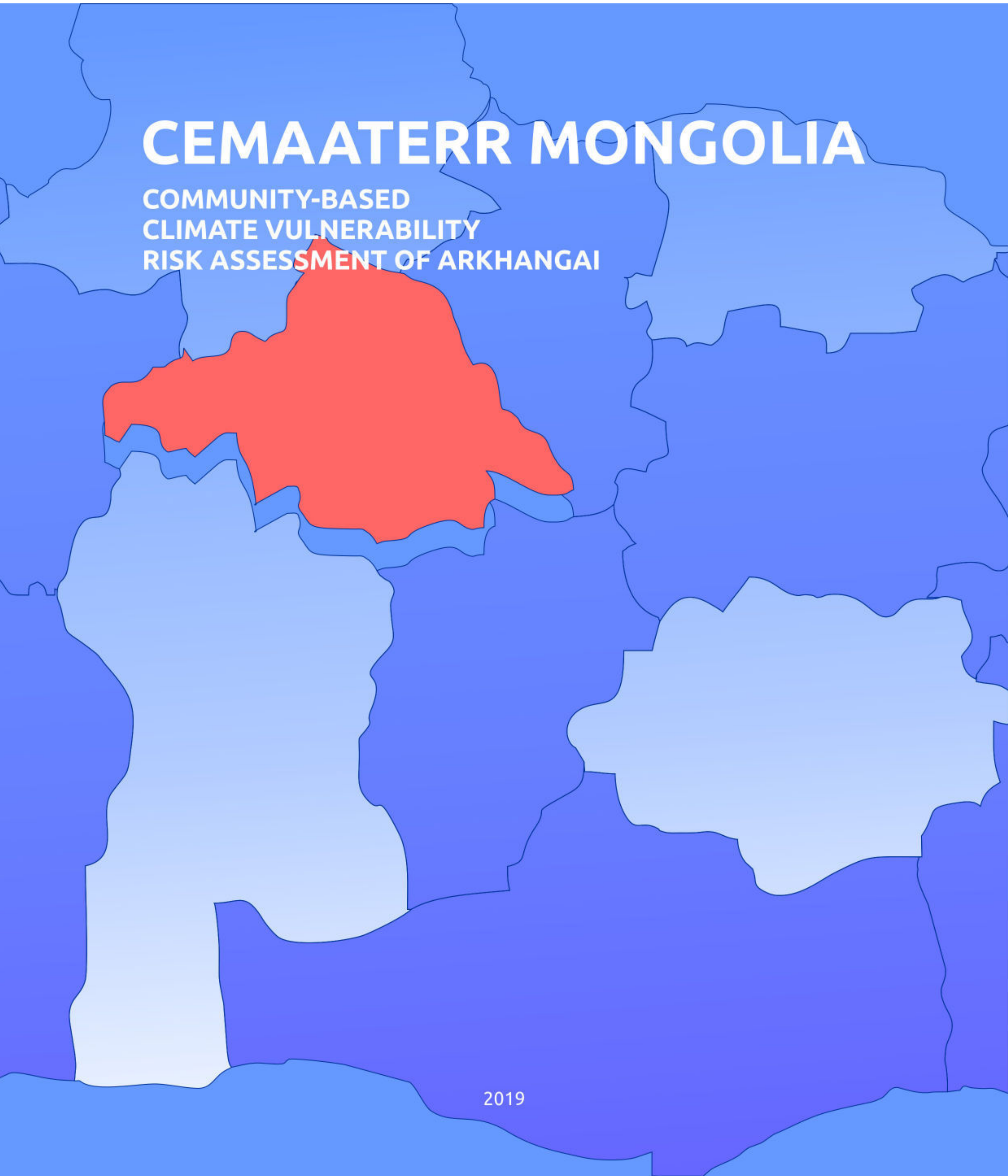
CEMAATERR MONGOLIA

COMMUNITY-BASED CLIMATE VULNERABILITY RISK ASSESSMENT OF ARKHANGAI



2019

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Abbrevation & Acronyms

3DPM – 3D Particpatory Mapping
AAGO - Arkhangai aimag governor's office
AFD – French Development Agency
AR5 - Fifth Assessment Report
CMIP5 - Coupled Model Intercomparison Project, Phase 5
CVRA – Climate Vulnerability Risk Assessment
GCMC – Ger Community Mapping Center
GDP – Gross Domestic Product
GHG – Greenhouse Gases
GIS - Geographic Information System
ICISB - Issues, Causes, Impacts, Solutions, Barriers
IPCC - Intergovernmental Panel on Climate Change
MNT – Mongolian Tugrik
ND-GAIN – Notre-Dame Global Adaptation Initiative
NDVI - Normalized Difference Vegetation Index
NGO – Non-Governmental Organization
RCP - Representative Concentration Pathway
USD – United-States Dollars

Short presentation of stakeholders

Team of authors

Khishigbayar Jamiyansuren – Research Advisor

- ✓ Advised on research methodology guidance;
- ✓ Provided relevant literature;
- ✓ Advised on research questionnaire, and provided relevant past research questions;
- ✓ Provided revision and feedback on final draft.

Erdenetsogt Sumiyasuren – GIS assistant

- ✓ Developed NDVI maps and advised on incorporating NDVI in the study;

Enkhtungalag Chuluunbaatar – Lead researcher

- ✓ Planned and coordinated all study activities;
- ✓ Reviewed past literature and relevant projects and similar studies;
- ✓ Developed research methodology including field interviews and participatory workshop exercises;
- ✓ Developed research questionnaire & open-ended questions;
- ✓ Conducted qualitative data analysis and coding;
- ✓ Wrote, revised and edited the study in English.

Tserenkhand Choijinnyam - Data analyst

- ✓ Reviewed past literature;
- ✓ Developed research methodology, and questionnaires;
- ✓ Conducted field interviews;
- ✓ Managed, cleaned, aggregated and processed all data collected
- ✓ Conducted data analysis to generate the framework for the study results.

Baasankhorol Lkhagvasuren – 3D mapping lead

- ✓ Researched and developed a 3D mapping methodology;
- ✓ Conducted all preparations for 3D mapping;
- ✓ Facilitated 3D participatory workshop;
- ✓ Digitized 3D mapping results;
- ✓ Drafted the section of the study for 3D mapping discussion and analysis.

Byambatsetseg Lkhagvasuren – Mapping and data analysis support

- ✓ Provided support in data analysis and map development.

Nyamsuren Tsadmid – Finance officer and field support

- ✓ Managed financial activities of the study (starting Jan 2018)
- ✓ Provided technical, facilitative, and logistical support during field workshops

Tsenguun Tumurkhuyag – Field support

- ✓ Conducted field interviews.

Unurtsetseg Tsevegjav– Field support

- ✓ Conducted field interviews
- ✓ Managed, cleaned, aggregated and processed all data collected

Batdorj Gongor- GCMC Team leader and Community architect, GIS expert

- ✓ Developed all GIS maps
- ✓ Conducted field interviews
- ✓ Organized community engagement workshop in province
- ✓ Support the planning and coordination of all field study activities
- ✓ Support the development of the research methodology
- ✓ Support the development of the community mapping work and community engagements
- ✓ Developed all GIS maps
- ✓ Conducted field interviews and
- ✓ Organized community engagement workshop in province

Oyuntuya Batmunkh - GERES Mongolia project manager

- ✓ Analyzed climate data
- ✓ Reviewed the overall study

Camille André – GERES Climate technical advisor

- ✓ Gave support to the team
- ✓ Participated to the climate data analysis
- ✓ Reviewed the overall study

About Geres

Geres is an international development NGO which has worked since 1976 to improve the living conditions of the poorest people, preserve the environment and limit climate change. Working in the field, it implements innovative energy and environmental solutions and adapt its efforts to the various socio-cultural contexts, in Europe, Africa and Asia, taking a professional approach to solidarity. It is open to co-operation with businesses and public authorities, with a view to empowering beneficiaries to take charge of the sustainable development of their own territories through exchanges of experience, transfer and ownership of lowcarbon technologies.

About GCMC

The **Ger Community Mapping Center (GCMC)** is a non – governmental organization dedicated to sustainable, equal access urban development through community engagement and participatory decision-making. The GCMC, formerly a community group named Eco Friendly Community, has been doing community mapping activities in the ger areas since 2012.

1 SUMMARY

"The ability of communities to meet their most basic needs - food, water, energy, sanitation is threatened by climate change."

Patricia Espinosa,
Executive secretary of the United Nations Framework Convention on Climate Change

Climate change is already affecting all countries in the world but with huge disparities among regions. Like a lot of countries, Mongolia is vulnerable to current effects and future impacts of climate change. However, studies and indexes show that the country can rely on its adaptive capacities to face it in the near future.

But, the current study emphasizes that this relatively encouraging situation for Mongolia is hiding disparities between aimags. Indeed, Arkhangai appears to be quite vulnerable to climate change, especially as far as local communities are concerned.

To conduct the present study, community-based analysis was implemented. It aims to collect climate data from scientific sources and from people's perceptions in terms of:

- ✓ Climate trends evolution such as temperatures and precipitations;
- ✓ Climate change effects and impacts;
- ✓ Potential adaptation solutions.

To do so, GCMC NGO with guidance and technical support from Geres, both involved in the CEMAATERR program, conducted this study at the Arkhangai aimag level. This process relies on the one hand on an analysis of main national and subnational policies related to climate change issues, and on the other hand on a community-based climate vulnerability risk assessment.

The province is therefore characterized by the following main livelihoods: animal husbandry, herding and its outputs and additional livelihoods such as tourism and forest products including timber, berries and pine nuts.

The main results of the climate data analysis, based on scientific data and local perceptions, show that Arkhangai is facing a global warming since 1985 with seasonal disparities. Indeed, winters are becoming colder and more rigorous, while other seasons are getting warmer. In terms of precipitation, it looks like it becomes shorter in duration and more frequently more intense than before.

This already results in impacts such as an increasing frequency of extreme climate-related events like dzud, snow storms, and dust storms. In some areas, the frequency of tornadoes is increasing as well. Impacts are also felt by communities regarding pasture quality, water availability & quality and forest coverage & pest or disease prevalence. Negative changes in pasture, forest, and water resources means limited resources, with ever increasing need. Therefore, land dispute is increasingly an issue between herders, farmers, locals and non-locals. This leads to either loss of livestock, or low quality livestock, leading to drop in market price for livestock products, and poor living standards for the herder family as a result.

Climate projections tend to confirm the existing global warming trends for the years to come. However, if the situation could be contained to a +1 or +3°C by 2040-2059 and 2080-2099, it could also increase to +5 or +6°C by 2080-2099 in the worst case scenario, with potential disastrous consequences for Arkhangai local communities. As far as precipitations are concerned, the shifts already felt in rainfalls/snowfalls patterns may continue to get accentuated in the years to come.

Taking into account this potential evolution of the climate situation in Arkhangai, adaptation options must be supported and reinforced at short, mid and long terms, such as:

- ✓ Capacity building and awareness raising for local community members and relevant officials on climate change and its impacts;
- ✓ Introducing and implementing pasture allocation system at the local level (subsequently at national level);
- ✓ Revisiting and developing policies to address the increasing land conflicts;
- ✓ Supporting value-added production of livestock produce;
- ✓ Strengthening the implementation of rehabilitation activities, legally budgeted from profits made from natural resource exploitation such as mining, and forests;
- ✓ Constructing watershed to better provide and manage water resource for livestock.

2.PART I - CONTEXT & METHODOLOGY

2.1 CEMAATERR PROGRAM DESCRIPTION

CEMAATERR program has been launched in November 2016 with the financial support of French Agency of Development. It involves 4 areas (Collines Province in Benin, Kampong Speu Province in Cambodia, Chefchaouen City in Morocco and Arkanghaï Province in Mongolia), particularly vulnerable to climate change, which has a major impact on local livelihoods in both short and longer term.

Through CEMAATERR program, Geres aims to illustrate the importance of a territorial approach to fight climate change in order to increase regions' social and economic resilience. It will raise awareness and support local actors in developing and deploying adaptation and mitigation strategies that take into account the interactions of different catchment areas.

It thus helps to create in the four-targeted areas:

- A framework for planning and for territorial governance in the field of climate and energy that is well-adapted to rural regions in developing countries;
- Innovative solutions the fields of energy, farming, forestry and territorial planning demonstrating to local stakeholders the potential to contribute to the achievement of adaptation and mitigation national objectives.

Through a transversal component of the program, Geres favors exchange of experience between the four countries and builds capacities of internal teams to address climate change challenges.

In the Mongolian Province of Arkanghaï, the territorial planning process taking into consideration climate change challenges is expected to favor local authorities (Aimag and Sums) involvement through a multi-scale process, such as shown in the scheme below:.

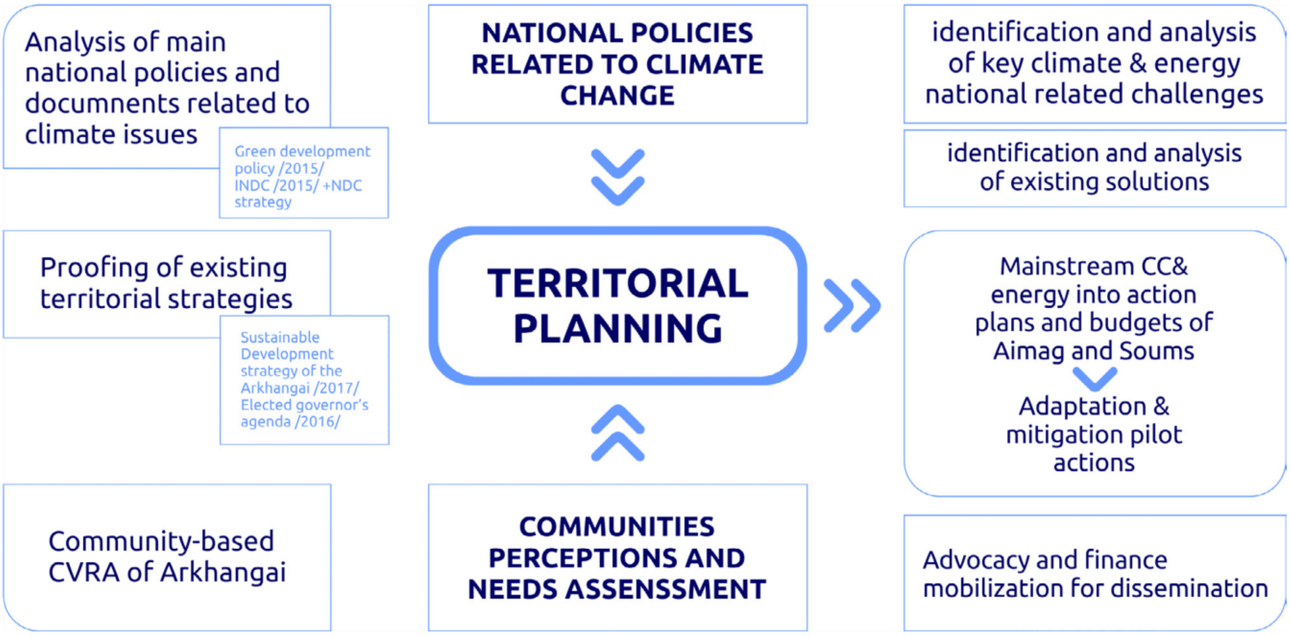


Figure 1: Overview of the territorial approach developed with Arkhangai Province

This process relies on the one hand on an analysis of main national and subnational polities related to climate change issues, and on the other hand on a community-based climate vulnerability risk assessment.

This planning method aims to identify priority policy areas and pilot projects meeting local communities needs to adress climate change adaptation and mitigation challenges. It thus gives a crucial opportunity to develop local actions that meet the needs of the population, based on their perception of climate change. In the same time, these local actions can efficiently respond to the objectives and targets established by national plans and policies.

This study presents the main finding of CVRA conducted by GCMC NGO with guidance and technical support from Geres at the Arkhangai Aimag level. This methodology combines scientific climate data analysis with local communities' perception of climate change effects and impacts. However, the use of people testimonies and perceptions constitute a limit itself because of the potential biases that come with it regarding memories and possible confusions between what is due to climate change and what is due to climate change and what is not.

2.1.1 Description of the Climate Vulnerability Risk Assessment methodology

WThe applied methodology is an adaptation of the Climate Vulnerability Risk Assessment (CVRA) developed by Geres. It relies on a participative diagnosis with local communities and specific stakeholders such as Local Representatives. It gives knowledges on the territory covered by this study in terms of climate, economic, social or environmental characteristics.

This methodology can be summed-up through the following steps:

Steps	Axes of assessment	Means
1 Characterization of the area	1. Analysis of the area 2. Determination of the components of livelihoods and targets 3. Livelihood quantification	1. Literature review 2. Interviews 3. Focus group discussions: resource map livelihood matrix and livelihood resources 4. Household surveys
2 Climate context and hazard exposure	1. Local perception of past climate trends 2. Hazards, climate risks and effects on resources 3. Impact on livelihoods 4. Evaluation of adaptive capacities to climate change 5. Blocking factors and adaptation to climate change facilitators	1. Literature review 2. Interviews 3. Focus group discussions: matrix of vulnerability analysis
3 Evaluation of the underlying vulnerability (sensibility)	1. Vulnerability level of each livelihoods face of global change (excluding climate change) 2. Evaluation of adaptive capacities 3. Blockers and facilitators for adaptation	1. Retrospective climatological study or, failing available and reliable weather time series data, literature review 2. Focus group discussions: calendar of events, climate risk matrix
4 Climate projections and impacts on vulnerabilities	1. Analysis of climate projections 2. Confrontation between possible futures and current adaptation strategies: development of scenario 3. Assessment of current adaptation strategies / practices cope with future requirements	1. Prospective climatological study (projections) 2. Interviews 3. Focus group discussions: scenarios
5 Adaptation options	1. Determining new adaptation solutions / options 2. Prioritization and selection of relevant and robust strategies	1. Literature review (including NAPA / NAP) 2. Interviews and meetings with all stakeholders 3. Scoring grid for practices and potential actions (including carbon sobriety)

Figure 2: Main steps of the CVRA

Characterization of the area

This step consists in getting a first understanding of the area of implementation of the study or the project. To do so, it requires to collect data and review the existing literature in order to determine the main livelihoods of the population. Livelihoods can be defined as *stocks and proper income flows and food products to cover basic needs of a household*.

Climate context and hazard exposure

This step aims to collect and analyze the past and current climate trends that affect the area of intervention. It mainly consists in gathering information about temperatures, rainfall/snowfall patterns and extreme weather events frequency and intensity. To attain these type of data it can be helpful to use climatic data from existing climate reports or local weather stations. But, it can also be relevant to get information from the communities through household surveys or focus groups.

