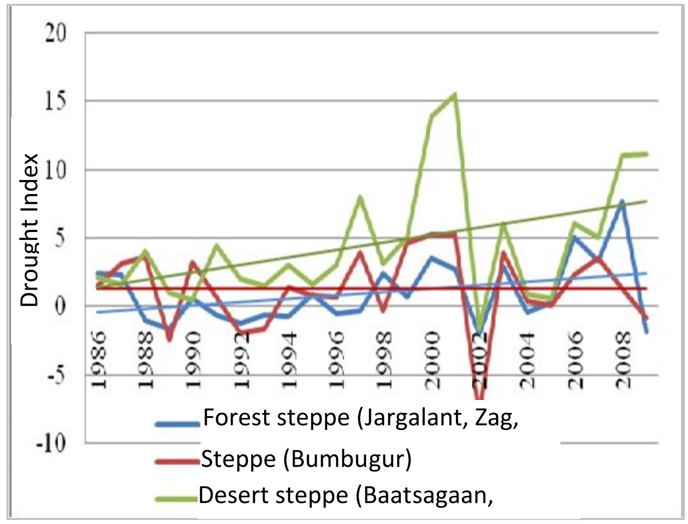


Figure 53. Drought assessment in the Baidrag river basin by ecosystem type, (1986-2010)

Integrated drought-*zud* was higher in Jinst and Bogd sums relative to other sums, and it had slightly increasing trend. However, integrated drought-*zud* had slightly decreasing trends in Erdenetsogt and Olziit during last decade (Fig 52). Our zud assessment was a new analysis in Mongolia because zud index included black zud index.

Ecological vulnerability assessment

Vulnerability study to drought and zud in Mongolia was done by research team after 1999-2000 zud. According to that study results, vulnerability of pastoral husbandry to zud has been increasing since 1990. It is related to total livestock number increase by 44% and total pastoral area's decrease by 20% in the past 70 years. Pastoral area per one animal decreased to 1.5 hectar from 2.4 hectar in the same period. (Batjargal, Z, et al., 2000).

M.Altanbagana and T.Chuluun (2010) did spatial and temporal vulnerability assessment of Mongolia at aimag level based on drought and pasture use assessment. According to this result, Bayanhongor aimag is one of vulnerable aimags.

Relations between average values of ecological vulnerability during 1986-2008 for Erdenetsogt, Olziit, Jinst and Bogd sums were 1:1:1.1:1.5, which indicate that desert steppe region of the Tuin river basin is more vulnerable to climate and land use changes (Figure 53).

Ecological vulnerability dynamics study shows 1986-2008 (Fig 53 and 54), that all sums are defined by high variability except forest steppe-sums including Galuut, Jargalant and Erdenetsogt sums, which are dominated by forest steppe zone. The most ecologically vulnerable sums were Bogd and Jinst sums in Tuin river basin and Baatsagaan and Buutsagaan sums in the Baidrag River basin. This is due to increased land use in addition to its location in the desert steppe zone with highly variable climate.

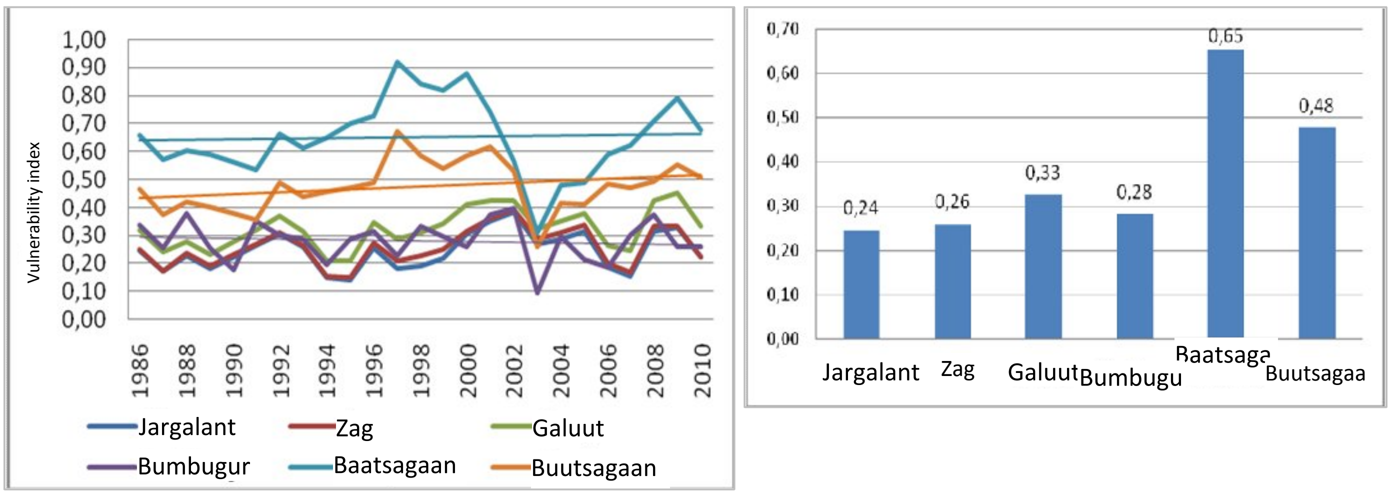


Figure 54. Ecological vulnerability assessment in the Baidrag river basin (dynamic for 1986-2010 and average)