Evaluation of the underlying vulnerability

In this step, the work consists of:

- Analyzing the risks associated with climate change effects in terms of livelihoods as far as resources, stocks and recourses are concerned. For this step it can be useful to rely on a risk matrix that allows to characterize these specific regarding a climate hazard or climate trends risks following several items such as:
    - Impacted component of the livelihood;
    - Impact on the this component;
    - Existing adaptation strategy;
    - Potential aggravating factors;
    - Impact on the livelihood linked with this component.
- Classify the main vulnerable components of the livelihood to climate hazard or climate trend.

Climate projections and impacts on vulnerabilities

Following the same logic than for the characterization of the climate context, this step consists in finding climate projections for the area of implementation and analyze the potential effects and impacts on people's livelihoods.

Adaptation options

This step aims to analyze potential existing adaptation options that were implemented by the communities and to propose ameliorations by taking into account climate projections.

2.1.2 Description of the community-based approach

The study was built around a participatory approach. The main data inputs collected during field interviews and community workshops have been synthesized.

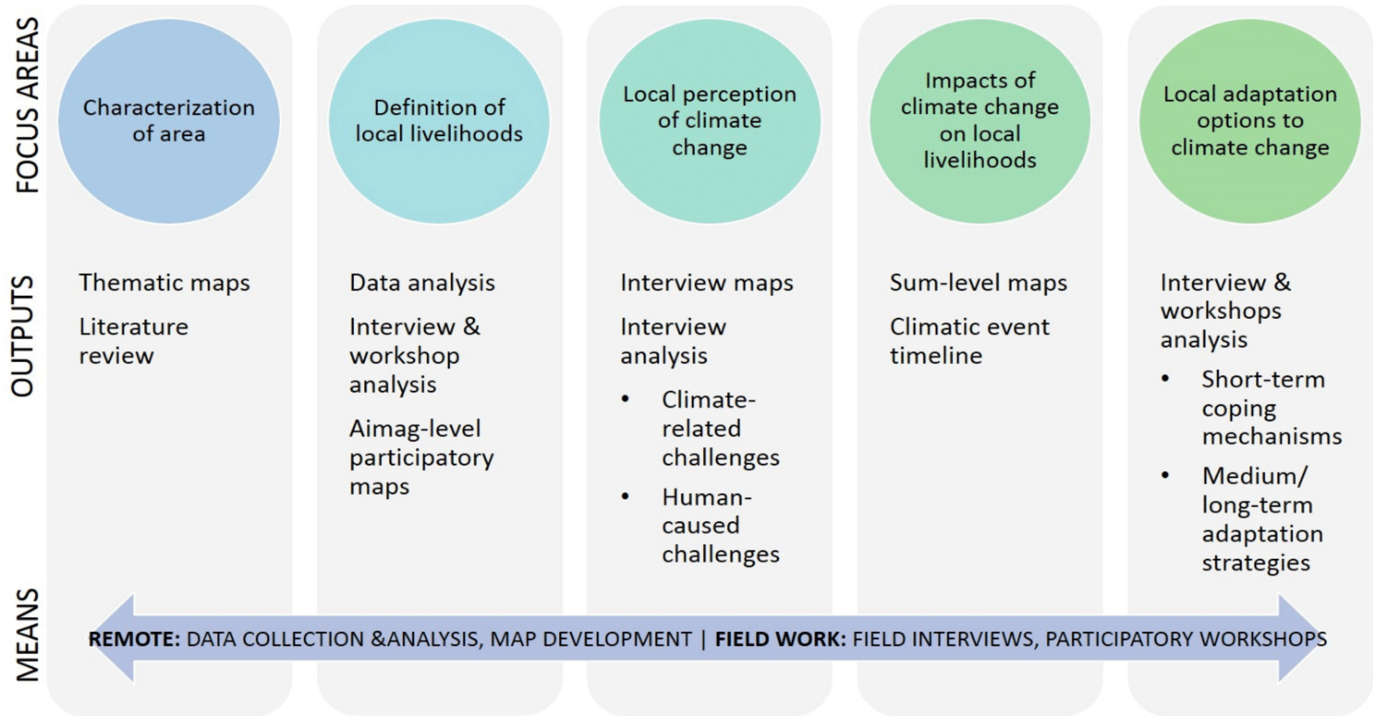


Figure 3: Participatory study framework

As a result, the study aimed to provide an understanding of local perception of climate change and its impacts in Arkhangai. All the tools used to conduct the participatory component of the methodology are described below.

Field interviews

The field interviews represent a large portion of the field work carried out by the team. The results of the field interviews includes:

i. Initial baseline scoping and identifying contact points for data collection from meetings with officials;
ii. Data collection on perception of climate change and challenges by local communities;
iii. Identification of interest areas regarding climate change impacts;
iv. Identification of local individuals knowledgeable about their territories for potential participation in future project activities.

The team interviewed 82 local community members in 19 soums of Arkhangai. The selection of interviewees in the soums was facilitated by the local governor, CRKh representative, and soum technical officer at the environmental departments.

The criteria for interviewees were:

- being over 45 years old;
- having lived in the area for the last 20 years;
- being active in the sector of herding, forestry, water resource inventory, environmental protection, climate & meteorology or holding / having held decision-making position in local office.

The field team aimed to interview a sample with an equal gender ratio. However, many potential interviewees referred to us (who are primarily herders or hold / have held jobs in forest patrol, water inventory officer or government officials) tended to be men.

In the end, the figures for the interviewed population are:

Previous profession	Herders	Government officials	Private sector	Other	N/A
	31%	49%	7%	6%	7%
Current profession	**Herders**	**Government officials**	**Private sector**	**Environmental officer**	**Pensionor**
	40%	18%	9%	13%	20%

Participants age group	45-55	56-65	66-75	Over 76
	44%	29%	22%	5%

Figure 4: Interview participants' data

Thematic maps

Thematic maps have been developed using the collected data. The thematic maps intended to provide a baseline understanding of the aimag and soums. It must be noted that not all the data were used to create maps. Some data were only available at the aimag level, which makes it meaningless to geocode as a map illustration.

Official data

At the beginning of the field mission, the team generated a list of official data aiming to generate thematic maps. The data were collected via local departments in Arkhangai, previous research, as well as national statistics information portals. Following the collection of official data, the team worked to clean and verify the data. Ineligible datasets have been eliminated from being used in the thematic maps based on the minimum requirements to be integrated into the GIS program. In the end, 30 individual thematic maps have been developed using cleaned, complete sets of data.

Interview data

The field data consists of transcribed interviews conducted using the scored interview questionnaire with locals from the 19 soums. In total, 29 perception maps have been developed using the answers provided to the questionnaire. These interview-based thematic maps illustrate how locals perceive the changes in their communities, region and natural landscape in terms of pasture, water resource, forest, harvest and so on.

These interview-based thematic maps are one of the main outputs of the study to understand the local perception of climate change and its impacts. During the vulnerability assessment working sessions, the results of the interviews will be compared to available official data when possible, to draw some conclusions on the local perception of climate change and its impacts.

Community workshops

Organizing workshops

The community workshops were organized with support from the AAGO, who facilitated the process of sending an official letter of request to selected soums to announce and gather relevant stakeholders. The workshop structure was built following the agenda below:

i. Introduction to CEMAATERR project by Geres Mongolia;

ii. Presentation of aimag level thematic maps (both official and interview data) and verification through room discussion;

iii. Participatory mapping exercise with participants to illustrate economic flow, and natural resource of the target soum in relation to the rest of the aimag and other aimags;

iv. Participatory mapping exercise with participants to illustrate soum area baseline, and issues faced;

v. A timeline of climate and livelihood significant events based on participants memories;

vi. A participatory exercise to identify 1. Issues; 2. Reasons; 3. Impacts; 4. Potential solutions; 5. Barriers to potential solutions;

vii. An exercise to prioritize issues in regards to urgency/severity as expressed by local participants.

Target soums for community workshop

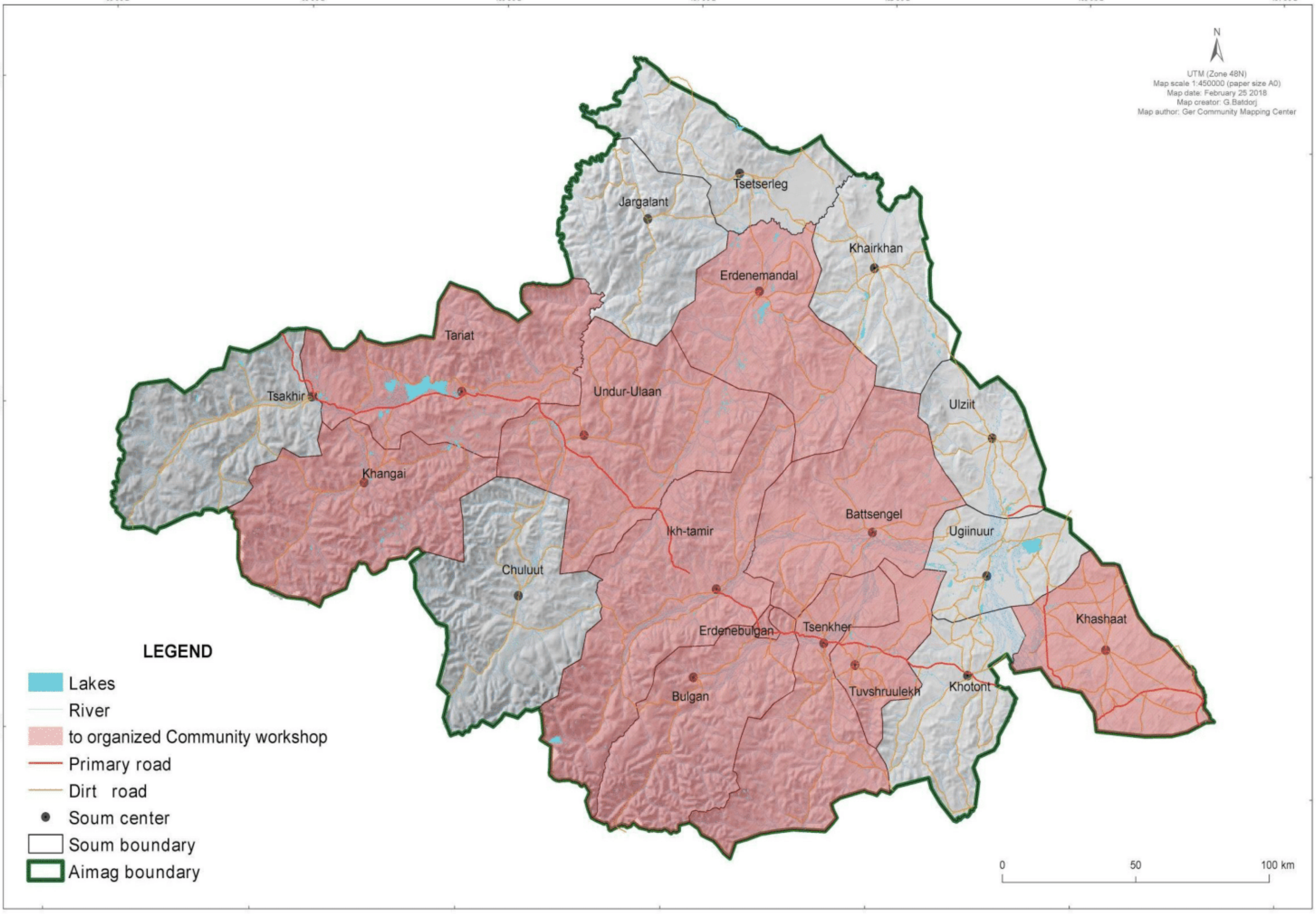


Figure 5: Soums targeted for community workshop

Discussions on thematic maps

At the beginning of the workshop, the team presented the thematic maps to the participants, and facilitated a discussion, encouraging participants to express their views on the maps. The discussion using the thematic maps resulted in the following:

i. Participants are informed about aimag-level baseline data;

ii. Facilitators check the information presented in the thematic maps to make corrections based on locals' feedbacks;

iii. Participants are primed to discuss their local situation towards the impacts of climate change;

iv. Facilitators get a sense of the participants (present local knowledge), and issues to focus particularly on during the workshop for the soum.

Depending on soums' characteristics, the facilitators prepared a set of thematic maps, considered most relevant to the local area prior to the workshops. Due to time constrnt and for actively engaging the participants, the thematic maps are presented succinctly, and the workshop focused on having participants to share as much content as possible.

Participatory mapping exercises

Following the presentation and discussion on the thematic maps, the participants were invited to illustrate their soum characteristics, resources and issues on aimag-level and soum-level maps.

- The aimag-level participatory mapping exercise intended to gather information on how the soum related to other soums in Arkhangai and other aimags in terms of natural resource economic flow.

  Participants were asked to illustrate those points using a prepared base map, and colored drawing tools. These illustrations provided the study with:

  i. Discussion that took place during the activity among participants;

  ii. Soum specific resources;

  iii. Natural resource economic flow;

  iv. Potential vulnerabilities due to the significance of natural resources, and interaction with other soums.

The soum-level participatory mapping exercise intended to focus on the soum-specific issues more in depth. Participants are locals, and are best at describing their own home area, its issues and which impacts of climate change it is facing.

Participants were asked to illustrate the soum's general landscape, resources, significant areas of forest, water or pasture resources. They were also asked to mark down any unique economic activity and settlement areas. After that, the participants were asked to illustrate the pressing issues on top of the soum baseline using a new layer. The illustrations provided the study with:

i. Discussions that took place during the activity among participants;
ii. Soum baseline information map with significant natural landscapes and resources;
iii. Soum-specific issues faced at and discussion on why those issues are happening;
iv. Potential and real vulnerabilities as illustrated by local community members.

Climatic event memory timeline

The next activity in the community workshop was to capitalize on the participants' knowledge and memory of their local area. The facilitators asked the participants to share any climate-related or livelihood-related significant events that took place in their lifetime. Participants were asked; 1. When? (year and month, if possible); 2. What happened?; 3. What was the impact? and 4. What did people do at that time to deal with it?

This specific activity relies on the memory of locals, in particular elderly locals, who are able to remember as far as a few decades earlier.

ICISB (issues, causes, impacts, solutions, barriers)
This exercise intended to summarize the workshop discussion into specific, tangible items that are articulated by the participants themselves. The contents generated from this exercise are aimed to support the overall project goal by informing its next steps. In this exercise, the participants were asked to collectively name items in each area including;

i. Pressing issues faced in the soum;
ii. Causes for those issues;
iii. Impacts experienced due to those issues;
iv. Potential solutions to resolve those issues;
v. Current barriers to potential solutions.

The flow of discussion through these five steps helped theorize the issues faced at the soum level, both for the participants, but in particular for the facilitators. Since this exercise required collective input, the participants went through the process of negotiating and weighting different suggestions expressed from within the group.

Finally, the exercise worked to establish a common understanding and agreement among the participants in a number of ways: which issues are important; which do they find the most urgent; why those are pressing issues (e.g. who is impacted and where and how); and potential solutions; but also realistic barriers faced to resolve those issues. The exercise intended to inform the future, short and long-term planning and intervention within the overall project by identifying potential solutions and current barriers.

Prioritization matrix
This method of prioritizing has been employed in community engagement workshops in other countries, often with small group of local community members. The goal of this exercise was to prioritize competing local issues that have varying level of relevance, significance, and urgency to different stakeholders.

While the previous exercise identified the issues and other related items, this exercise aimed to gain a consensus among the participants to determine the priority of different issues. This was an important element in the community workshop to conclude while bringing participants on the same page.

Pilot 3D participatory mapping in Tariat soum, Arkhangai

3D Participatory Mapping (3DPM) fosters the participation of a large array of stakeholders and integrates the local and scientific knowledge as well as bottom-up and top-down actions in climate change mitigations[1]. There are two main objectives to build 3DPM: to understand how climate change is being perceived in the context of Tariat soum and to understand the perceived impacts of climate change on local livelihoods.

3DPM is most effective on a limited area, on specific issues instead of an entire soum. Tariat soum was selected for its unique tourism activities surrounding the Terkhiin Tsagaan Lake.

Photo credit: Peter Bittner

During the process, people from a variety of socioeconomic backgrounds were invited: local officials, herdsmen, landowners, community leaders, citizens' representatives, professionals as well as civil servants to this activity. In order to effectively conduct the 3DPM, a research was conducted for both first and secondary data of the site to better understand the communities' needs and priorities. This included interviews with the locals, discussions with the community, historical information, climate data analysis, natural records and disastrous events that happened previously in the site as well as basic socio-economic and political information as housing, education, health care, politics, agriculture and livestock of the soum. Understanding the community context helped the team to anticipate what to prepare and what to be aware of during the mapping activities.

The base map was prepared in a size of 1.6m x 0.8m covering area of 40km x 20km with a scale of 1:25000. This included a lake and forest as well as the surrounding mountains that are of great importance to the livelihoods of locals.

Gaillard, J. and Cadag, J. R. D, 2013, https://www.preventionweb.net/files/workspace/7935_cadaggaillardp3dm.pdf

2.1.3 Climate data summary

Past and current data

Climate data for the province of Arkhangai were collected at the Provincial Meteorological Center. It comes from four automated meteorological stations that were installed in 1950. These stations are disseminated in different places of the territory and give quite a representative mean of the past and current situation in the aimag.

Only these four automated dataset were used because all the other stations of Arkhangai are based on manual transcription of the data and do not follow the same regular pattern. Moreover, the manual collected data were available only for 1999 to 2016.

Weather monitoring station type

No	Name	Period	Description
1	Mean annual temperature in °C	1985-2017	Mean annual temperature based on month average data coming from the 4 automated stations
2	Total amount of precipitation in mm	1985-2017	Mean annual precipitation based on month average data coming from the 4 automated stations

Figure 6: Type of past & current local climate data collected

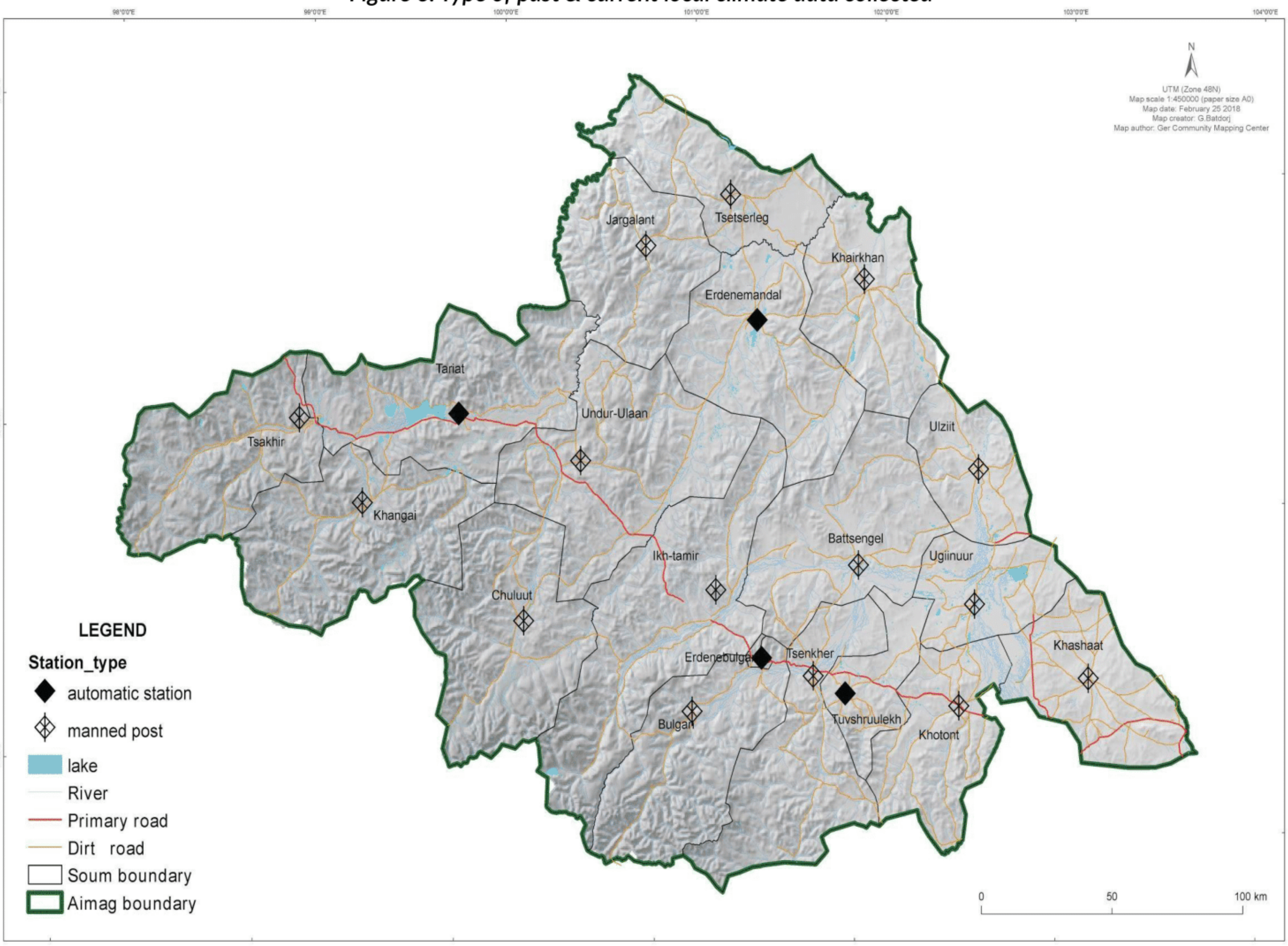


Figure 7: Locations of weather monitoring automatic stations and manned posts

However, it is important to note that even with an annual analysis of snowfalls/rainfalls it is difficult to get information on the distribution of the precipitation along the year and get an accurate level of analysis.

Source : https://climateknowledgeportal.worldbank.org/
Source : https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf
Source : https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

Projections data

All the projections data used for the study come from the World Bank Climate Knowledge Portal[2]. They are based on the Coupled Model Intercomparison Project, Phase 5 (CMIP5) models included in the Intergovernmental Panel on Climate Change (IPCC)'s Fifth Assessment Report (AR5)[3]. Under these models, 4 Representative Concentration Pathway (RCPs) scenarios have been established by the IPCC. The RCPs are consistent with a wide range of possible changes in future anthropogenic greenhouse gas (GHG) emissions, and aim to represent their atmospheric concentrations[4]:

- RCP2.6 assumes that global annual GHG emissions peak by 2020, with emissions declining substantially thereafter;
- In RCP4.5 emissions peak around 2040, then decline;
- In RCP6, emissions peak around 2080, then decline;
- In RCP8.5, emissions continue to rise throughout the 21st century.

The team chose both RCP2.6 and RCP8.5 scenarios to conduct the analysis.

No	Name	Period	Description
1	Projected temperature anomalies, °C Scenarios: RCP2.6 & RCP8.5	2040-2059	It represents the expected evolution of mean monthly temperature under the most optimistic and worst case scenario for the whole Mongolia with extrapolation for the Arkhangai aimag
2	Projected temperature anomalies, °C Scenarios: RCP2.6 & RCP8.5	2080-2099	It represents the expected evolution of mean monthly temperature under the most optimistic and worst case scenario for the whole Mongolia with extrapolation for the Arkhangai aimag
3	Projected precipitation anomalies, mm Scenarios: RCP2.6 & RCP8.5	2040-2059	It represents the expected evolution of mean monthly precipitation under the most optimistic and worst case scenario for the whole Mongolia with extrapolation for the Arkhangai aimag
4	Projected precipitation anomalies, mm Scenarios: RCP2.6 & RCP8.5	2080-2099	It represents the expected evolution of mean monthly precipitation under the most optimistic and worst case scenario for the whole Mongolia with extrapolation for the Arkhangai aimag

Figure 8: Type of climate projections data collected

It is important to note that there are uncertainties in some climatic models, notably as far as precipitation patterns are concerned. It is due to a greater spatial variability and the complexity of processes that lead to precipitation. Moreover, regarding projections and climate futures, it is also difficult for climate models to get a totally accurate projection of the future, once again because of climate natural variability. It implies to elaborate different scenarios that can lead to different answers in terms of strategies and actions.

This can lead to persistent uncertainty regarding conclusions and recommendations towards climate change adaptive strategies and options

2.2.1 Brief description of the area

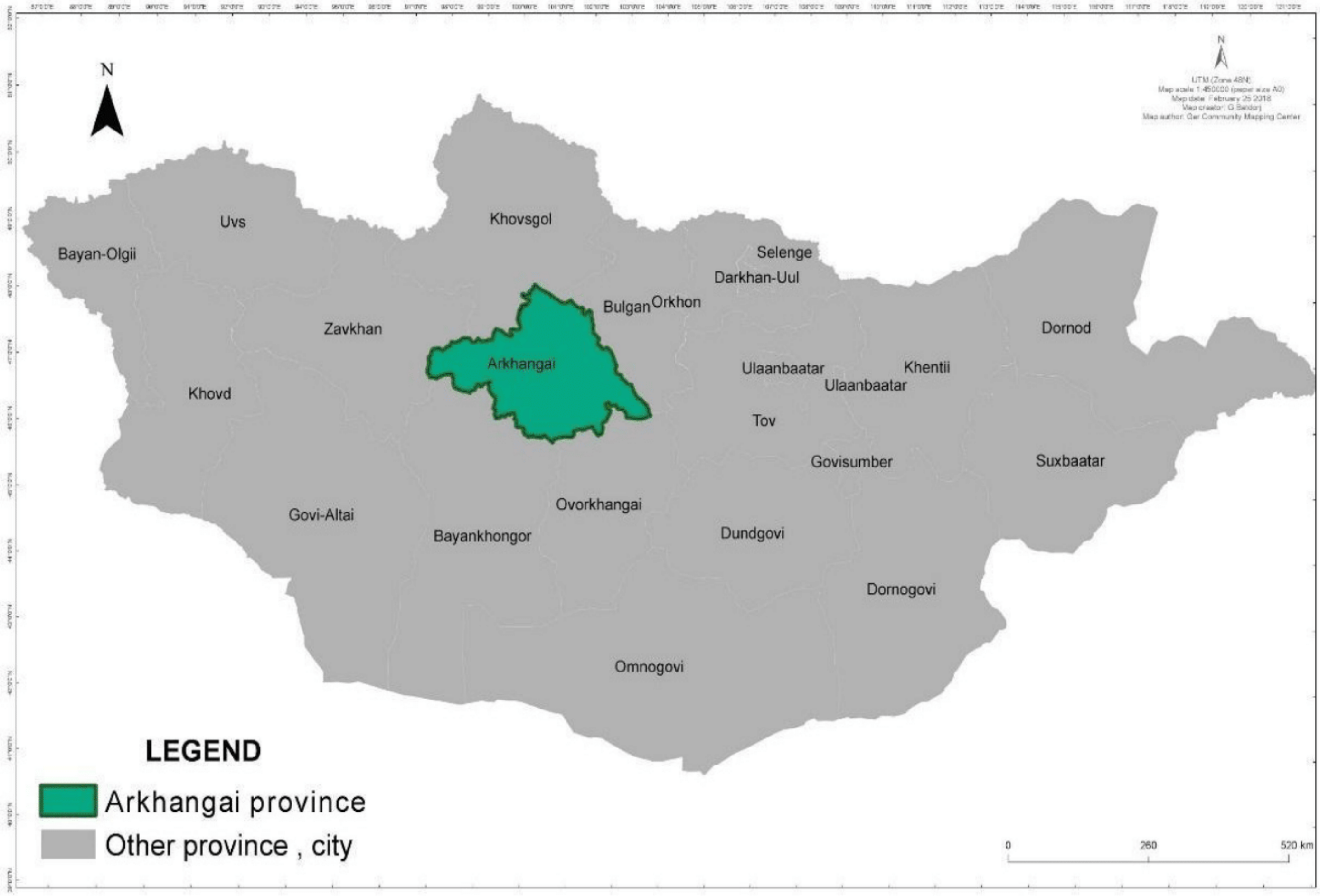


Figure 9: Location of Arkhangai province

Arkhangai aimag, or province, is located in central Mongolia to the west of the nation's capital, Ulaanbaatar. Situated on the northern slopes of the Khangai Mountains, Arkhangai is composed of 19 soums, or counties.

	Mongolia at a Glance[1] [2]	Arkhangai at a Glance[3] [4]
Population	3,119,935	94,000
Total Area	1,564,116 sq. km	55,300 sq. km
Livestock	66 million head	5 million head
GDP per capita	$12,600	$1,686
GDP	$11.16 billion	$156 million
Unemployment	7.3%	N/A

Figure 10: Arkhangai aimag in a Mongolian perspective

Source:https://www.cia.gov/library/publications/the-world-factbook/geos/mg.html
Source: http://www.1212.mn (National Statistics Office, Mongolia)
Source: Provincial Competitiveness Study. 2017. http://en.aimagindex.mn/province/arkhangai
Source:https://mongolianeconomy.mn/mongolian-livestock-count-reaches-61-5-million/

Population of density by soum, 2016

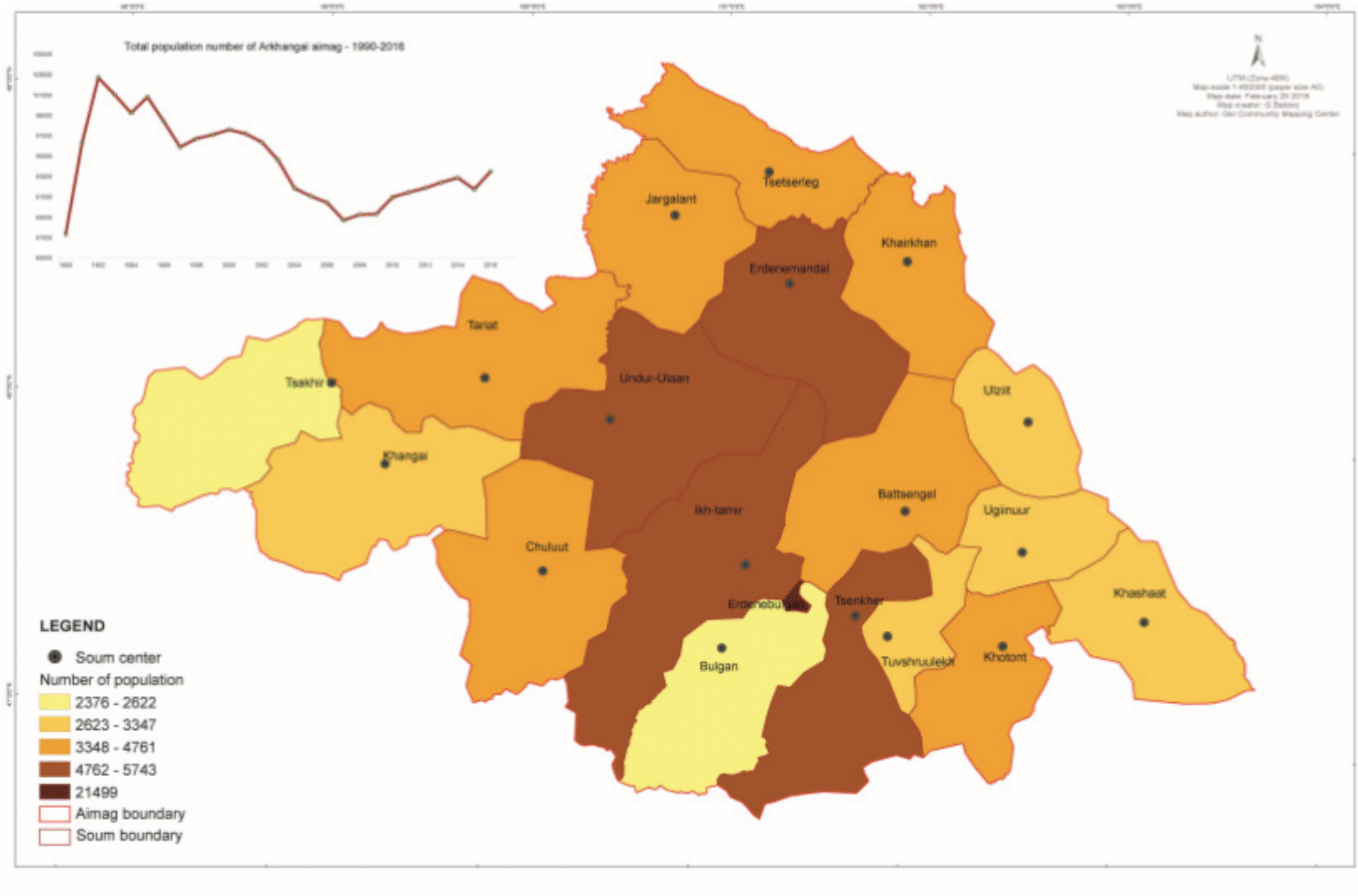


Figure 11: Population density by soum in the Arkhangai aimag

The aimag capital, Tsetserleg city, is located in Erdenebulgan soum in the south of the aimag. Arkhangai covers an area of 55,300 square kilometers, making it the 15th largest of Mongolia's 21 aimags. The current population of Arkhangai is about 94,000 people – the seventh most populous aimag. It also boasts the nation's seventh largest provincial economy. Its GDP stands at roughly 382 billion MNT, or $156,333,500 USD.

While its reported unemployment figures are very low at 5%, its standard of living is second to last in the nation with a per capita annual GDP of 4,121,000 MNT, or 1,686.52 USD. Arkhangai ranks 20th, or second to last, in overall economic competitiveness out of Mongolia's aimags. Arkhangai's government efficiency score and infrastructure come in last place. The aimag's main economic sector is agriculture, predominantly pastoral animal husbandry.

2.2.1 Determination of livelihoods in Arkhangai

The main livelihood across all soums of Arkhangai is animal husbandry, herding and its produce such as dairy and meat. Additional livelihoods include tourism and forest produce including timber, berries and pine nuts. These types of employment activities are often seasonal and supplemental, but can be primary income-generating activities as well.

Provincial Competitiveness Study. 2017. http://en.aimagindex.mn/province/arkhangai
Official statistics, however, community workshops revealed a much higher numbers - stat discrepancy issue
Source: Provincial Competitiveness Study. 2017. http://en.aimagindex.mn/province/arkhangai
All the data shown in this section come from communities interviews & workshops

Figure 12: Local resources and livelihoods of Arkhangai

The chart above illustrates the livelihoods and their associated resources. The main resources on which existing local livelihoods depend on are: pasture, forest, water, fertile soil, forage, natural landscape & wildlife and extractive resources. For example, animal husbandry depends on good pasture, while timber making depends on availability of forest. The livelihoods identified during the study are identified in correlation to the resources.

Furthermore, the chart aimed to illustrate the main interdependence of resources. For example, pasture is dependent on water and fertile soil. Forest relies on water and maintaining its natural state (natural landscape & wildlife). Water is dependent on keeping forests healthy and soil fertile. Forage resources such as nuts, berries and medicinal plants (and fish - where available) are dependent on forest and water resources. Mining activities are dependent on soil (and its extractive resource make-up) and water.

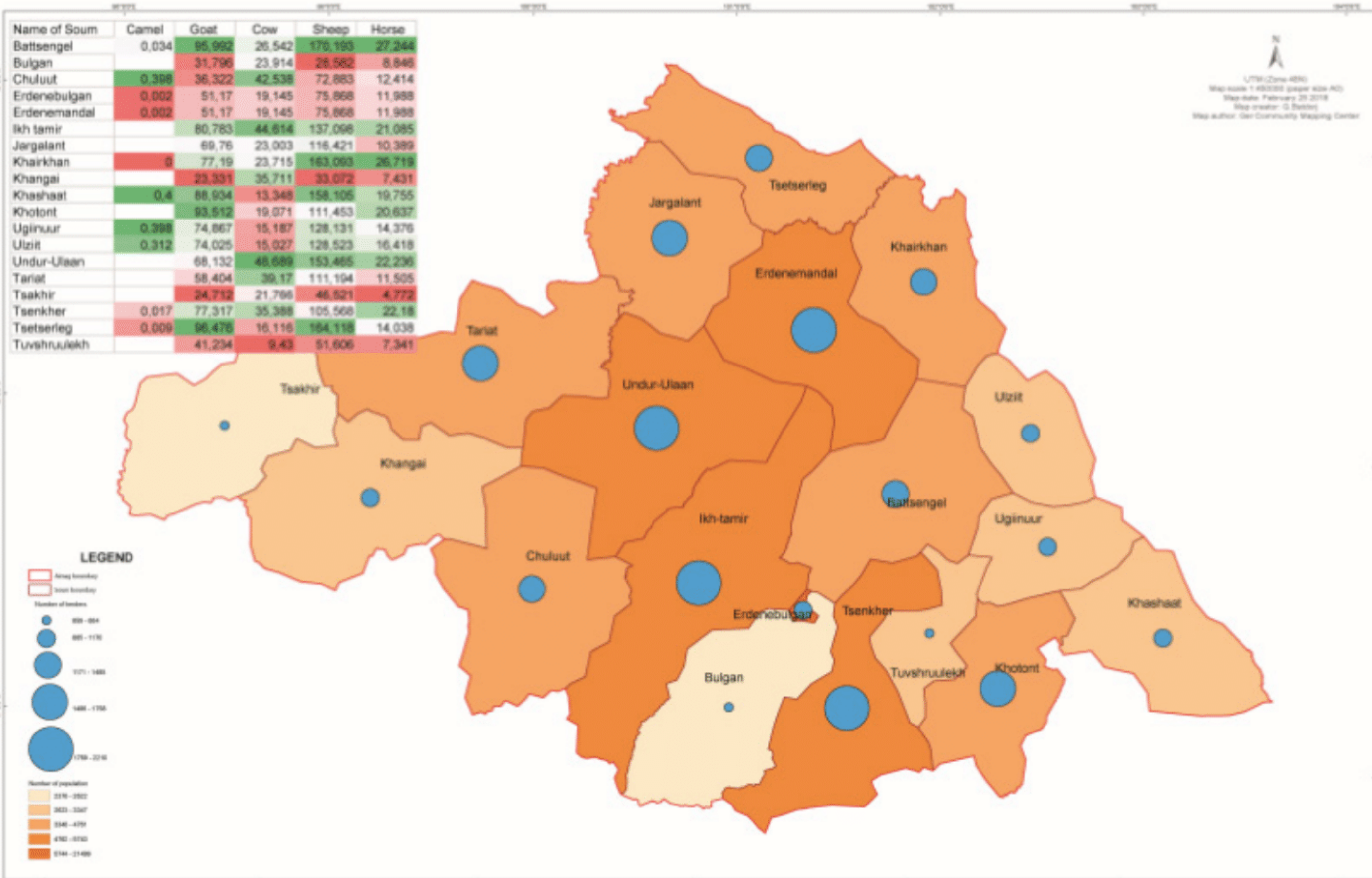
Animal husbandry/herding

On average, 66 percent of the total population of a soum in Arkhangai is made up of herders. This is nearly 1 on 3 persons in Arkhangai aimag that is a herder. This illustrates the high level of dependency of local livelihood on animal husbandry. Almost all soums herders raise cows, sheep, goats and horses. Some soums raise yaks and camels, depending on the geographical location. For example, Undur-Ulaan soum has the highest number of yaks.