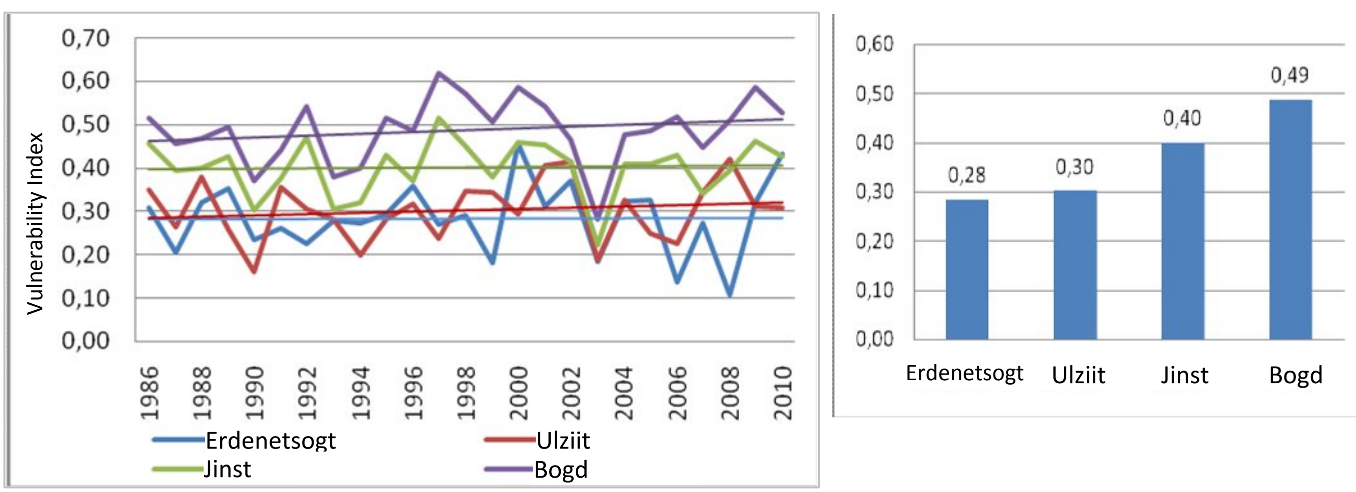


Figure 55. Ecological vulnerability assessment in the Tuin river basin (dynamic for 1986-2010 and average)

Vulnerability to climate disasters, pasture use and ecological vulnerability (Fig 55) were assessed in ecological zones. 7 aimags were integrated in the Gov' region, 3 aimags – in the transition zone between the Gov' and Khangai mountains, 2 aimags – in the steppe region, and 6 aimags – in the forest steppe region. The drought-*zud* index in the Gov' zone was the highest relative to other ecological zones until 2000, however, the drought-*zud* index in other ecological zones increased during last decade. For instance, the drought-*zud* index in the steppe zone even increased during last decade. The pasture use intensity is the lowest in the steppe region, but it was the highest in the Gov' region since 1990 and became more dynamic too.

Ecological vulnerability of pastoral human-environmental systems, calculated as sum of drought-zud and pasture use indexes, had increasing trends in all ecological zones during the last decade, especially in the forest-steppe zone.

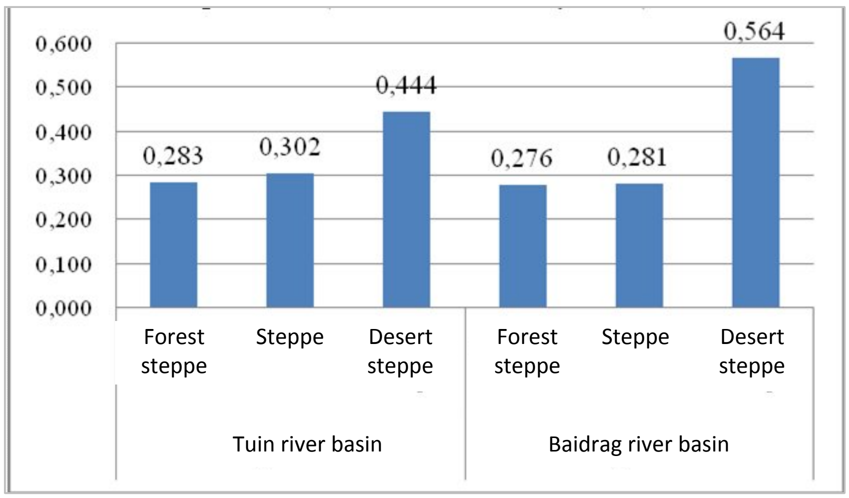


Figure 56. Ecological vulnerability assessment by ecosystem type (average for 1986-2010)

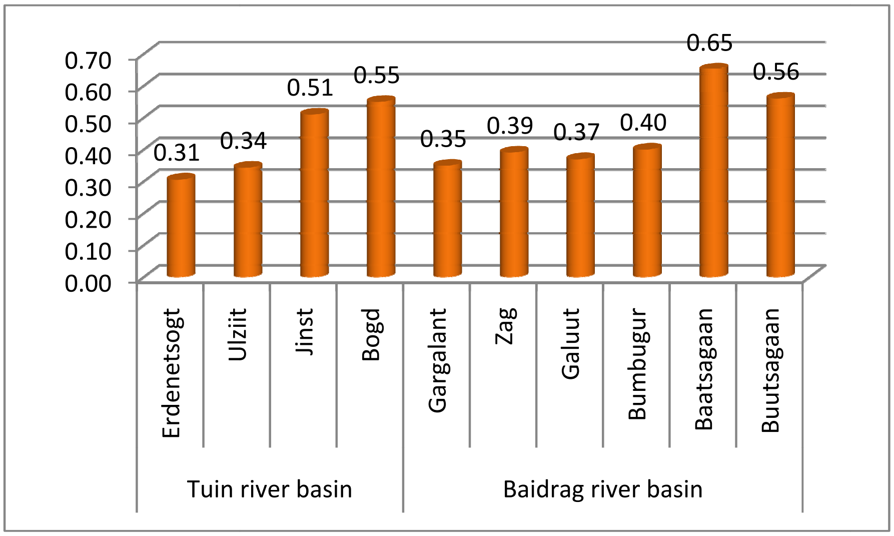
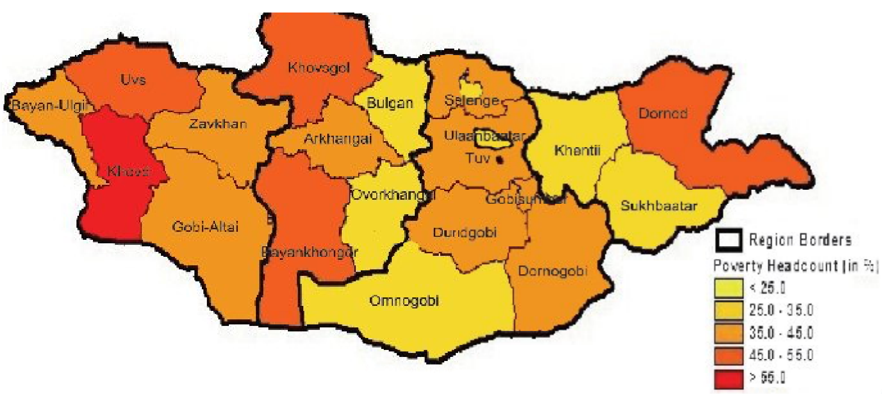


Figure 57 . Integrated vulnerabiliy assessment Social-ecological system

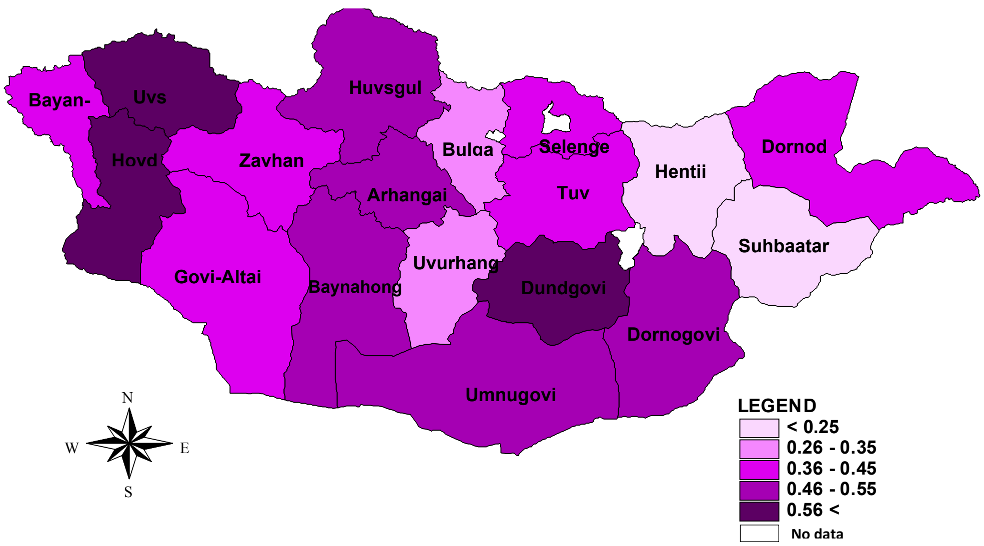
The figure 58 to shows aimag-poverty level of Mongolia based on population census of 2000 (UNDP and NSO, 2009). Social vulnerability index determines poverty level because vulnerability increases due to poverty. In remote areas social-economic vulnerability increases because of high transportation cost, low infrastructure development and high poverty level. According to the most vulnerable aimags are Hovd, Uvs, Bayanhongor and Huvsgul aimags.

Figure 58. Aimag-level Poverty Headcount Map



Social-ecological vulnerability was assessed combining ecological vulnerability and poverty indexes. Social-ecological vulnerability is the highest in Hovd, Uvs, and Dundgovi aimags (Fig 59).

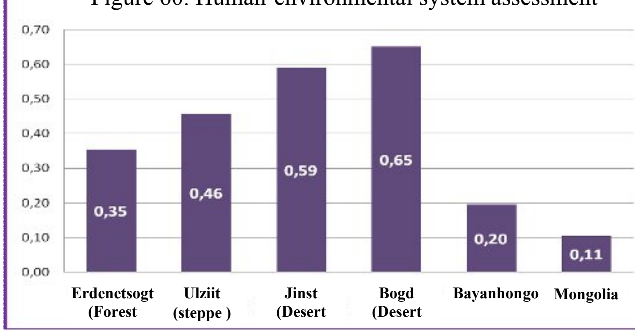
Figure 59. Vulnerability assessment of social-ecological systems



Integrated assessment of human-environmental system in the Tuin river basin of Bayanhongor aimag, combining environmental vulnerability index and human development index, was calculated at sum, aimag and national scales. The integrated index of human-environmental system is high when human development index is high and ecological vulnerability is low. Ecological vulnerability assessment includes indexes of pasture use, and black and white zud. Human development index includes indicators of education, GDP per capita, health or average life expectancy.

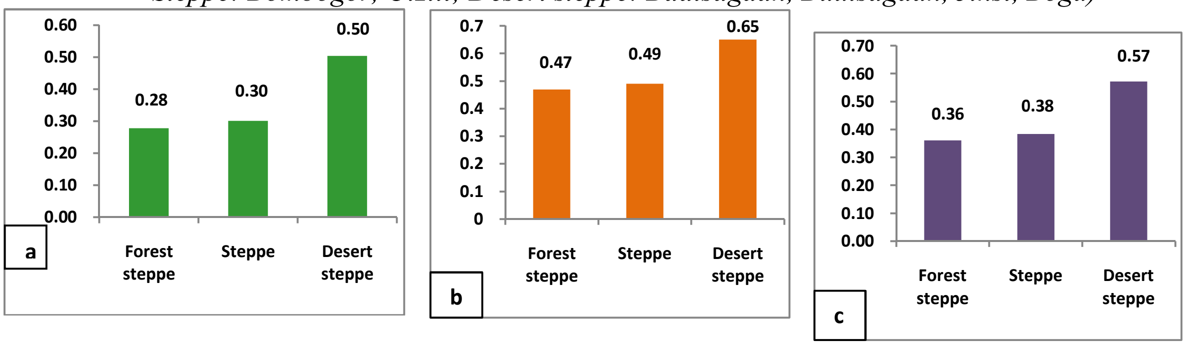
Integrated index of human-environmental system in Tuin river basin (Fig 60) has been decreased along the transect from north to south or from the forest steppe zone (Erdenezogt sum) to the desert steppe zone (Jinst and Bogd sums). According to this assessment, we can conclude that our study area is more vulnerable; especially desert steppe zone is the most vulnerable ecologically and socially in the country.

Figure 60. Human-environmental system assessment



Ecological vulnerability (drought, stocking rate relative to carrying capacity) and social vulnerability (livestock number per capita, distance to the market, livestock loss during the zud) assessment trends showed that social-ecological vulnerability have increased in desert steppe region compared to other ecological zones. This indicates that the desert-steppe region is becoming more vulnerable from climate change, land use change and transition to market economy point of view.

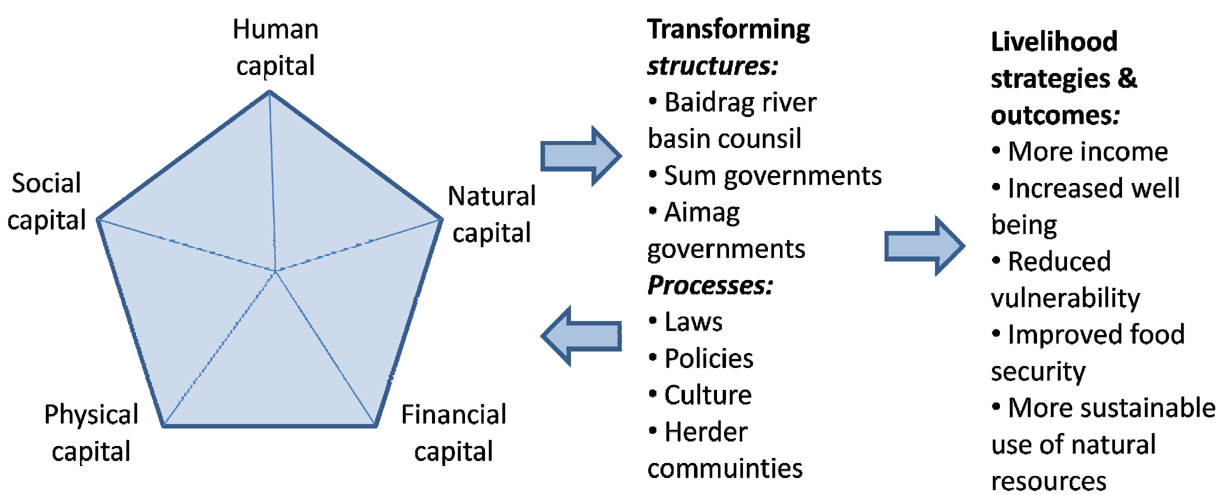
Figure 61. Ecological (a), social (b) and social-ecological vulnerability (b) assessments in Tuin and Baidrag river basins by ecosystem type (1986-2010) (Forest steppe: Jargalant, Zag, Galuut, Erdenetsogt; Steppe: Bombogor, Ulziit; Desert steppe: Baatsagaan, Buutsagaan, Jinst, Bogd)