Community groups exist as cooperatives that run value-added yak wool production at the local level. Herding is a household-level arrangement, and almost every member of the family is involved. In some cases, relatives or community group of herders work together.

The following maps illustrate the geographic concentrations of herders throughout Arkhangai aimag. The below map illustrates the number of herders in each soum, where Tsenkher, Ikh-Tamir, Erdenemandal and Undur-Ulaan lead in this category.

Number of herders - 2016



Name of Soum	Camel	Goat	Cow	Sheep	Horse
Battsengel	0,034	95,992	26,542	170,193	27,244
Bulgan		31,796	23,914	26,582	8,846
Chuluut	0,398	36,322	42,538	72,883	12,414
Erdenebulgan	0,002	51,17	19,145	75,868	11,988
Erdenemandal	0,002	51,17	19,145	75,868	11,988
Ikh tamir		80,783	44,614	137,096	21,085
Jargalant		69,76	23,003	116,421	10,389
Khairkhan	0	77,19	23,715	163,093	26,719
Khangai		23,331	35,711	33,072	7,431
Khashaat	0,4	88,934	13,348	158,105	19,755
Khotont		93,512	19,071	111,453	20,637
Ugiinuur	0,398	74,867	15,187	128,131	14,376
Ulziit	0,312	74,025	15,027	128,523	16,418
Undur-Ulaan		68,132	48,689	153,465	22,236
Tariat		58,404	39,17	111,194	11,505
Tsakhir		24,712	21,786	46,521	4,772
Tsenkher	0,017	77,317	35,388	105,568	22,18
Tsetserleg	0,009	96,476	16,116	164,118	14,038
Tuvshruulekh		41,234	9.43	51,606	7,341

Figure 13: Number of herders per soum, Arkhangai

Sustainability factors: suitable climatic conditions (no dzud/drought), pasture with capacity to regenerate, clean and sufficient water source, healthy and productive livestock, adequate fodder (both capital and hay), sufficient herder workforce, veterinarian and land conflict resolution mechanism.

Meat and dairy products

Directly related to animal husbandry is production of dairy products and wholesale of meat. Arkhangai soums are known for the quality of their dairy products and are sold in most urban centers. Meat and dairy products are sold at markets in aimag centers, but in a higher proportion in urban areas, such as Ulaanbaatar.

Battsengel soum for example, sells 80 percent of the meat it produces at Ulaanbaatar meat market, and remaining 20 percent are sold in aimag center market while Erdenemandal soum sells animal products to Ulaanbaatar, Orkhon, and aimag center. Tsenkher soum sells its dairy products to gobi aimags and Ulaanbaatar. In addition, livestock skin, wool and sometimes cashmere is sold to markets in other aimags and cities.

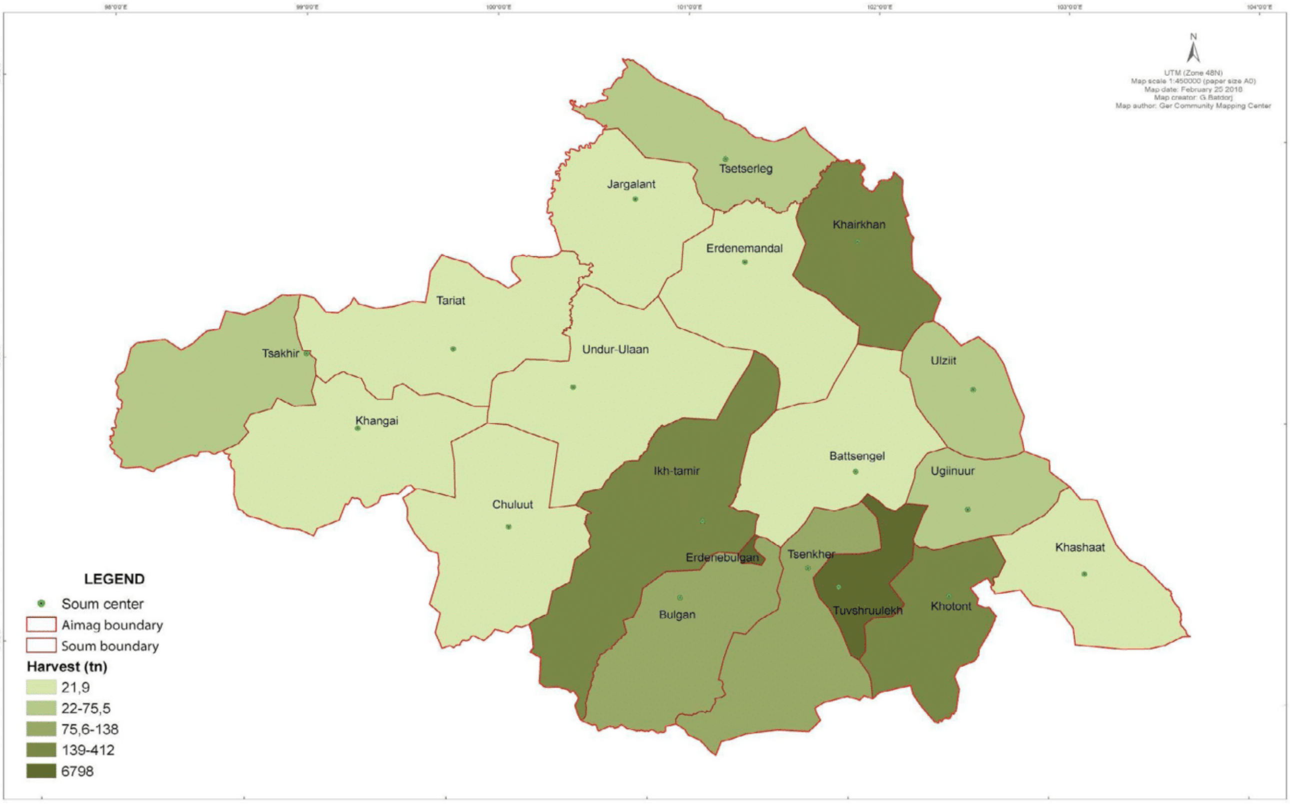
Sustainability factors: clean and sufficient water source, healthy and productive livestock, local knowledge on production, and market demand for products, value-added production of dairy and meat.

Agriculture

A very small percentage of the Arkhangai population runs vegetable and berry growing and derived businesses as a mean of livelihood. For example, only 24 households in Tsekher soum works in agricultural exploitation. Otherwise, most of large scale agriculture is growing and preparing fodder or animal feed.

While traditionally, herders prepared fodder themselves for the winter, the need to buy fodder is increasing among herders, particularly during years when they are experiencing droughts. Locals are facing increasing land conflicts between agricultural exploitation and animal husbandry due to ever more limited land cover. The map below illustrates the soums regarding the amount of agricultural harvest prepared. Khairkhan, Erdenebulgan, Tuvshruuleh, and Ikh-Tamir lead.

Amount of argicultural harvest by soum - 2016



Area of tilth by soum -2016

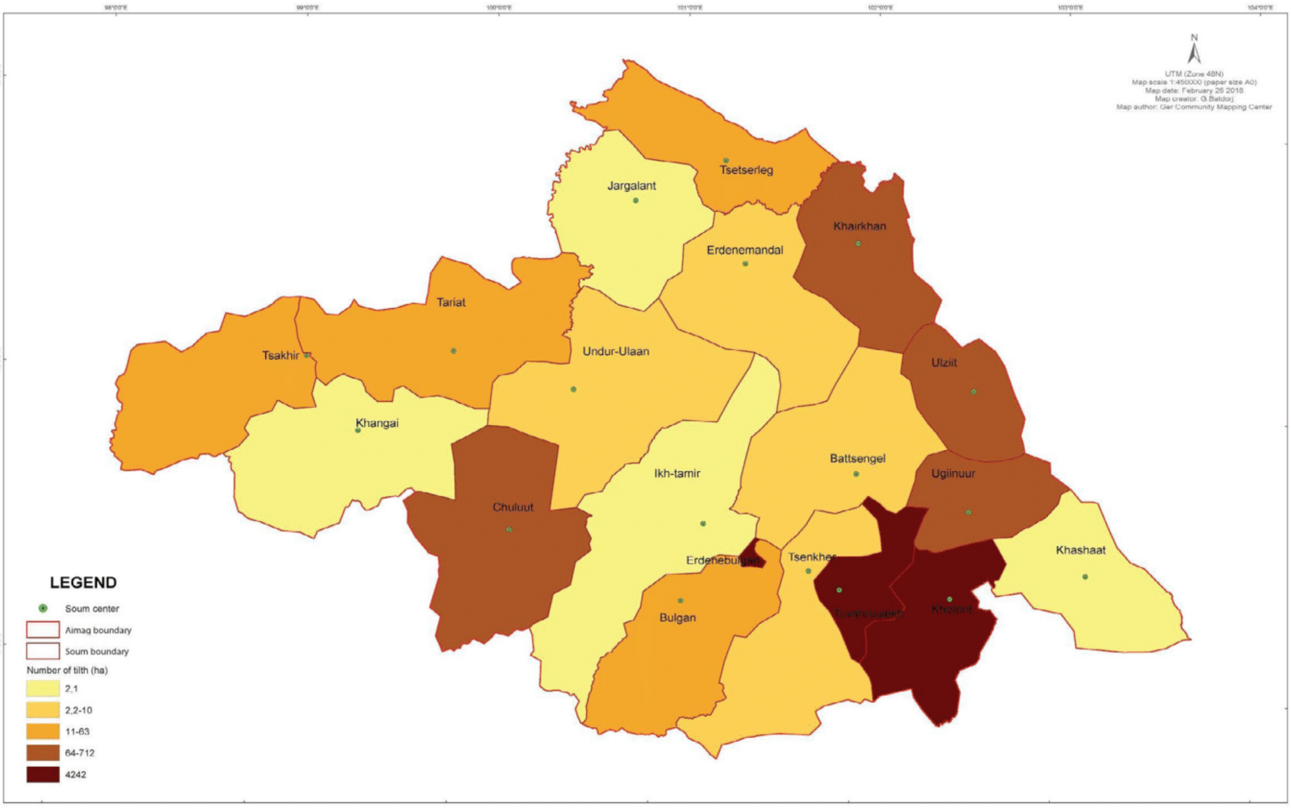


Figure 14: Maps of amount of harvest and tilth per soum, Arkhangai

Sustainability factors: suitable climatic conditions (adequate growing season), natural and man-made irrigation source, agricultural inputs (seeds, fertilizers, pest control), agrarian knowledge, equipment, sufficient workforce, and land conflict resolution mechanism.

Photo credit: Batdorj Gongor

Arkhangai has relatively high forest cover across the aimag, particularly in the central and northern west region. Timber preparation from the natural forests is the second main livelihood after animal husbandry among locals. The prepared timber is sold within the aimag in soum centers and to other neighboring and low or none reserve of forest aimags within the country.

Timber is also sold to urban areas, and distributed to aimag centers along the main road. Timbering activities are carried out under licensed timbering companies, as well as illegal timbering without licenses. Timber is not only a source of livelihood for Arkhangai locals, but also other individuals from neighboring soums and other aimags.

Sustainability factors: forest reserve with capacity to regenerate, reforestation measures, adequate timbering regulations and enforcement (including protection from human-caused forest fire), market demand for timber and value-added wood products.

Forage & Fishing

Directly related to the available forest reserve of Arkhangai, wild berry, nut, and medicinal plant picking is a common livelihood for locals and non-locals alike. This means of income is always seasonal and serves as a main source of income for many individuals and their families without regular employment.

Arkhangai earns a significant amount of natural resource income from pine nut harvesting. The pine nut, berries and medicinal plants are harvested from the forests and sold at aimag center markets and are distributed to other urban markets. There are some fishing activities in the river and lakes of the aimag, for example in Tariat.

Sustainability factors: sufficient and self-generating natural resources, foraging and fishing period regulations and enforcement, market-demand, and value-added production.

Tourism

Arkhangai's natural scenery has been and still is a popular tourist destination for local and foreign tourists. Locals near tourist areas run family scale ger camps, sell food, souvenir, and provide horseback riding services. Larger tourist camps are numerous and active during summer months, both run by and/or employ locals and non-locals. Many soums of Arkhangai has tourist destinations, and popular soums include Tsenkher with hot-spring, Ikh-Tamir, and Tariat with volcano and large lake with wildlife.

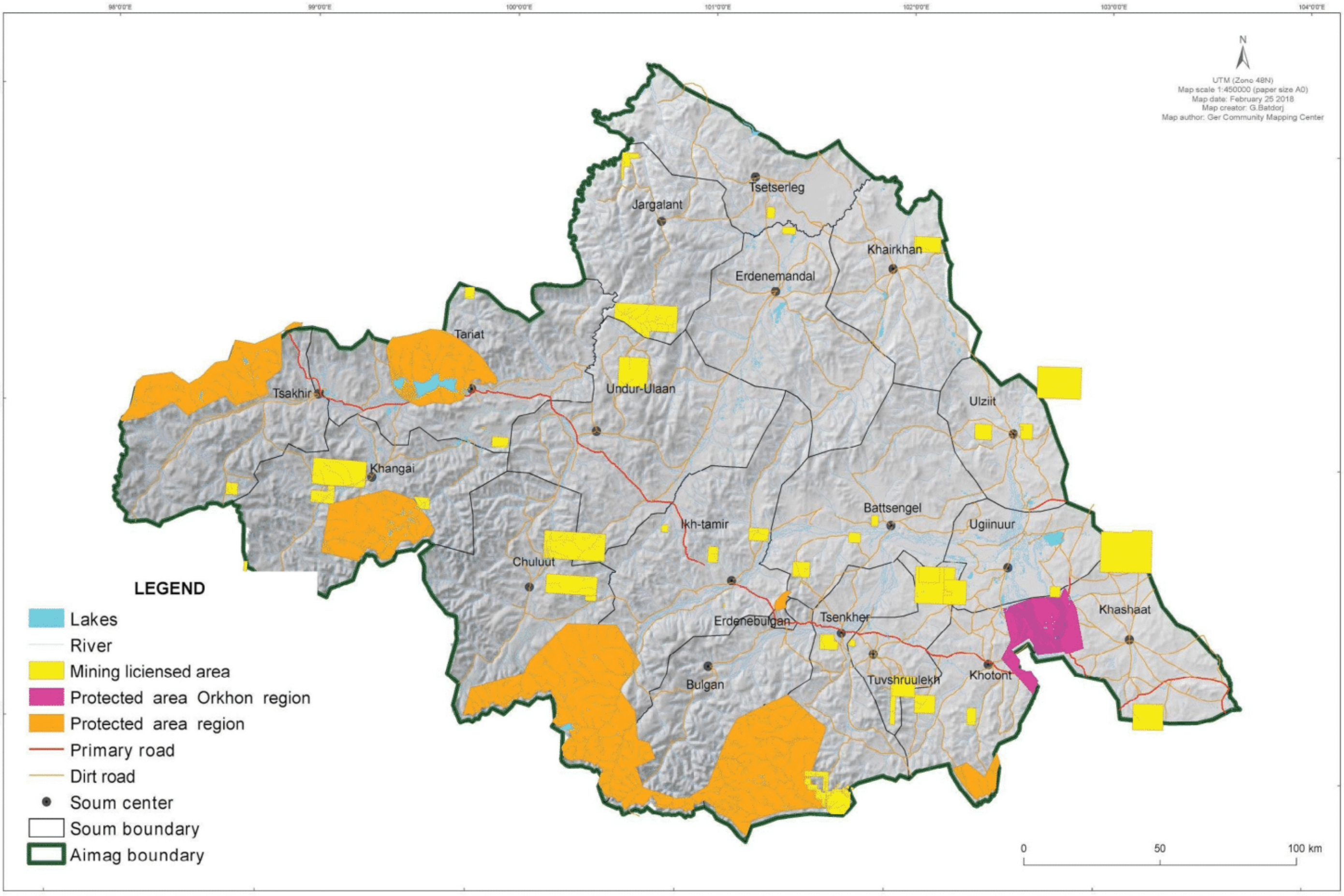
Tourism peak seasons also contribute to income generation for locals to sell dairy products, and meat, particularly near the main roads. However, regular income generation from tourism for majority of locals is still not the case.

Sustainability factors: market-demand, availability of tourism services (social, health, activity, safety), tourism impact management and reinforcement (waste management).

Mining

In Arkhangai, in total of 58 mining licensed areas are registered. In areas where mining operations began, locals have been both employed by the mine and carry out artisanal mining. For example, Tsenkher soum has seen a change in the form of livelihood from animal husbandry to mining.

Protected and minng licenced area - 2016



Hand-made production

Traditional clothes, wooden products and other hand-made products are another source of livelihood. As Arkhangai has forest-reserve, carpentry is more common than in other aimags, for example in Tsenkher and Khashaat. In addition, there are some leather handicrafts making.

Sustainability factors: market-demand, skills and knowledge, raw material resources (cost-efficient, available)

3.1 Brief introduction to the climate context of Mongolia

3.1.1 Climate change trends in Mongolia

There is unequivocal evidence that the Earth's climate is changing, very likely due to anthropogenic forces. There is, nevertheless, far larger uncertainty about how exactly the climate is changing and what impacts these changes will have at regional and local levels. This is certainly the case in Mongolia, though a growing body of research points to alarming trends regarding the impacts of a changing climate.

Mongolia's climate is characterized by extreme fluctuations in both temperature and precipitation, differences accentuated by the country's expanse and topographical diversity. The country has six ecological zones ranging from high mountain alpine systems in the north and east to the vast Gobi Desert in the south. Since 1940, Mongolia has witnessed a 2.14°C rise in average annual temperatures, twice the global average over the same period. It is projected to witness an additional 2-3°C rise in temperature by 2050.

Coinciding with the recorded temperature rise is a greater variability in precipitation levels and occurrence; summer rainfall has been observed to be decreasing while winter precipitation increasing.Precipitation are less frequent and more intense, correlating with more extreme weather including droughts and harsh winters known as dzuds. In addition, dust storms, forest fires and flooding are all growing problems at the national level.

3.1.2 Climate and environmental vulnerability of Mongolia

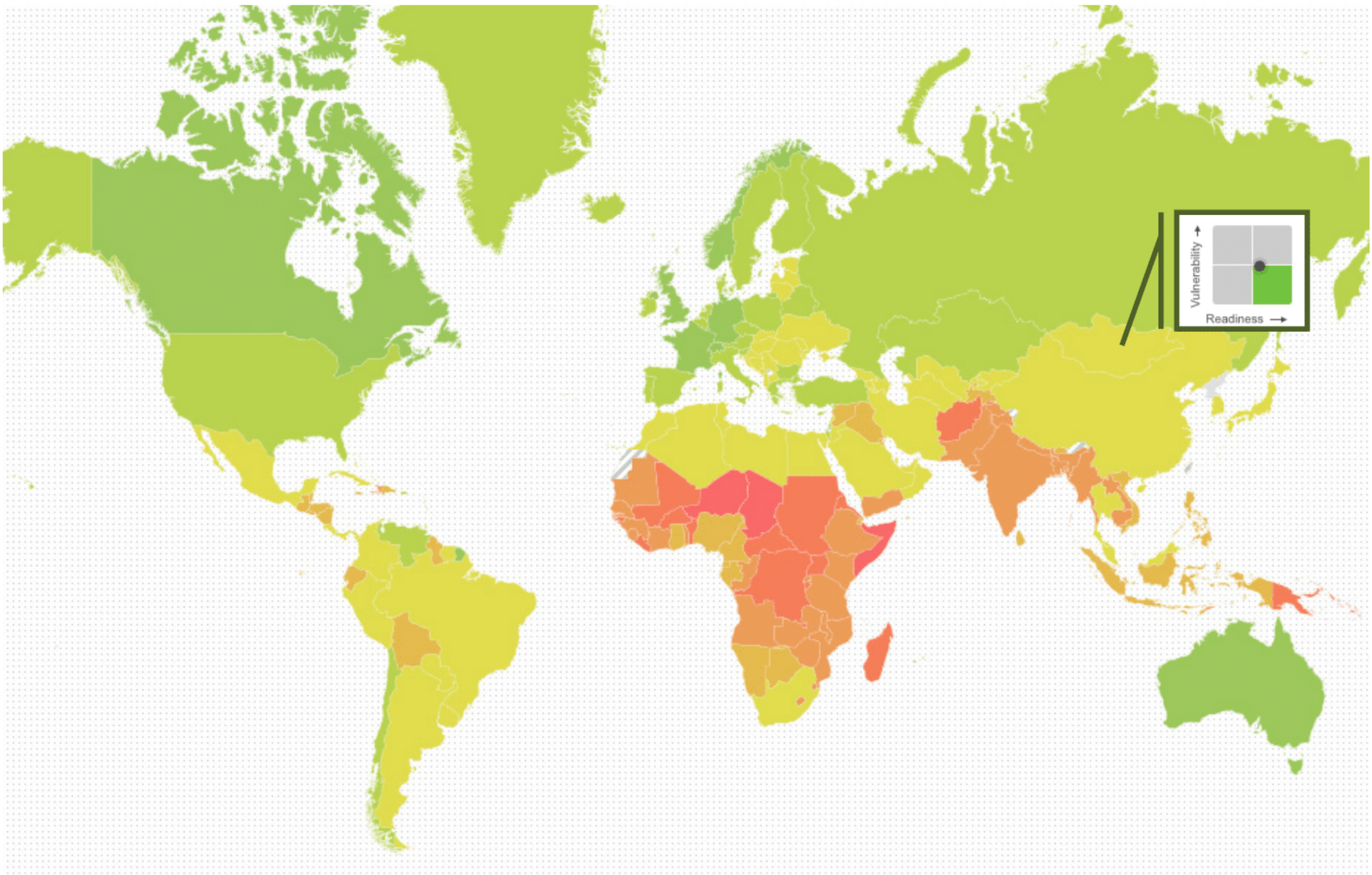


Figure 16: Map of the vulnerabilities according to the ND-GAIN Index

Source:http://sdwebx.worldbank.org/climateportal/countryprofile/home.cfm?page=country_profile&CCode=MNG&ThisTab=Dashboard
Source:http://sdwebx.worldbank.org/climateportal/countryprofile/home.cfm?page=country_profile&CCode=MNG&ThisTab=ClimateFuture
Source:http://sdwebx.worldbank.org/climateportal/countryprofile/home.cfm?page=country_profile&CCode=MNG
Source:http://index.gain.org/

To quantify it, the Notre Dame - Global Adaptation Initiative (ND-GAIN) [W]developed an assessment methodology based on several components:

- Food – *Projected change of cereal yields, food import dependency, agricultural capacity, projected population change, rural population and child malnutrition.*
- Water – *Projected change in annual groundwater runoff, fresh water withdrawal rate, access to reliable drinking water, projected change of annual groundwater recharge, water dependency ratio and dam capacity.*
- Health – *Projected change in vector-borne diseases, slum population, medical staff, projected change in deaths from climate change induced diseases, dependency on external resources for health services and access to improved sanitation facilities.*
- Ecosystem service – *Projected change of biome distribution, dependency on natural capital, protected biomes, protected change in marine biodiversity, ecological footprint and engagement in international environmental conventions.*
- Human habitat - *Projected change of warm periods, urban concentration, quality of trade and transport-related infrastructure, projected change of flood hazard, age dependency ratio and paved roads.*
- Infrastructure - *Projected change of hydropower generation capacity, dependency on imported energy, electricity access, projection of sea level rise impacts, population living under 5m above sea level and disaster preparedness.*
-

The low vulnerability score and high readiness score of Mongolia places it in the lower-right quadrant of the ND-GAIN Matrix. Adaptation challenges still exist, but Mongolia is well positioned to adapt. Mongolia is the 79th least vulnerable country and the 67th most ready country.However, Mongolia is currently facing effects and impacts of climate change. Indeed these impacts include reduced pasture biomass, and an increasing prevalence of invasive species. Increases in water scarcity, changes in water quality and access, and reduced permafrost and snowpack have also been observed. Hundreds of rivers, lakes and other bodies of water have dried up.This has resulted in reduced livestock productivity, lower crop yields, and greater household vulnerability, particularly among pastoralists. The impacts of climate change have led to the loss of livelihood and forced migration of nomadic families to urban areas.

Livestock production accounts for nearly 80 percent of Mongolia's food sector, making food security for Mongolia's predominantly agricultural economy a top area of concern – and a priority for policy makers. Reduced quantity and quality of pasture biomass are correlated with reductions in productivity of livestock as well as their susceptibility to weather extremes, resulting in higher mortality rates. These impacts are exacerbated by pasture degradation, malnutrition, an increased prevalence of invasive insects and rodents.

The majority of Mongolians are vulnerable to water security issues. Seventy percent of Mongolia's population resides in urban areas where access to clean water is critical. Unfortunately, only 30 percent of Mongolians are connected to water supply infrastructure, while the rest access private or public wells, buy trucked water, or collect water directly from rivers and springs. These trends are compounded by a rapidly urbanizing population. Nearly half of Mongolia's population lives in the capital, Ulaanbaatar where the current water supply network is expected to be insufficient as early as 2021. Waterborne diseases are likely to become more serious issues. In addition, as temperatures rise many Mongolians are at risk of increased incidence of heat stress, which exacerbates many cardiovascular diseases.

3.1.3 Current climate change impacts in Mongolia

Current estimates of environmental degradation in Mongolia, mainly based on remote sensing, point to sociopolitical as well as climatic causes;however, there is little scientific consensus on the extent or causes of recent rangeland changes in Mongolia. Further, the results of some field studies have not been consistent with conclusions from remote-sensing studies. Nevertheless, there have been a number of rigorous studies conducted related to climate change's impacts which point to alarming trends in the conditions of surface water and precipitation across Mongolia, as well as grassland deterioration.

In 2002, it was estimated that over 70% of Mongolia's total territory was degraded relative to its natural state .The study concluded that "(1) almost the entire Mongolian steppe region experienced significant vegetation biomass declines between 1988 and 2008; (2) about 60% of the decline can be attributed to climate trends: in particular, decreasing precipitation and increasing temperature; and (3) the dramatic increase in goat numbers and grassland burning is likely to account for most of the remaining decline."

A separate study found an increase in temperature correlated with a projected decreased weight for livestock, with the same level of pasture biomass, suggesting that sheep in particular become stressed under higher temperatures associated with climate change. A 2016 United Nations factsheet illustrates that Arkhangai ranked third in the number of preventable livestock death that year. This is partly due to the sheer number of livestock herded in Arkhangai, but it is also an indication of higher vulnerability to extreme climatic events.

The Ministry of Nature, Environment and Tourism conducted a surface water inventory in 2007. The survey revealed 852 rivers and streams (out of 5128), 2277 springs (out of 9306), and 1181 lakes and ponds (out of 3747 water bodies) have disappeared since the previous survey in 2003. Changes in precipitation are largely to blame, with changes in water usage also part of the issue.

3.1.4 Adaptative capacities of Mongolia

Studies focusing on the adaptive strategies of Mongolians to successfully overcome the challenges presented by climate change have mainly centered on the interactions between herders and rangelands. The main types of adaptive strategies for nomadic pastoralists to deal with the impacts of a changing climate include: 1) mobility, 2) storage, 3) diversification, 4) communal pooling and 5) community-based reciprocity and exchange.

Mobility

Herders' capacity and willingness to adapt their management to a changing environment depends in part on their ability to detect and respond appropriately to feedback from the ecological systems they manage at relevant spatial and temporal scales . Mobility in this context does not refer to migration exodus, but rather a seasonal search for better pasture and other resources as traditional practice of herders. In this respect, mobility strategies are crucial for nomads before, during, and after winter dzuds . For example, an "otor" is a rapid long-distance movement of all or a portion of the herd and household undertaken to fatten animals in fall or escape a weather disaster such as drought or dzud.

Storage

Storage was a widely used and critically important strategy for surviving the dzud. Storage takes the form of stored hay, homemade hand fodder, fodder purchased in advance of the winter, and reserved winter, spring, and dzud pastures. "In vivo" storage in the form of animal weight gain and fat reserves is also critical. Storage may also be in the form of cash savings and stockpiled food supplies. The negative impacts of incoming otor herders on hosts' soums during dzud exposure highlights the need for more effective storage and use of standing forage in soum otor reserves.

Diversification

Diversification can be expressed in a variety of adaptive strategies, including traditional multispecies livestock herds, access to a diversity of pastoral resources (different pasture types, varied topography, riparian and forested areas, salt licks, etc.), income from multiple sources rather than a single livelihood, diverse social networks, and access to a diversity of information sources. In both study regions the dzud disproportionately affected particular types of livestock (cattle in Akhangai and goats in Bayankhongor), suggesting that a diverse and balanced herd composition is a wise hedge against the risk of dzud.

Communal pooling

Communal pooling involves sharing resources, labor, or wealth, distributes risk across households, and improves the efficiency of many production activities. Pooling was a common strategy in the study sites with labor sharing and joint management of pastures and otor reserves being the most common pooling strategies. Labor sharing focused on haying and other winter preparations, and herding during the dzud.

Exchange and reciprocity

Norms of reciprocity are central to Mongolian herding culture and support mobility strategies such as otor movements during dzud and drought. In the context of dzud responses, norms of reciprocity, especially regarding sharing pasture with herders on otor from other areas, can be essential to the survival of those who are moving. However, they can also increase exposure and overall vulnerability of communities hosting incoming otor herds

Source:http://sedac.ciesin.columbia.edu/aiacc/progress/AS06_July03.pdf
Source: http://www.un-mongolia.mn/new/wp-content/uploads/2016/04/MONGOLIA-Dzud-Response-and-Preparedness-Plan.pdf
Jargalsaikhan, Azjargal&Batbuyan, B &Batkhishig, B &Ulambayar, Tungalag&Lhagvasuren, Tamir&Tsogtbaatar, Solongoo. (2015). Contemporary Mobility of Herders in Central Mongolia.
Ulambayar, Tungalag& Fernandez-Gimenez, Maria &Batkhishig, B &Batbuyan, B. (2016).Social Outcomes of Community-based Rangeland Management in Mongolian Steppe Ecosystems: Social outcomes of CBRM in Mongolia.Conservation Letters. 10.1111/

3.1 Temperatures evolution from1985 and 2017

Annual temperatures analysis

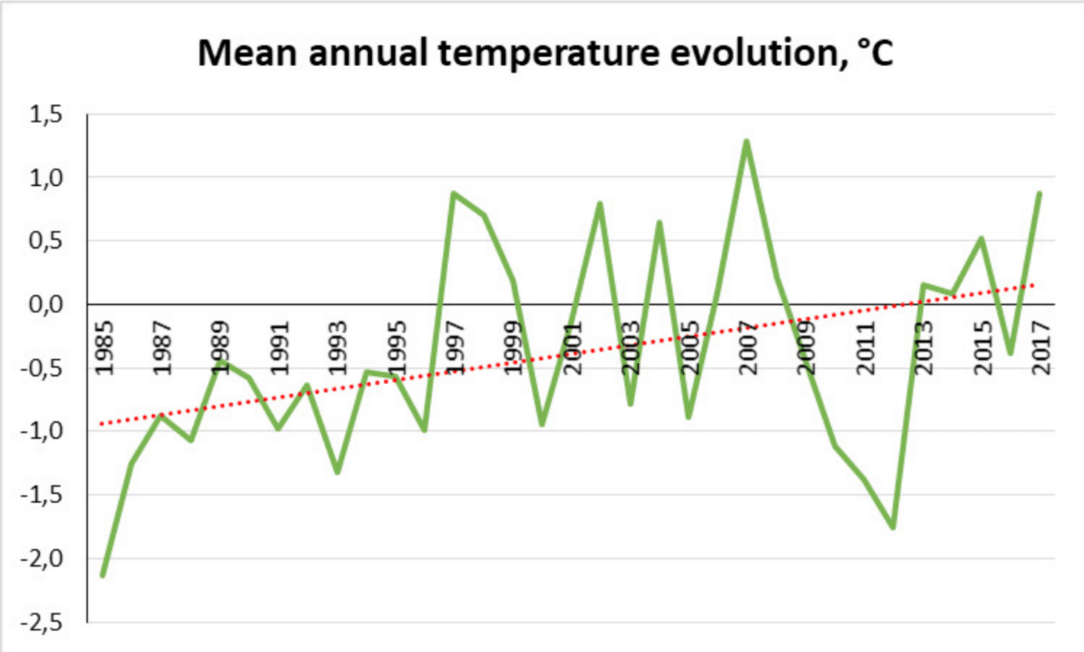


Figure 17: Evolution of mean annual temperature in Arkhangai from 1985 to 2017

This chart shows that since 1985, mean annual air temperature is highly increasing. Indeed the trend seems to follow a regular increasing phenomenon.

However, it is relevant to evaluate if this trend is accelerating over the years by searching for a breaking point in the trend.

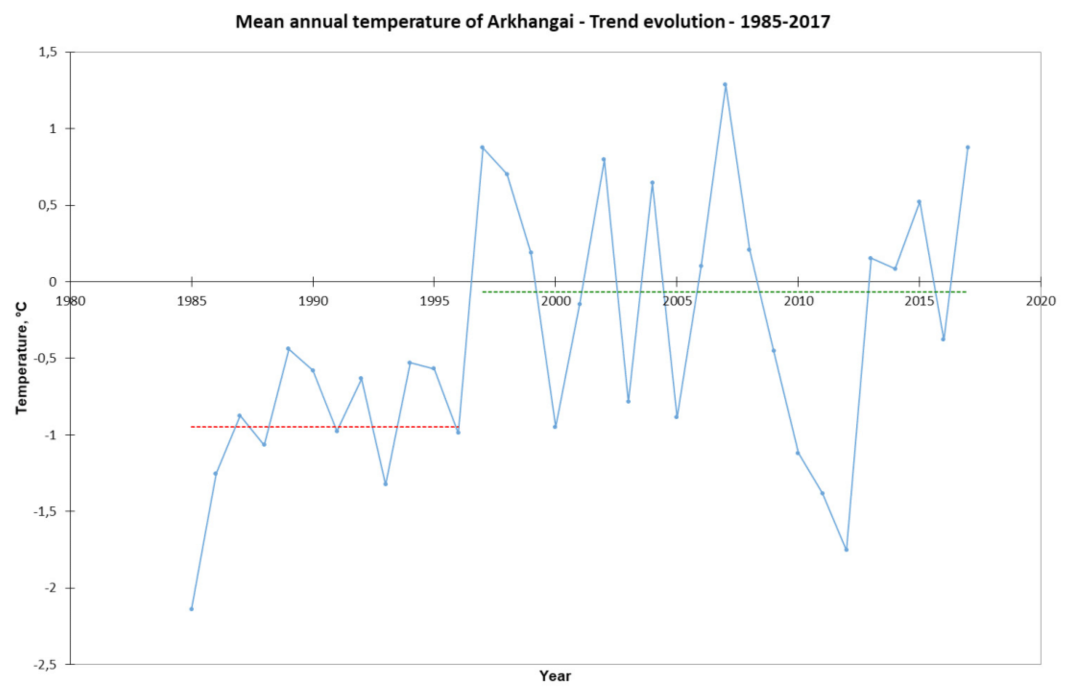


Figure 18: Trend analysis of mean annual temperature evolution

The chart above shows that since 1996, the increasing trend of mean annual temperature in Arkhangai is accelerating. It underlines the strength and intensity of the warming phenomenon at the aimag level. Indeed, from 1985 to 1996, the average annual temperature was close to -1°C, whereas it is closer to 0°C since 1996. However, to get a more precise analysis, it is necessary to implement a seasonal analysis.