Social vulnerability of sums (districts) was calculated based on wealth (livestock number per capita), robustness (livestock loss during zud events of 1999-2002 and 2009-2010) and distance to the Bayanhongor aimag center (Figure 61b). Social vulnerability is high when wealth and robustness low, and distance to the market is long. Sums located in desert-steppe zone have higher social vulnerability relative to sums located in forest-steppe and steppe zones. Vulnerability of social-ecological systems in desert-steppe zone is higher than vulnerability in steppe and forest-steppe zones (Figure 61c).

Pastoral socio-ecological system and sustainable livelihood framework web analysis

Figure 62. Sustainable livelihood's social-ecological pentagon framework



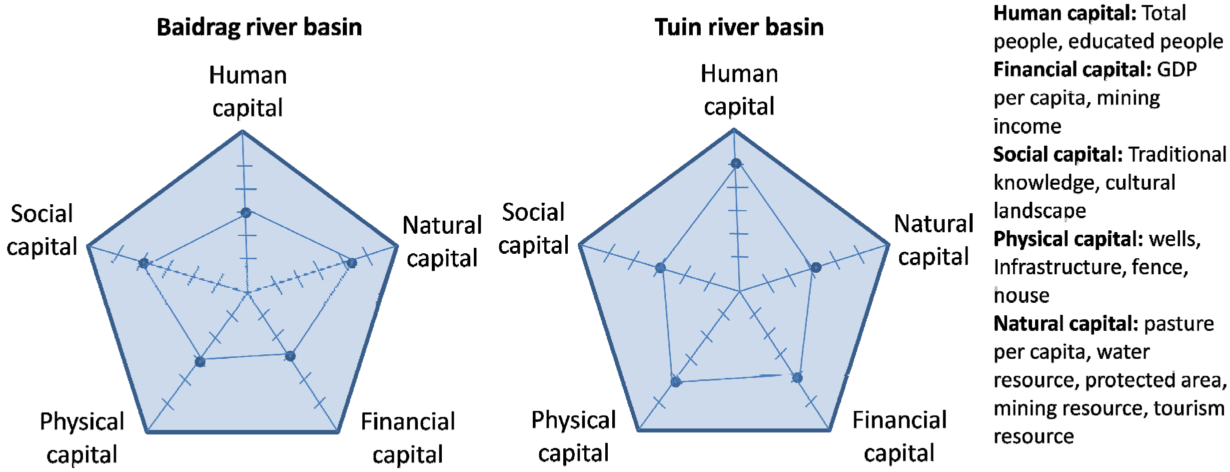
Source: Sustainable livelihood guidance sheet, DFID, 1999

Transforming Structures and Processes within the livelihoods framework are the institutions, organisations, policies and legislation that shape livelihoods. Their importance cannot be veremphasised. They operate at all levels, from the household to the international arena, and in all spheres, from the most private to the most public (Figure 69). They effectively determine:

- **access** (to various types of capital, to livelihood strategies and to decision-making bodies and sources of influence);
- the **terms of exchange** between different types of capital; and
- **returns** (economic and otherwise) to any given livelihood strategy.

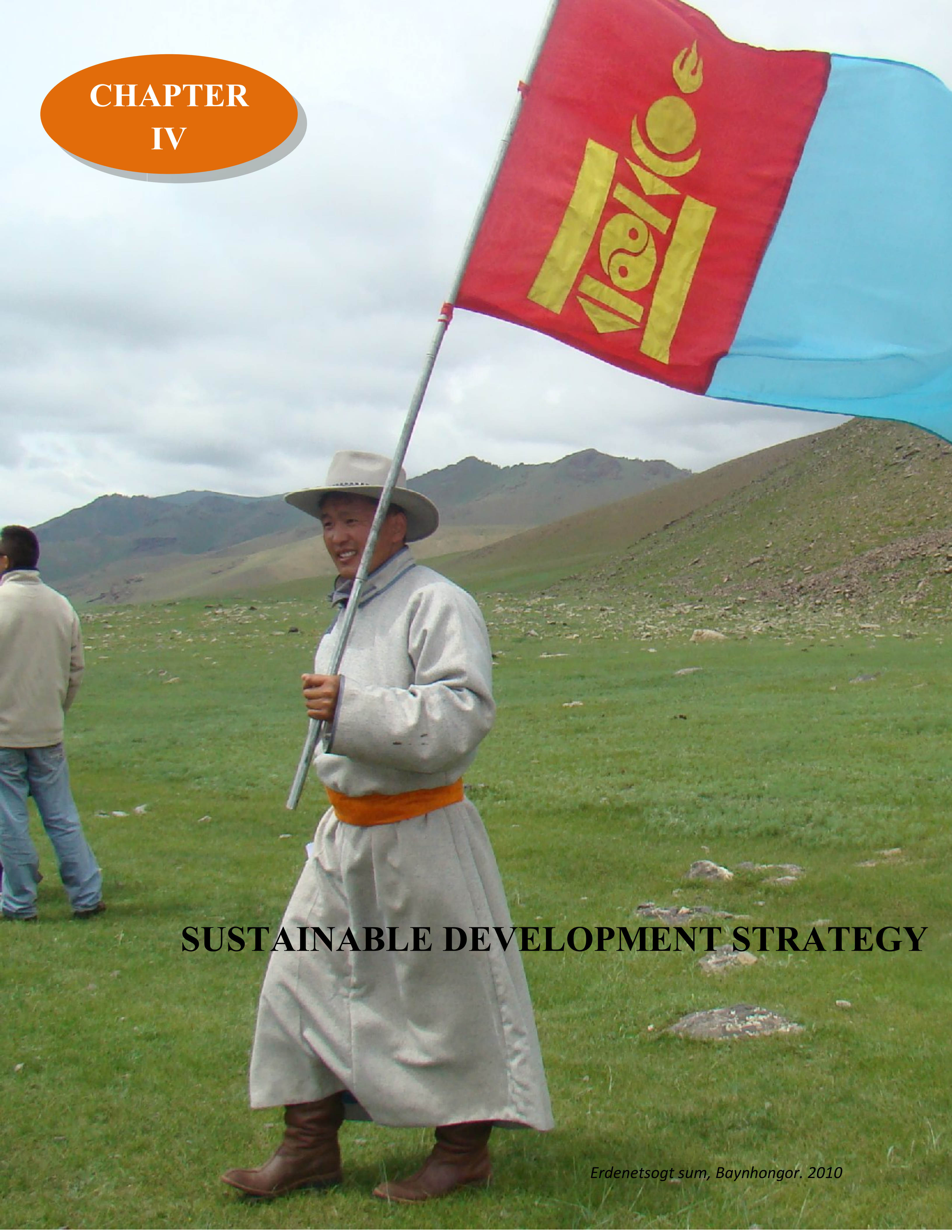
In addition, they have a direct impact upon whether people are able to achieve a feeling of inclusion
and well-being. Because culture is included in this area they also account for other 'unexplained' differences in the 'way things are done' in different societies (Sustainable livelihoods guidance sheets, 1999).

Figure 63. Baidrag and Tuin river basin's sustainable livelihood assessment's comparision



According to sustainable livelihood web-assessment, vulnerability of Baidrag river basin is lower than the Tuin river basin (Fig 63)

CHAPTER IV



SUSTAINABLE DEVELOPMENT STRATEGY

Erdenetsogt sum, Baynhongor. 2010

SUSTAINABILITY STRATEGY

Policy recommendations

- **Management plan of social-ecological system of the Tuin river basin**
- **Adaptation options of the Baidrag river basin**
- **Adaptation based-new proposal on administrative-territorial division**

The Dryland Development Paradigm was applied for the study of the Tuin and Baidrag river basin social-ecological systems. Dynamics of coupled human-environmental system is defined by primarily by two opposite factors such as climatic disasters and market forces. Privatization of livestock caused a private interest to increase livestock numbers, especially goats due cashmere value. However, drought followed by *zud* causes livestock losses. Global warming is indeed the most critical slow variable in these drylands. Water resource decrease due to global warming in the region already exceeded the threshold level according to local residents. For example, only 3 rivers out of 25 (based on a map 1969) were inflowing into the Tuin river during our filed survey in summer of 2009. Orog lake was completely dry in summer of 2009, and depth of the Boontsagaan lake is decreasing rapidly (Davaa. 2010). Residents of the Tuin river basin concluded that global level regulation is more important, but residents of the Baidrag river basin was claiming that local regulation is the most critical. These differences are explainable by level of water stress of the Orog and Boon Tsagaan lakes. A body of up-to-date local knowledgeis essential for management and policy development of pastoral human-environmental systems.
For nomadic herding culture, pastoral risk co-management is very important. Advantages of it are followings (Tabl 8).

Table 8. Advantages of pastoral risk co-management

Pastoral management activities	Collective action	Individual
Setting aside pastures of winter and spring to be rested	↗	↘

Seeding haymaking areas and pastures	↗	→
Discussing a reduction in the number of animals	↗	↘
Repairing and building wells in inaccessible areas	↗	↘
Making fences to protect sources of spring and river	↗	↘
To grade breed of livestock	↗	↗
To ensure animals	→	→
Fighting grasshoppers and rodents	↗	↘
Vaccinating animals	→	↗
Preventing and coordinate pastoral conflicts	↗	↘

According to the social learning activities of the DDPPaS project, adaptation to the adverse impact of climate change and sustainable development has recognized as a priority area for local policy and herders' communities. The research findings of the DDPAS have emphasized the urgency of action and the scale of response needed to cope with climate change outcomes such a learning-by-doing approach is essential to implement concrete adaptation actions. This strategy was developed with participation of all stakeholders and based on research findings, and participatory workshops. However, this draft needs to be discussed at the final closing workshop this spring before handing over to local government.

Management plan of social-ecological system of Tuin river basin

Unofficial translation into English

Final version adopted and revised by stakeholders
in the Aimag workshop (2010.05.12)

Goal

Main goal of this management plan is to strengthen adaptive capacity of social-ecological systems to climate and land use changes, to reduce vulnerability and risks, and to manage sustainable use and protection of ecosystem services and goods in the Tuin river basin.

Objectives

- To increase adaptive capacity of social-ecological systems to climate change;
- To manage sustainable use of natural resources and protect pastoral ecosystem
- To increase local stakeholders' participation in protection and improve awareness and knowledge of local citizens;
- To develop cooperation of local stakeholders, including private sectors, government and NGO's;

Documents supported and are based on:

- Millennium Development Goals-Based Comprehensive National Development Strategy of Mongolia
- Law on Water
- National Programme on Water
- National Programme on Climate Change
- National Programme on Public education on sustainable development
- Development Programme of Bayanhongor aimag for 15 years
- Aimag Governor's Action plan (2009-2012)

Organizations of Bayanhongor aimag to implement this management plan:

- Government of aimag
- Department of Environment and Tourism
- Council of Tuin river basin
- Water and meteorological center
- Department of Education and Culture
- Office for Land affairs, construction and urban development
- Disaster department
- Department of Food, agriculture and small and medium enterprises
- Erdenezogt sum
- Bayanhongor sum
- Ulziit sum
- Jinst sum
- Bogd sum
- NGO
- Herder communities and herder households

Management plan of social-ecological system of Tuin river basin (2010-2015)

According to social learning activities of the DDPAS project, adaptation to the adverse impacts of climate change and sustainable development, the Tuin river basin has been recognized as a priority area for local people and ecosystems. The research findings of the DDPAS have emphasized the urgency of action and the scale of response needed to cope with climate change outcomes such a learning-by-doing approach is essential to implement concrete adaptation actions. This strategy was developed by participation of all stakeholders and based on research findings.