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Seasonal temperatures analysis

Taking into account the fact that Mongolia is characterized by strong seasonal disparities regarding its climate with a warm and a cold season, it is quite relevant to proceed to a seasonal analysis of temperatures evolution

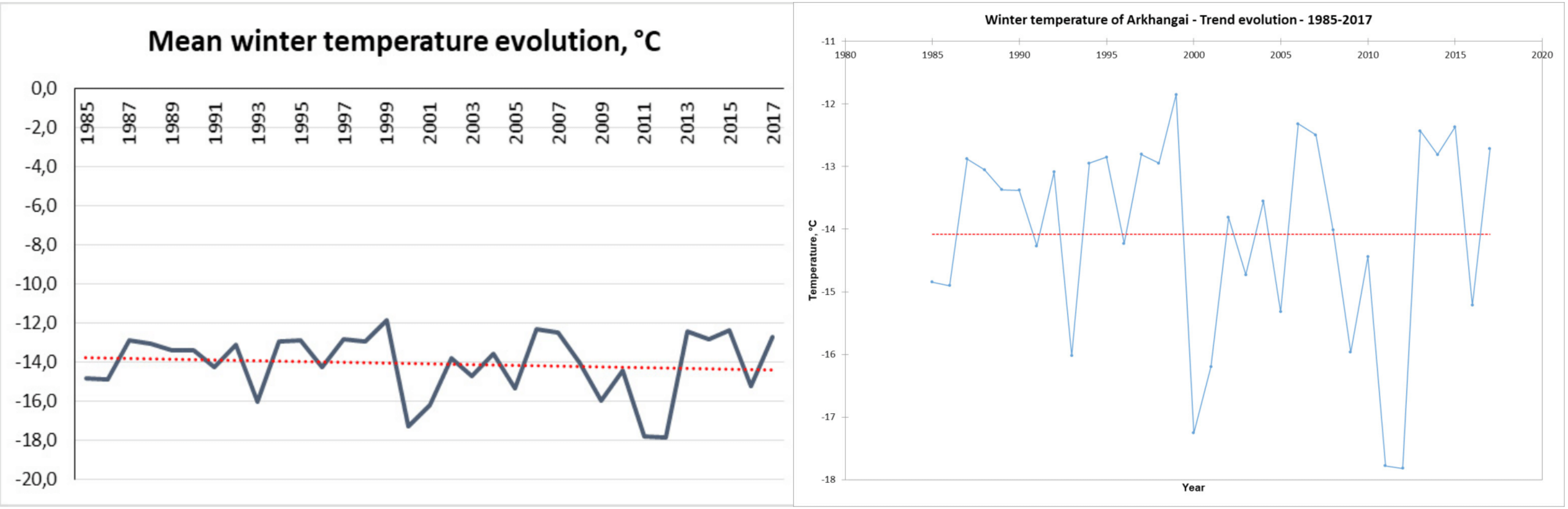


Figure 19: Evolution of mean winter temperature in Arkhangai from 1985 to 2017

Winter temperature analysis shows that since 1985, the cold season tends to become more rigorous. However, it seems to be a regular phenomenon with no acceleration or breaking point in the trend.

Spring season temperature evolution

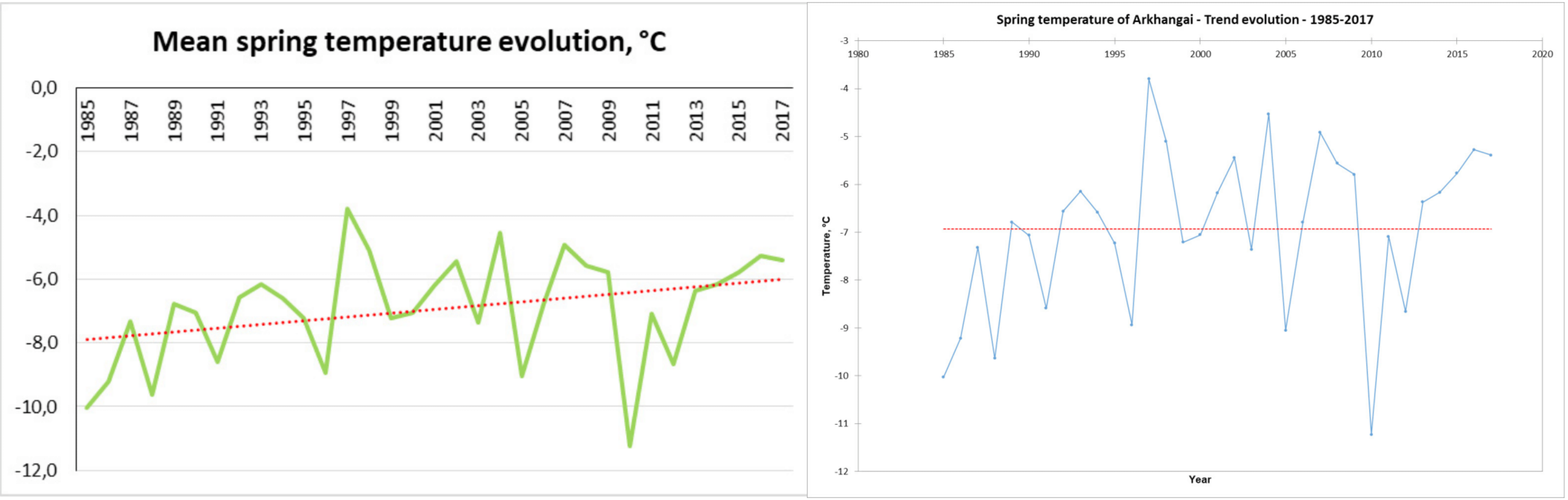


Figure 20: Evolution of mean spring temperature in Arkhangai from 1985 to 2017

Spring temperatures are following a strong warming trend since 1985, except for a few colder years between 2009and 2013. However, as for winter, the trend does not look to face any brutal acceleration, but this can also be "hidden" by the particularly cold year as mentioned above.

Summer season temperature evolution

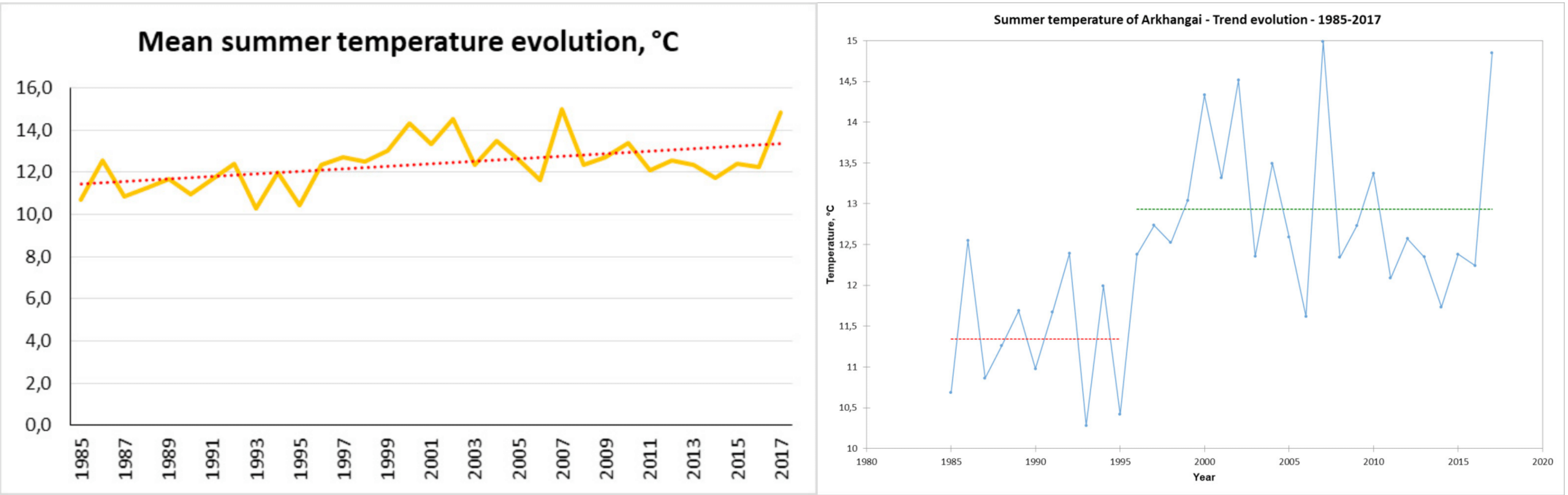
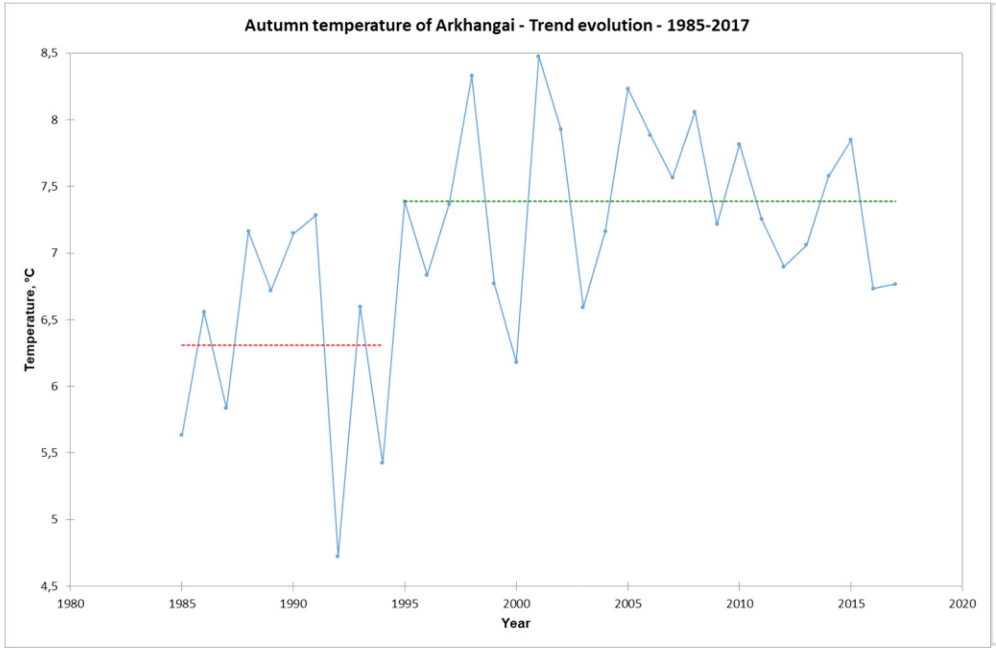


Figure 21: Evolution of mean summer temperature in Arkhangai from 1985 to 2017

As for springs, summers are getting quite warmer over the years since 1985.But here, the phenomenon is accelerating since 1994 meaning that temperatures are getting severely warmer over the years. This could have strong impacts on summer temperature evolution for the years to come.

Autumn season temperature evolution



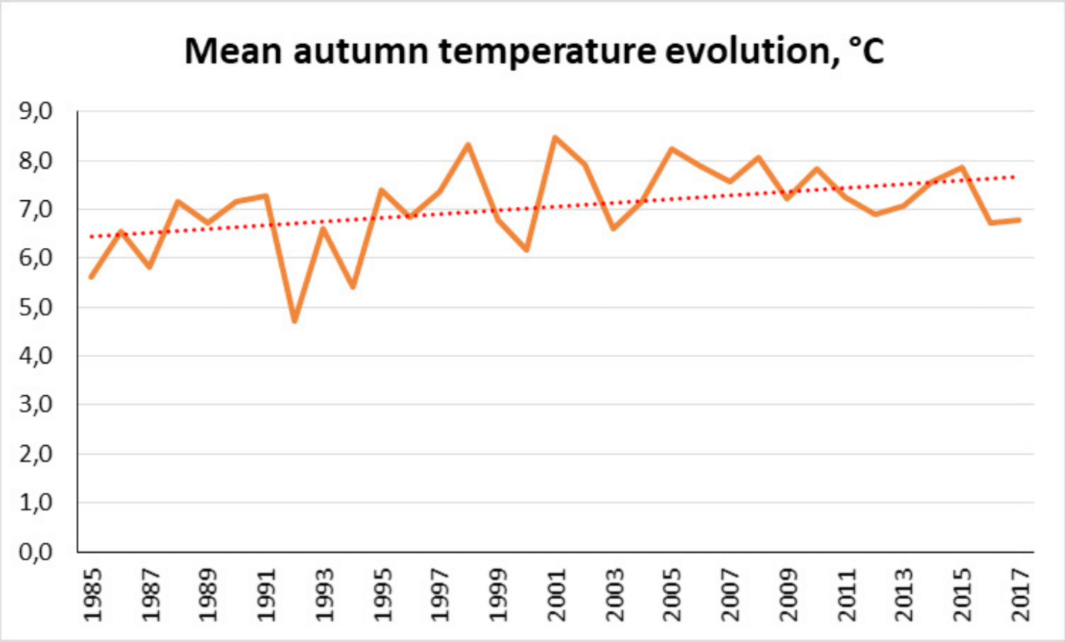


Figure 22: Evolution of mean autumn temperature in Arkhangai from 1985 to 2017

As for springs & summers, autumns are getting warmer in Arkhangai. As in the summers case, the rise in autumn temperatures is accelerating since 1994 meaning that the trend might evolved quite faster in the years to come.

In the end, according to the data between 1985 and 2017, it looks like all the seasons are becoming warmer in Arkhangai, except for winters which tend to become a little bit colder. This shows that extreme seasons (winters & summers) are getting tougher. It underlines the strength and intensity of past and current climate change at the aimag level.

3.2.1 Precipitation evolution from 1985 and 2017

Annual precipitation analysis

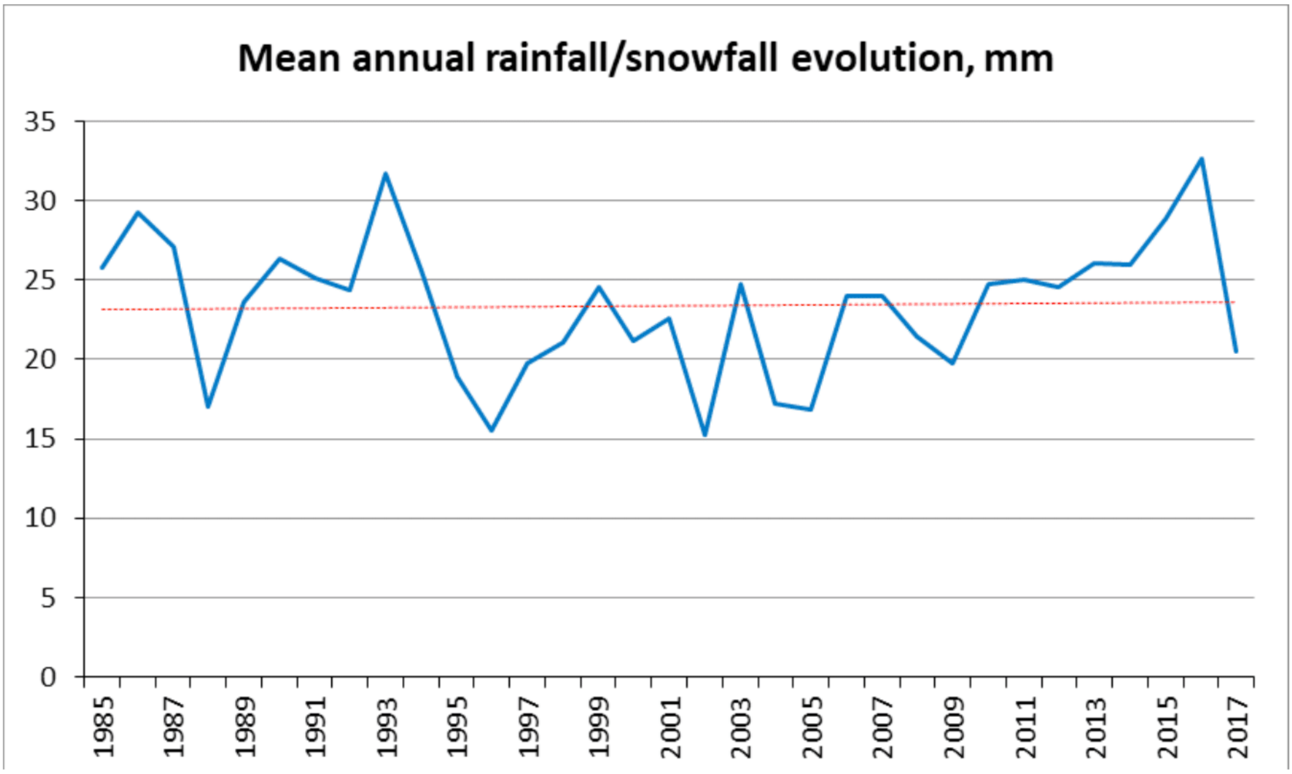


Figure 23: Evolution of mean annual precipitation in Arkhangai from 1985 to 2017

This chart shows that precipitation slightly increased on the overall period (1985-2017). However, to get a more detailed level of analysis, it is also relevant to make a seasonal analysis.

Regarding the precipitation pattern in Mongolia, the analysis is based on two main seasons:

i. The cold season that covers October, November, December, January, February and March

ii. The warm season that covers April, May, June, July, August and September.

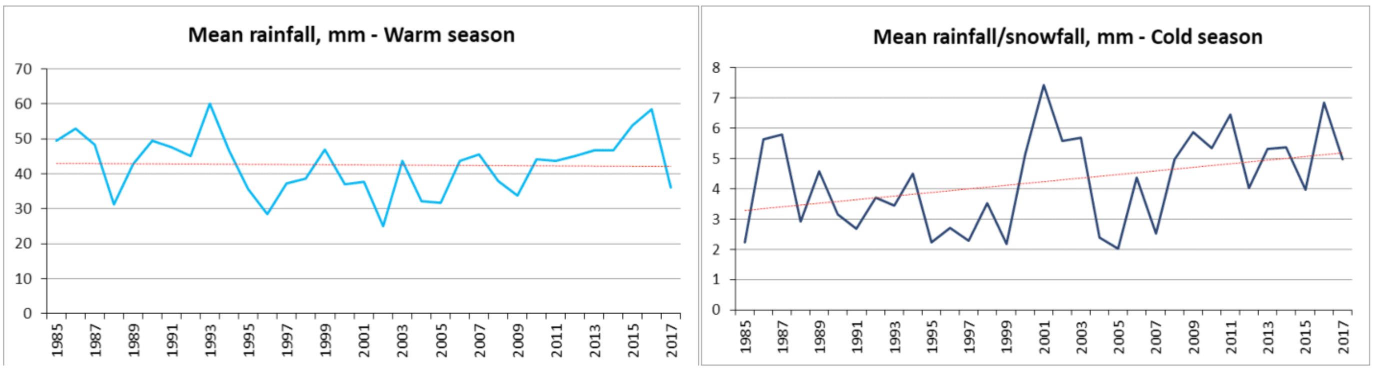


Figure 24: Evolution of mean precipitation in Arkhangai for cold and warm seasons from 1985 to 2017

These charts show that precipitation (mainly snowfalls) are increasing during the cold season since 1985 but precipitation (mainly rainfalls) are slightly decreasing over the warm season.