Activity direction	Activity	Practices	Responsible stakeholder
1. Rangeland Ecosystem management: Healthy rangeland ecosystem as a climate shock insurance			
Pasture management	Decrease of overgrazing	• To control livestock number for not exceeding carrying capacity. • Lack of rotation or residence time of grazers on a sub-plot of the landscape unit. • Grazing at appropriate times relative to the flora productivity cycle.	Erdenezogt, Jinst sum Government, Ogoomor ortomt,
	Restoration traditional cultural landscape	Complex use of 4 seasonal pastures, reserve, otor, sacred area and hayland along river basin	Herder communities Sum administration
	Proper ratio of goats in livestock composition	To keep proper ratio of goats in livestock composition along with different ecological zone	Herder communities
	Rangeland ownership of herder communities	Local herder communities will conclude bilateral agreement with sum administration for sustainable land management and decrease tragedy of the commons.	Sum Governments Herder communities
Conservation	Involvement to state's protected area	Tuin riverhead area will be to become as a national park	Aimag and sum government
	To control mining	To manage and decrease uncontrolled mining of gravel, river meadow and soil's black earth in Tuin river basin	Aimag and sum government Herder communities
	To protect natural specific vulnerable ecosystem	To protect Gobi's oasis	Jinst and Bogd sum government and herder communities
Water management	Spring and streams ecosystem protection	Protection of spring source ecosystem as an Ogotnot spring	Bayanhongor, Erdenezogt sum
	Green fences protection	Plantation and protection with fences along Tuin river basin	Orog lake-Tuin river movement Bayanhongor, Jinst sum, Herder communities

	To build water bodies	To build water bank to gather and keep rainfall water	All sum government
Forest management	Proper use for fuel	Decrease deforestation for fuel	Erdenezogt sum, and Ogoomor Ortomt herder community
		Stop deforestation for commerce	Erdenezogt sum
		To ban to use keystone plants as a karagana and saxaul in pastoral ecosystem for fuel	All sum government and herder communities
Restoration of ecosystem owing to mining-driven degraded land	Restoration with sowing	To sow indigenous plants as saxaul and garagana along river basin area	Orog lake-Tuin river movement, Jinst, Bayan-Ovoo, Bayanhongor sum
	Non-grazing for natural remediation	Non-grazing in mining induced degraded land in order to support natural remediation	Orog lake-Tuin river movement Erdenezogt, Bayan-Ovoo, Bayanhongor sum
	Biological effective restoration to be done by mining company	Biological effective restoration to be examined by sum and local communities	Mining companies Orog lake-Tuin river movement Sum government
	Purification of polluted rivers	Purification of polluted Tuin river water using nanotechnology	Project by Japanese grant
2. Socio-economic activities: People living in areas affected by climate change/land degradation and drought to have an improved and more diversified livelihood base and to benefit from income generated from sustainable land management.			
Economic diversification and increase animal husbandry's productivity	Milk production for market of aimag center, hot-spring resort of Shargaljuut	Sweet and fruit curds and cheese fermented milk of mares	Erdenezogt, Bayanhongor, Bayan-Ovoo sum Herder communities
	Agriculture for their food supply and commerce	To plant crop of potato and vegetable	Erdenezogt, Bayanhongor sum
	Fruit plantation has both benefits with ecosystem protection and income increase	Plantation of fruits as seabucktorn	Bayan-Ovoo, Bayanhongor, Jinst sum
	Develop tourism	Community-based natural and cultural tourism	Herder communities
	Additional economy	Support other economic activities except animal husbandry in sum and aimag center	Aimag and sum governments
	Innovation and nano-technology	Artificial pollination for well-bred animal's in order to increase animal husbandry's productivity	Herder communities
Administrative and territorial division new	Enlargement of administrative and territorial units for	To develop new proposal on administrative-territorial unit: socio-economically optical, historically	Dryland Sustainability Institute (DSI)

proposal	cultural complex landscape use including 4 seasonal pasture, otor, reserve pasture and hay	acceptable, environmentally sustainable	All sums
Incentives for sustainable animal growth	Support sustainable growth of animals with low risk at natural disaster and high income	Support herder household who keep averagely 400-600 animal in sheep unit	Sum government Herder households
	Proper ratio of goats in livestock composition	To keep proper ratio of goats in livestock composition along with different ecological zone	Herder communities Sum governments
Institutions strengthening	Strengthening herder communities	Informal communities to as formal form as NGO	Herder communities DSI (legislative support)
	Develop leadership of herder communities	Improvement of leadership: Present communities as "Powerless spectator"(has a low adaptive capacity and weak capacity to govern, do not have financial or technological options, and lack natural resources, skills, institutions, and networks.) and "Coping actor" to develop as "Adaptive co-management"	Herder communities Sum governments
	To develop co-operation and capacity building	Knowledge sharing from local professor herder to young herder	Herder communities Sum government
		Informal training programme on climate change adaptation at local secondary school	Sum government
		Co-operation between rich and poor herders or herders communities for rangeland management	Herder communities
		Co-operation between neighboring sum for cultural landscape use and otor movement	All sums
	Restore and sharing traditional knowledge on environmental protection	Traditional religious believes to protect nature, and clean the Ortomt river every season;	Ogoomor ortomt community Bayanhongor sum
		Incentives for maintaining environmentally sustainable practices	Sum governments
	Human proper settlement	According to human population natural increase, to prepare young generations for rural-urban migration: improvement and possession high education and	Herder communities
Modern technological transformation	Improvement of renewable energy supply	Solar and wind energy supply	Herder communities
	Communication information technology	Improve wireless, cell phone and distance learning network	Private companies

3. Natural disaster management			
Lessons learnt from past natural disasters	Lessons learnt from past (1999-2001, 2009-2010) drought and zud	Adaptation and resilient options	All sums and herder communities
Drought management and decrease future vulnerability to climate-related natural disaster	Cultural landscape use	To manage "Otor" movement in hard winter's condition	Aimag and sum government
		Reserve pasture for harsh winter and spring	Herder communities
	Sale animals in wholesale	To sale animals in wholesale before they not lost their weight in order to prevent from loss during potential zud, if they had drought in summer	Herder communities
	Enough forage preparedness	To prepare hay and fodder fund enough to keep animal weights in harsh winter	Herder communities
	Economic security	To be insured herders animals to livestock indexed insurance every year	Herder communities
		Community and household have to have bank savings for security fund	Herder communities
		To build meat storages in each sum in order to preserve meat in winter time	Sum governments