This underlines the fact that winters are getting more and more rigorous over the years with increasing levels of snowfalls. In the same time, it looks like the warm season is not experiencing strong changes on the overall period.

3.2.3 Brief description of current climate change impacts on Arkhangai

In a 2016 study five aimags, including Arkhangai, get an environmental and socio-economic vulnerabilities analysis. It suggests that Arkhangai's soums are differently vulnerable to climate change impacts due to the aimag geographical location and its environmental and socio-economic conditions.

The study analyses eight environmental indicators including drought-dzud index, NDVI index, pasture use index, land degradation and desertification index, surface water loss index, preventable livestock loss, prepared hay and fodder, and ten socio-economic indicators including decrease in population, poverty, unemployment, savings per person, livestock number per person, damages by drought-dzud on livestock number per person, harvest amount per person, healthcare personnel per person, population number in in-patient care, and literacy rate.

The study illustrated only 3 out 19 soums were below or at the median value of both environmental and socio-economic vulnerability, while five soums were above the median value of both environmental and socio-economic vulnerability. Out of the remaining, 4 soums were above the median value of socio-economic vulnerability, and the last 5 soums were above the median value of environmental vulnerability.

Another study revealed "a distinct geographical pattern of vulnerability. Herding households in the northern and northeastern (relatively wet and plain) areas were found to be well prepared for harsh winters, with shelters against wind and availability of forage, including hay, as well as easy access to major urban markets. By contrast, herding households in the southern and southwestern (arid and mountainous) areas were poorly prepared, with inadequate circumstances that facilitate pursuing of otor (movement of nomadic herders in search of better pastures) and lack of access to markets and dzud relief support because of their remote locations.

3.3 Climate Projections data analysis for Arkhangai

3.3.1 Projected evolution in temperatures by 2040-2059 & 2080-2099 in Arkhangai

According to the World Bank, there is good agreement among models that the whole Mongolia should expect temperature rises at rates well above the global average. Under the highest emissions scenario (RCP8.5) Mongolia is projected to experience a rise of around 5.3°C by 2080-2099, compared to a global average of around 3.7°C. A significantly lower rise of only 1.4°C is projected under the lowest emissions pathway (RCP2.6) over the same time horizon.

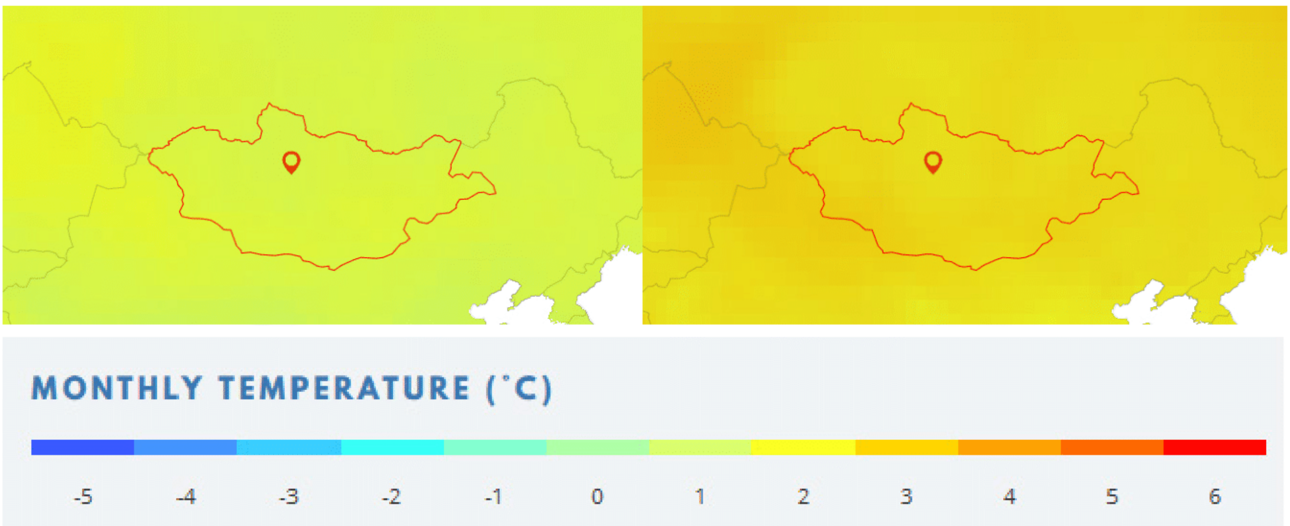


Figure 25: Temperature projections for Arkhangai - 2040-2059 - RCP2.6 vs. RCP8.5

As far as Arkanghai is concerned, it looks like, even in the best case scenario (RCP2.6), temperatures are going to increase up to +1°C by 2040-2059. In the worst case (RCP8.5), it could reach up to +3°C for the same period.

This shows that in a mid-term perspectives, choices that would have to be made in terms of adaptation options must integrate the fact that temperatures will inevitably rise by +1°C to +3°C in the whole aimag.

Source: Chunling Du, Masato Shinoda. Mongolian herders' vulnerability to dzud: a study of record livestock mortality levels during the severe 2009/2010 winter. https://link.springer.com/article/10.1007%2Fs11069-017-2893-4
Source:https://climateknowledgeportal.worldbank.org/

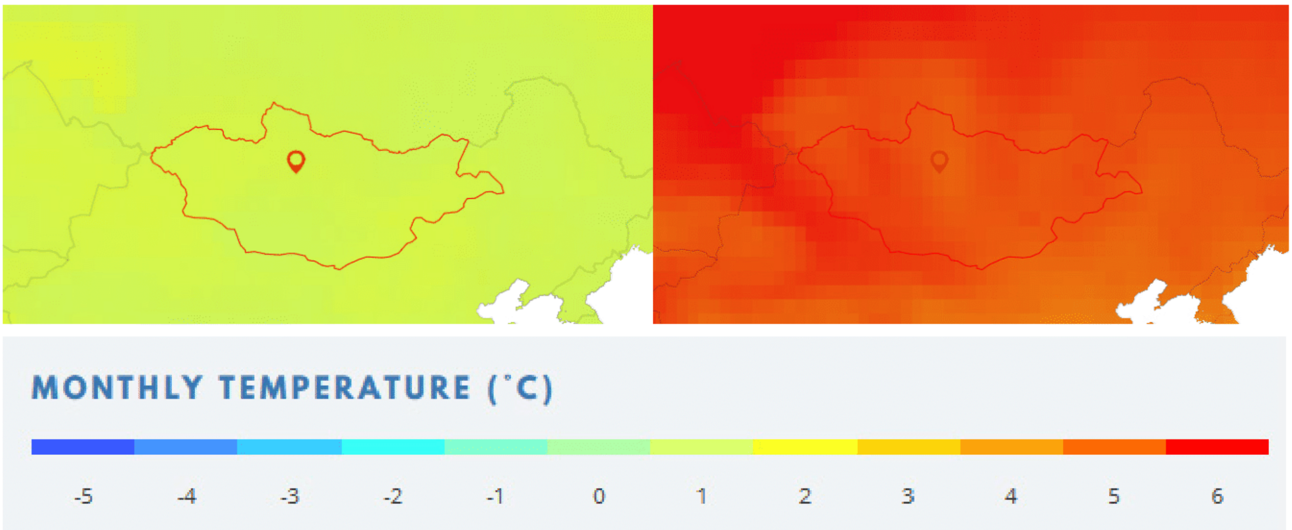


Figure 26: Temperature projections for Arkhangai - 2080-2099 - RCP2.6 vs. RCP8.5

For the 2080-2099 period, disparities between scenarios projections are much stronger. Indeed, under the RCP2.6, it looks like temperature rising may be contained at +1°C for Arkhangai. But, in the worst case scenario, the aimag will be facing a temperature increase by +5°C to +6°C.

This makes it really difficult to design relevant long-term adaptation options. However, current GHG emissions tendencies are closer to RCP8.5 than RCP2.6 which means that it could be more prudent to elaborate long-term climate policies and plans for the Arkhangai aimag integrating options in case tendencies would not reverse in the coming years.

3.3.1 Projected evolution in temperatures by 2059 & 2080-2099 in Arkhangai

According to the World Bank, there is reasonable agreement among climate models that Mongolia can expect a slight increase in annual precipitation under most emissions scenarios. By 2080-2099 this increase is projected by the CMIP5 model ensemble to be in the range of 8-14%.

Alongside these annual trends Mongolia is expected to experience an increase in the intensity of extreme rainfall events. The CMIP5 model ensemble projects increases in the total maximum rainfall falling in one and five day periods over Mongolia.

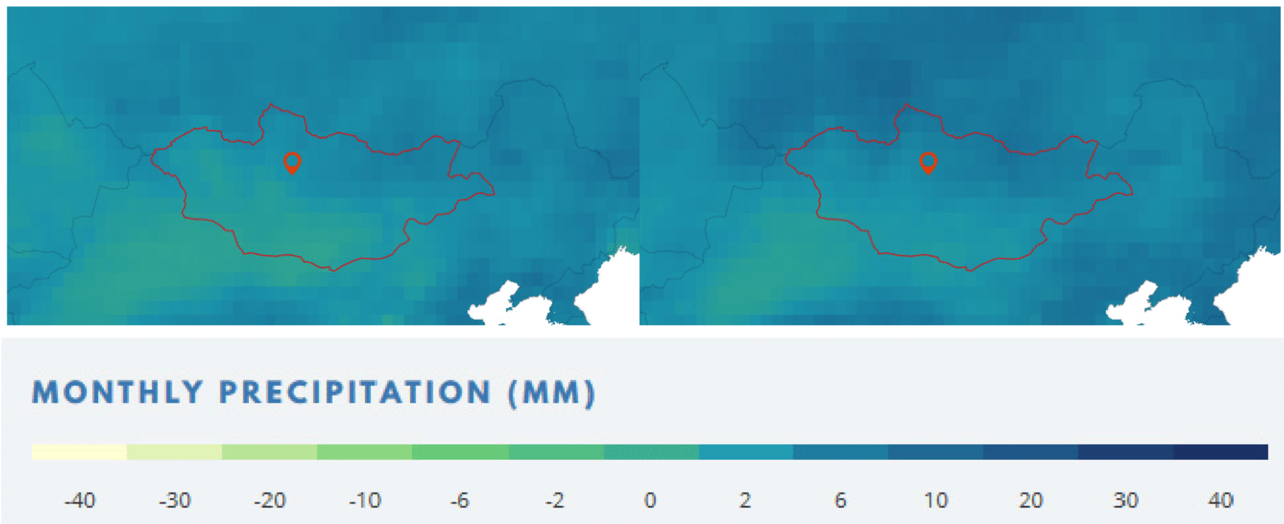


Figure 27: Precipitation projections for Arkhangai - 2040-2059 - RCP2.6 vs. RCP8.5

As far as Arkhangai is concerned, it looks like under the RCP2.6 scenario, precipitations are not going to experience severe changes. This is also the case for the RCP8.5 scenario, even is the trend seems to be a bit stronger in that case, with variation from 2 to 6 mm.

This makes it difficult to assess the potential impacts of precipitation evolution on adaptation choices for the years to come.

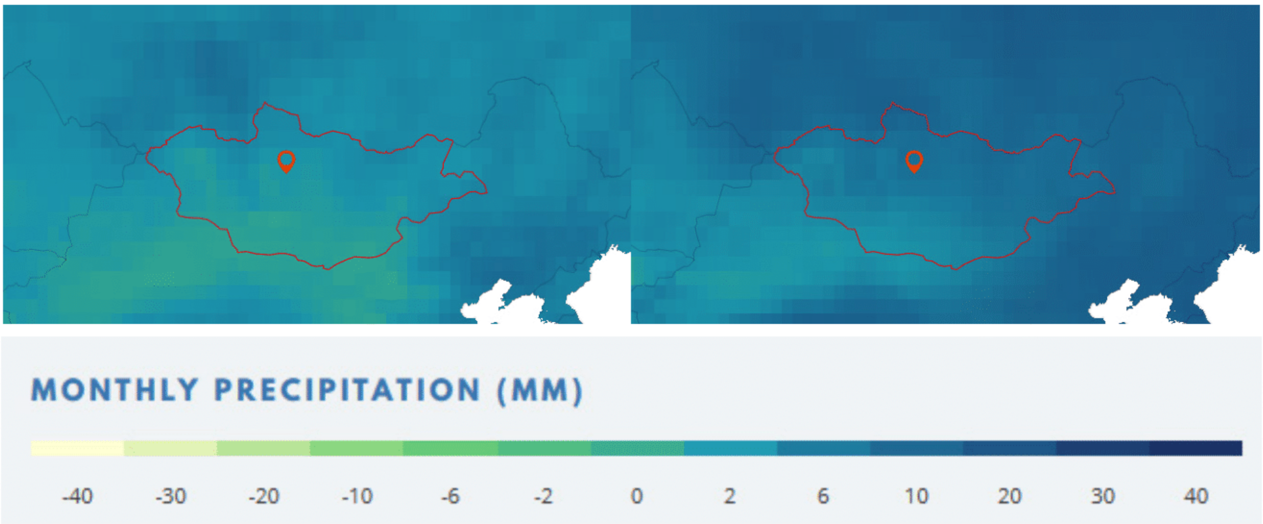


Figure 28: Precipitation projections for Arkhangai - 2080-2099 - RCP2.6 vs. RCP8.5

For the 2080-2099 period, disparities are also stronger than for the 2040-2059 one. In the worst case scenario, precipitation may increase up to 10 to 20 mm with potential severe implications for local communities among the entire aimag.

This underlines the fact that, as for temperatures, policies and plans must integrate this perspective in order to propose relevant adaptation options.

4.1 Communities perception of climate change

4.1.1 Temperature

The changes in the seasonal temperatures, as observed and experienced by the local community interviewed reveal the vulnerabilities linked with temperature. The following maps illustrate the local perception on temperature change during the four seasons of the year.

How has the average winter temperature changed in the last 20 years?

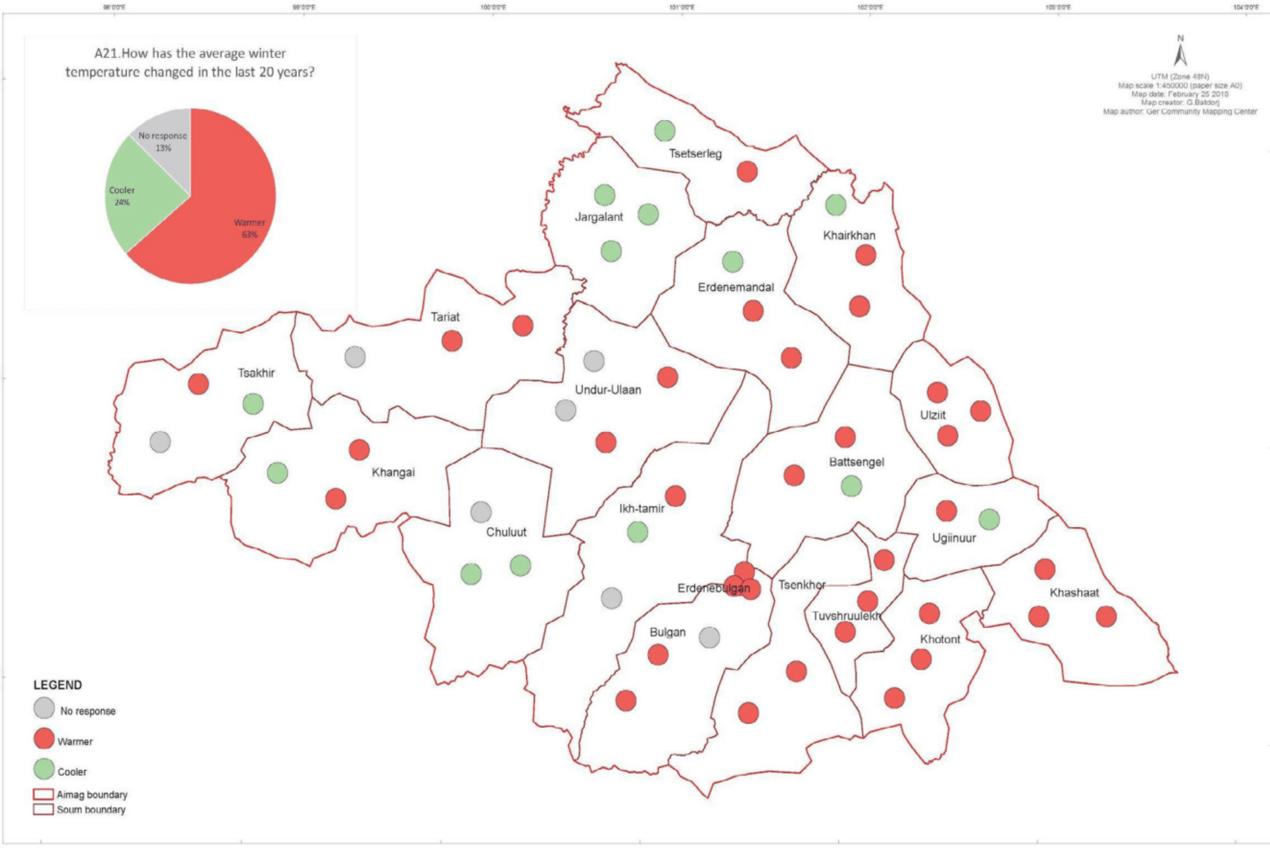


Figure 29: Local perception of temperature change in the last 20 years, winter

The majority of the interviewees, however, perceived the winter temperature to have become warmer in the last 20 years. Warmer winters were often linked with lack of snowfall, or intermittent melting and freezing of snow cover. While winters are perceived to be warmer, this does not translate to an easier time for herders, especially after hot summer and cold fall season, where preparation for winter is inadequate and the animals are weak. This does not confirm the trend observed in scientific climate data.

How has the average fall temperature changed in the last 20 years?