Baidrag river basin's adaptation options based on local participation

Sector	Adaptation options	Responsibility
Sustainable mining management	Activities of gold mining companies should be stopped on the source area of Baidrag river.	Local movements, aimag government
	Legal environment and its implementation is very weak in local level.	Aimag government, local people
	Ecology-economical assessment of mining companies for resource use are needed.	Mining companies and sum government
	To get financial support from mining companies because we have no budget to recover water ecosystem.	Mining companies, river basin council and sum government
	There is urgent need to do recovery activities these companies for their responsibility.	Mining companies
Fuel sustainable management	To stop deforestation and support to plant trees in forest-steppe.	Neg goliinhon, herder households
	To decrease using bush and karagana for a fuel. So, to use compressed fuels and dry droppings of cattle cattle.	Neg goliinhon, herder communities and herder households
Sustainable pasture management	To protect some vulnerable and significant pastures such as Huitnii am and Daldiin am as reserve pastures.	Sum and aimag government
	To support migration from overgrazed and exceeded carrying capacity to low pasture use area.	River basin council and herder households
	To develop social institutions such as herder communities and "neg goliinhon" in mountain steppe zone.	River basin council and herder households
	Otor and reserve pasture and hay-fields to be determined in river basin level	River basin council and aimag government
	It is needed more seasonal movements in areas which have more vulnerable to climate change and high dynamics of pastoral ecosystem	River basin council, sum government
	To decrease carrying capacity exceeding in more vulnerable zones such as boundary aseas between forest steppe, steppe and desert steppe	Pastoral communities, neg goliinhon
	To keep Pastural herding structure adapted to pastoral ecosystem in forest steppe and mountain steppe zone	Herder communities and herder households
Water ecosystem management	Development of ecological-economical assessment of springs and stopping to pan off through river water for artisanal miners should be done.	Local government
	To close water canal which was used as agricultural irrigation from Baidrag river.	River basin council
	To build water "huv" using flood water and melting snow. "Harz water" is one of the main sources to support Baidrag river flows. So, to protect "harz water".	River basin council
	To build water reservoirs and ponds in forest steppe in order to conserve water resource	River basin council and aimag government
	To avoid water ecosystem degradation along river bank because of mining and overgazing.	Local communities, artisanal miners and mining companies

Training on adaptation and water management	Development of capacity building for herders group for protection forest	NGO's and
	Public brochures on traditional knowledge and water management including building "water hov" are very needed.	NGO's and donor organizations
	Development of capacity building for herders group for protection forest	Protected area offices
	It is needed to do training and publicity activities for keeping and cleaning river's water.	River basin council
Protection natural resources	Tsagaanturuut gol, Devhergiin burgas in Zag sum and Nariin gol, Tsagaanii gol and Adgiin gol in Baatsagaan sum as a national protected areas with significant resources would be protected as state protected areas.	Aimag government
	Altay mountain should be protected as a world natural heritage.	Government of Mongolia
	Surrounding area with saxaul tree and sweet tasting grass should be protected as a state or aimag protected area.	Government of aimag and Mongolia
Adaptation-based sustainable livelihood management	Increase preparedness to natural disaster zud and drought.	Herder communities and sum governments
	To avoid increased settlement and movements along river banks because shrinking springs and water shortage are leading to water ecosystem degradation and overgrazing.	River basin council and local governments
	To develop adaptation fund at multiple scales (Baidrag river basin, sum and community level)	River basin council and local governments

Adaptation based - New proposals on administrative and territorial units: the Tuin, the Baidrag and the Boontsagaan khoshuu

We are proposing one administrative-territorial unit for the Tuin river basin, combining all 5 sums into one and 2 units for the Baidrag river basin, combining 3 sums each other. All these sums are connected through the Tuin river and Baidrag river, which are invaluable ecological capital basis of sustainable livelihoods of about 13,000 households. Keys for for sustainability of social-ecological systems in this river basin are the Tuin and Baidrag river themselves. A reform of the administrative territorial division is necessary from the following points of view:

- ***Human development.*** Human population in Jinst was reduced, and it increased in other sums since transition to a market economy. Level of social services will be not changed, but administration expenses will become more efficient with this reform. Actually, opportunities for and economic development, and quality improvement of education and health services are greater when human resources are used efficiently.
- ***Reduction of ecological vulnerability and adaptation to climate change.*** Ecological vulnerability increased in Bogd and Jinst sums in Tuin river basin, Baatsagaan and Buutsagaan in Baidrag river basin and it is increased in whole aimag since 1991. Opportunity to reduce an ecological vulnerability and increase an adaptive capacity to climate change will be increased in larger administrative unit.
- ***River basin scale.*** It is necessary to develop sustainable management strategy of the river basins, involving all sums. It will be better if all 10 sums in 2 river basins to be in 3 administrative units in order to provide sustainability of social-ecological system in the river basin.
- ***Traditional cultural landscape restoration.*** Traditionally, all sums located in the Tuin river and Baidrag river basin used to be in the same unit to our new proposals according to historic documents. The khoshuu territory situated in the north-south direction, covering different ecological zones. This geographic feature was essential for nomadic pastoralism bor four seasonal pastures, improved capacity to cope with climatic disasters and genes exchange for people and livestock (Bazargur 2005). Dr. Bazargur studied cultural landscape fragmentation during transitions to socialism and capitalism.

For example, traditionally, pastures in Erdenetsogt were dominantly for summer, and pastures in Jinst and Bogd sums – dominantly for winter and spring. A reduced mobility is one of reasons for rangeland degradation. In addition, “if the landscape of arid regions is divided into parts, the seasonal pastures are not maintained in order to conserve specific portions of the landscape or ecosystem type, then management of these isolated portions of the cultural landscape would require higher amounts of investment…Therefore, reviving and enlarging the traditional cultural landscape by making the administrative and territorial divisions larger would improve the adaptability of pastoral nomadism to climate change and provide a positive effect on the livelihoods of rural people (Ojima & Chuluun 2008, Galvin et al. 2008).

Therefore, we are proposing to combine Erdenetsogt, Olziit, Jinst and Bogd sums into one administrative-territorial unit-Tuin hoshuu (Fig 64), Zag and Jargalant sums into one unit-Baidrag hoshuu, and Galuut, Bombogor and Baatsagaan into one unit-Boontsagaan hoshuu (Table 9) in order to promote sustainable development, reduce ecological vulnerability and land degradation, improve water management, and adapt to climate change. A reform of administrative-territorial division of Mongolia will accelerate human development, because business will be developed due to increased market, quality of social services in education and health sectors will be improved in the center of the unit with increased population.

Figyre 64. Enlargement of administrative-territorial units of sums in Tuin river basin of Bayanhongor aimag

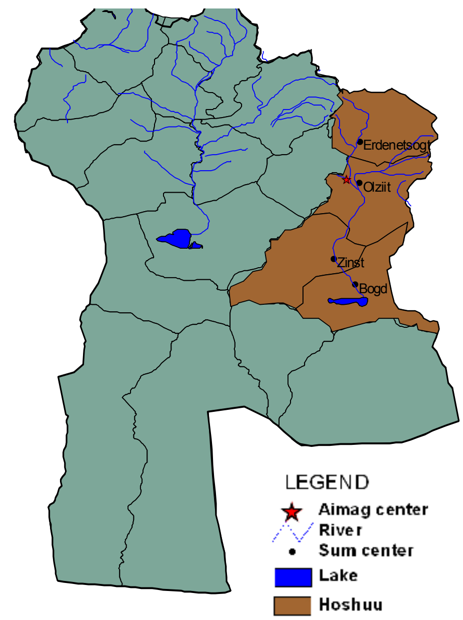


Table 9: Culture-traditionally acceptable, ecologically sustainable and socio-economically rationally - New proposal for Administrative-territorial unit in Baidrag river basin

№	Proposal name	Sum name	Ecosystem	Historical-traditionally division	Distance to aimag center, km	Unit center	Livestock density	
							sum	hoshuu
1	**Baidrag hoshuu**	Zag	Forest steppe	1 unit - Erdene zasgiin hoshuu	183	Hoshuu center-**Zag sum** due to geographical position	54	45.4
		Jargalant	Forest steppe		158		51	
		Buutsagaan	steppe, desert-steppe		181		38	
2	**Boontsagaan hoshuu**	Galuut	Forest steppe	1 unit - Darkhan zasgiin hoshuu	80	Hoshuu center - **Bombogor sum** due to geographical position, road network and human population increase	86	46.9
		Bombogor	steppe		102		43	
		Baatsagaan	desert-steppe		141		30	

Publications, Appendixes & Activities

Publications (to date and/or pending)

1. Chuluun, T. and M. Altanbagana. 2010. Vulnerability and Adaptation Policy Options of Social-Ecological Systems to Climate Change. Proceedings of the Conference on "Development, Science and Technology of the Western Region", Ulaanbaatar, 369-384 (In Mongolian).
2. Chuluun, T. 2010. Recommendations for "Institutional capacity in pastoral risk management", Sustainable Livelihoods Project II, Mongolia. Executive summary of the National Conference on "Community participation in local development", Ulaanbaatar, 2010, 46-53.
3. Altanbagana, M., and T. Chuluun. 2010. Vulnerability assessment of social-ecological system of Mongolia. The Proceedings of the 4th International and National workshop "Applications of Geo-informatics for Natural Resource and Environment", June 2010, Ulaanbaatar, Mongolia.
4. Chuluun, T., B. Tserenchunt[2], D. Ojima[1], R.Tsolmon[3], N. Enkhjargal[3], T. Erdenezaya[3] and B. Batbileg. 2010. Vegetation trends analysis in Mongolia: Using long-term remotely sensed vegetation index NDVI (1982-2008). The Proceedings of the 4th International and National workshop "Applications of Geo-informatics for Natural Resource and Environment", June 2010, Ulaanbaatar, Mongolia.
5. Ojima, Dennis, Togtokh Chuluun, and Myagmarsuren Altanbagana. 2010. Vulnerability and Resilience of the Mongolian Pastoral Social-Ecological Systems to Multiple Stressors. GLP book.

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10. Tserenchunt, B., T. Chuluun and D. Ojima. 2010. Plant productivity trends analysis using remotely sensed information. Pages 141-142 *In*: Chuluun Togtokh and Masataka Watanabe (eds). 2010. Proceedings for Consultative meeting on "Integration of Climate Change Adaptation into Sustainable Development in Mongolia", June 17-18, Ulaanbaatar, Mongolia.
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12. Chuluun, T., M. Altanbagana, D. Ojima, S. Davaanyam and B. Tserenchunt. 2011. Diverse Rangelands for Social Sustainability in Mongolia. IRC, April 2-8, Rosario, Argentina.
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14. Chuluun, T., M.Altanbagana, S.Davaanyam, B.Tserenchunt and D.Ojima. 2009. Vulnerability of Pastoral Communities in Central Mongolia to Climate and Land Use Changes. Book Workshop on Vulnerability and Resilience of Land Systems in Asia, Beijing, China.
15. Chuluun, T. 2010. Land degradation and desertification in Mongolia. Background paper for the "Human Development Report-2010-Mongolia".
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to climate and land use changes. (Accepted to 2nd International Conference: Climate, Sustainability and Development in Semi-arid Regions (ICID). 16 - 20 August 2010. Brazil)

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1. June 17-18, 2010. Consultation meeting of the Asia-Pacific Adaptation Network on “Integration of Climate Change Adaptation into Sustainable Development of Mongolia”, Ulaanbaatar, Mongolia.
2. August 16-20, 2010. Panel Chair on “Climate Change Adaptation and Sustainable Development of Mongolia”. The Second International Conference on Climate, Sustainability and Development in semiarid regions – ICID, Fortaleza, Brazil.
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5. September 30-October 3, 2010. Chuluun, T. Adaptation of pastoral social-ecological systems to market economy and climate change in Mongolia, North American Regional Meeting of the International Association for the Study of the Commons (IASC), Tempe campus, Arizona, USA.
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7. October 21-22, 2010. Chuluun, T. and B. Tsogoo. Vulnerability of pastoral social-ecological systems at multiple scales in Mongolia. Asia-Pacific Climate Change Adaptation Forum: Mainstreaming adaptation into development planning, Bangkok, Thailand.
8. April 2-8, 2011. Chuluun, T. "Vulnerability and adaptation of pastoral social-ecological systems at multiple scales in Mongolia". IX International Rangeland Congress -

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9. June 8-10, 2010. Dryland science visioning meeting on Coupled Human-Environmental (CHE) systems in the MAIRS region. Harbin, China.
10. June 15-17, 2009. International Workshop on Vulnerability and Resilience of Land Systems in Asia, Beijing, China.
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13. September 12-15, 2009. Inter-Agency Collaborative Technologies in Earth Observations for Global Change Research in the Asia-Pacific Region, International Training Workshop, Ulaanbaatar, Mongolia.
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16. November 4-6, 2009. Meeting on Impacts, Adaptation and Vulnerability to Climate Change in Developing Countries, São José dos Campos, Brazil.
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20. August 16-20, 2010. Panel on Mongolia on "Climate Change Adaptation and Sustainable Development of Mongolia" The Second International Conference on Climate, Sustainability and Sustainable Development in semiarid regions – ICID, Fortaleza, Brazil.

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Erdenetsogt sum, Mongolia. Photo by M.Altanbagana, 2009

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