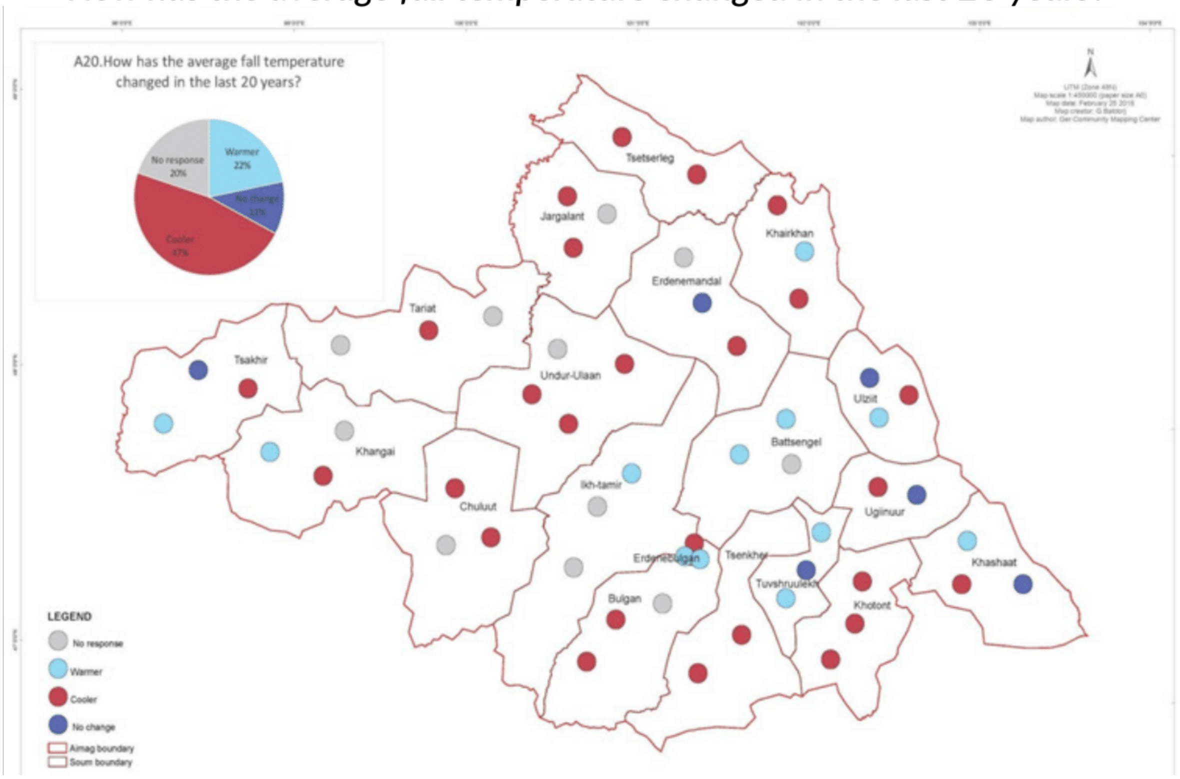
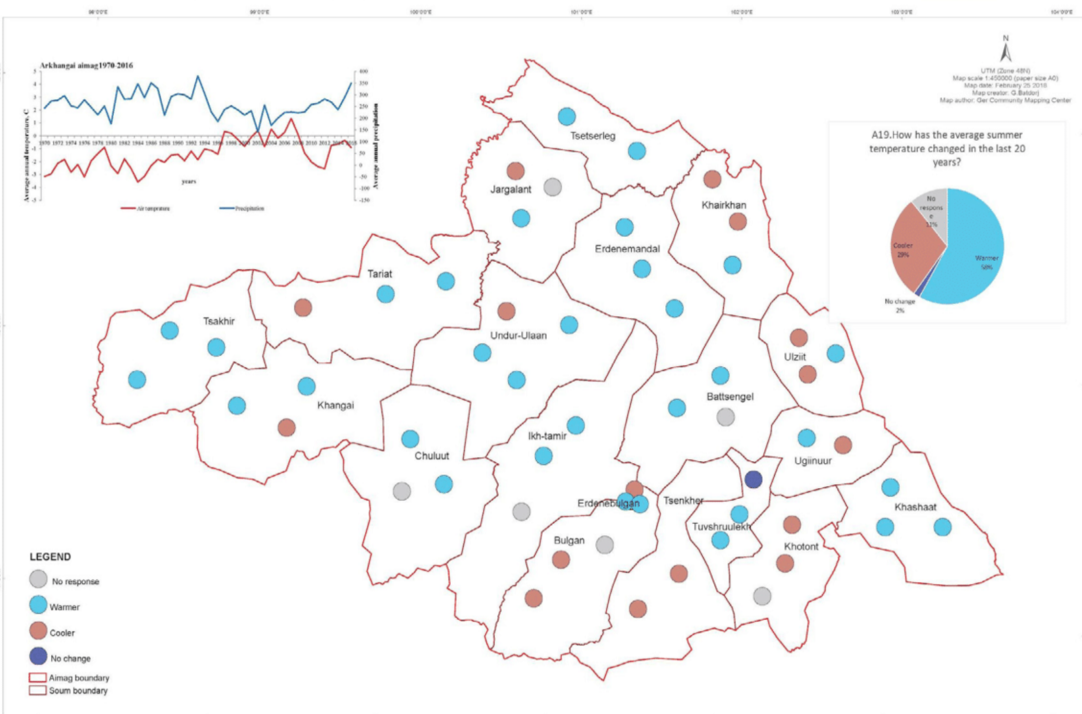


Figure 30: Local perception of temperature change in the last 20 years, fall

Locals expressed that they felt a decrease in fall temperature, in contrast to the scientific climate data analysis where the trend indicates an increase in fall temperature. This can perhaps be due to the relatively stronger increase in summer temperatures, contrasted with the fall temperature. In addition, herders experiencing summers marked with drought could perceive fall to be a difficult time since the livestock is not properly nourished.

How has the average summer temperature changed in the last 20 years?



igure 31: Local perception of temperature change in the last 20 years, summer

The locals perceived the summer temperatures to have become warmer in the last 20 years. This tends to confirm the trend observed in scientific data. Higher summer temperatures are associated with droughts by locals, where grass is sparse and water scarce. The impact of summer drought is the inability for livestock and its offspring to grow stronger for preparation for the cold seasons. Higher summer temperatures not only bring drought but also field pests that further deplete the pasture.

How has the average spring temperature changed in the last 20 years?

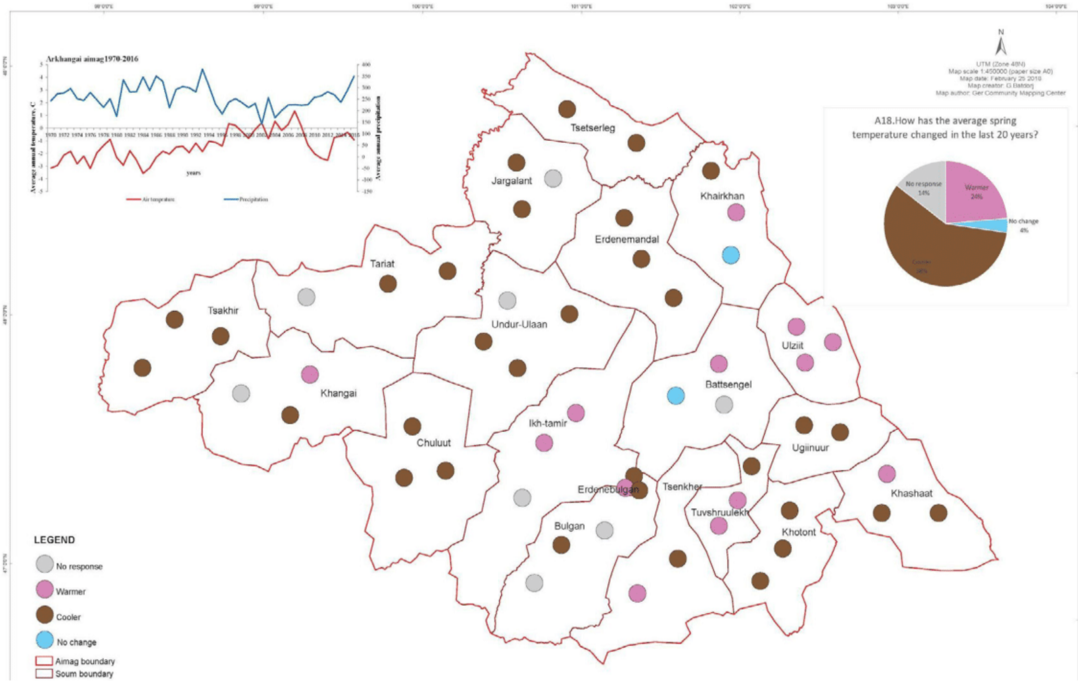


Figure 32: Local perception of temperature change in the last 20 years, spring

The last map illustrates that majority of the locals perceived spring temperatures to have become cooler in the last 20 years. Colder spring could mean extended winter seasons, where fatigued livestock further suffers the unexpected seasonal temperatures. This does not confirm the scientific data analysis but this can also shows that in average temperatures are increasing but this is hiding a more volatile distribution of the temperatures toward the whole season.

In conclusion, the locals perceive seasonal temperatures to have changed but not always in the same way that what scientific data indicate. The changes in the seasonal temperatures were seen as disrupted climatic trends in general, leading to unpredictable climatic hazards for the unprepared.

4.1.2 Precipitation

Cnges in temperature is closely tied to changes in precipitation. The following maps illustrate how locals have observed the precipitation trends change in the last 20 years, in their local areas.

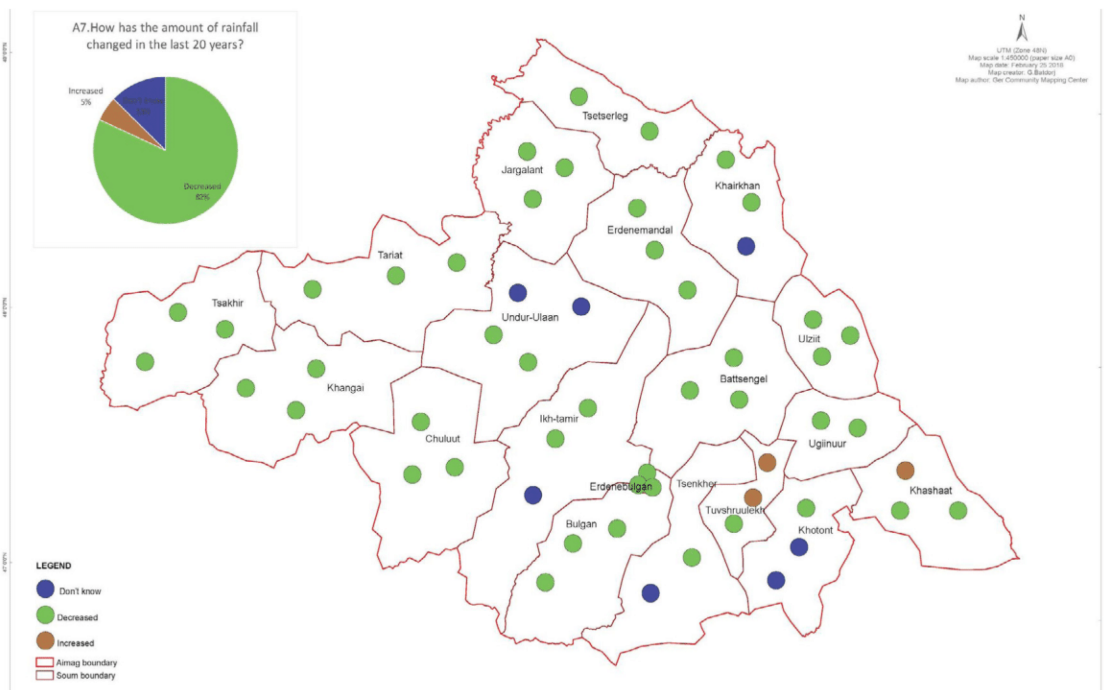


Figure 33: Local perception of change in the amount of rainfall in the last 20 years

This map shows that communities are perceiving precipitation to be shorter in duration and more frequently more intense than before. It means that, according to them, it does not rain when it commonly used to, and it does not rain as long as it used to do. Moreover, the accentuated intensity of rainfalls leads to a more frequent phenomenon of erosion because soils are dry when the rains start to flow.

These communities' inputs are a good complement of the scientific data analysis because it gives concrete feedbacks on how precipitation patterns are evolving over the years, instead of an only quantity-focused analysis.

How has the rainfall duration temperature changed in the last 20 years?

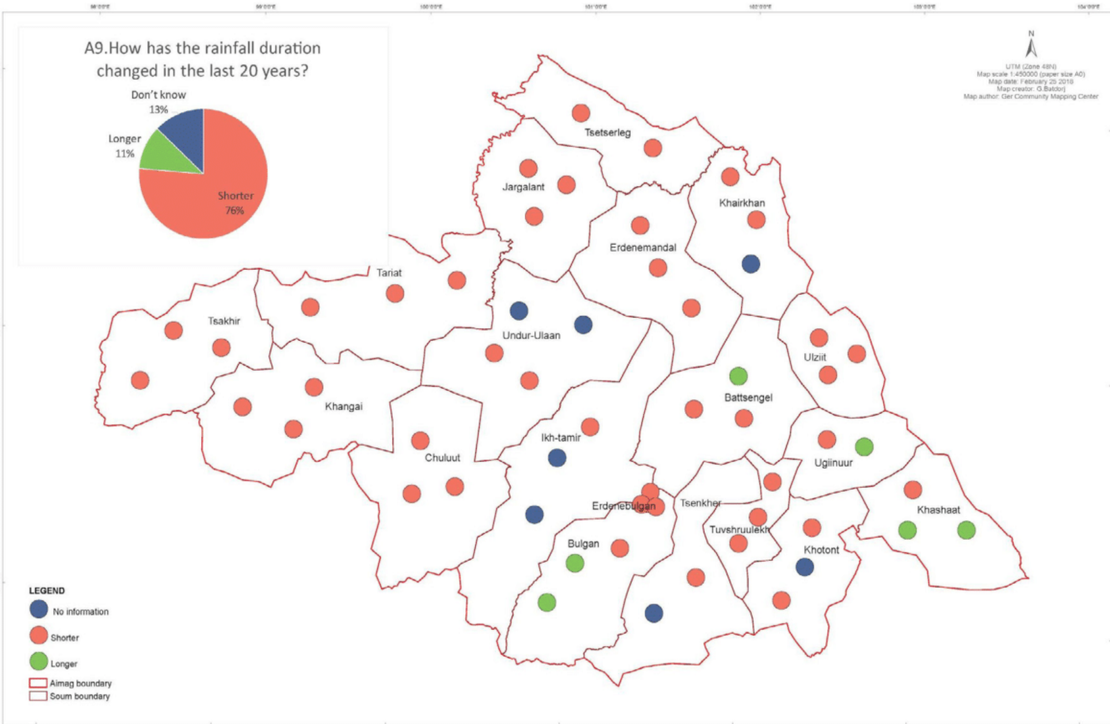


Figure 34: Local perception of change in rainfall duration in the last 20 years

The changes in rain duration, timing, and intensity are frequently reported in the literature. These changes in the rainfall, coupled with increasing summer and more volatile evolution of temperatures during spring and autumn creates conditions in which pasture is degraded and do not make it possible for herders to support the needs of their live

How has the rainfall intensity temperature changed in the last 20 years?

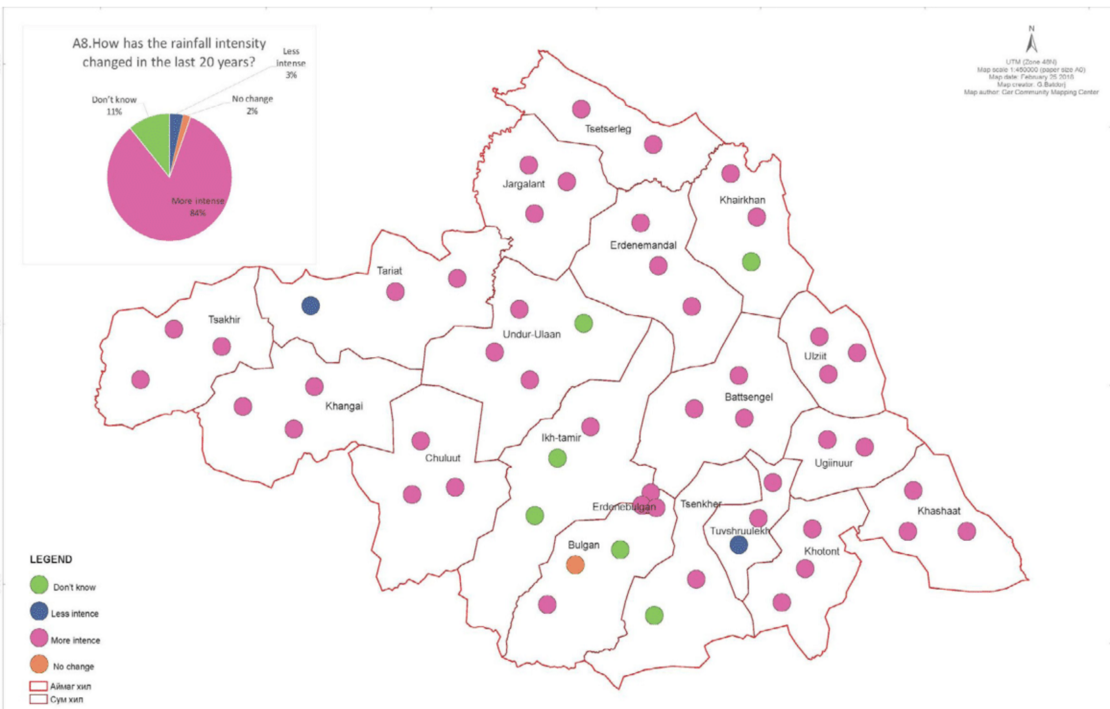


Figure 35: Local perception of change in rainfall intensity in the last 20 years

This last map illustrates that not only that rainfalls are more intense, but it is also less frequent. Most respondents observed that the number of days between precipitations is higher.

4.2 Communities perception of climate change impacts on their livelyhoods

The field study findings are summarized in the following chart. The scheme was created based on the inputs from the field data, including interviews and community workshops with locals. The scheme illustrates the relationship between local livelihoods, and factors affecting those.

The main components of the scheme include:

- Local livelihoods and main resources sustaining those livelihoods;
- Human behaviors and influence manifested through the existing livelihoods;
- Hazards (climate related, and human-caused);
- Risk exposure: disasters, climatic event, changes in natural environment, and consequent issues from those changes and events;
- Impacts on local livelihoods of Arkhangai;
- Adaptation options: short-term coping mechanisms, and medium/long term strategies.

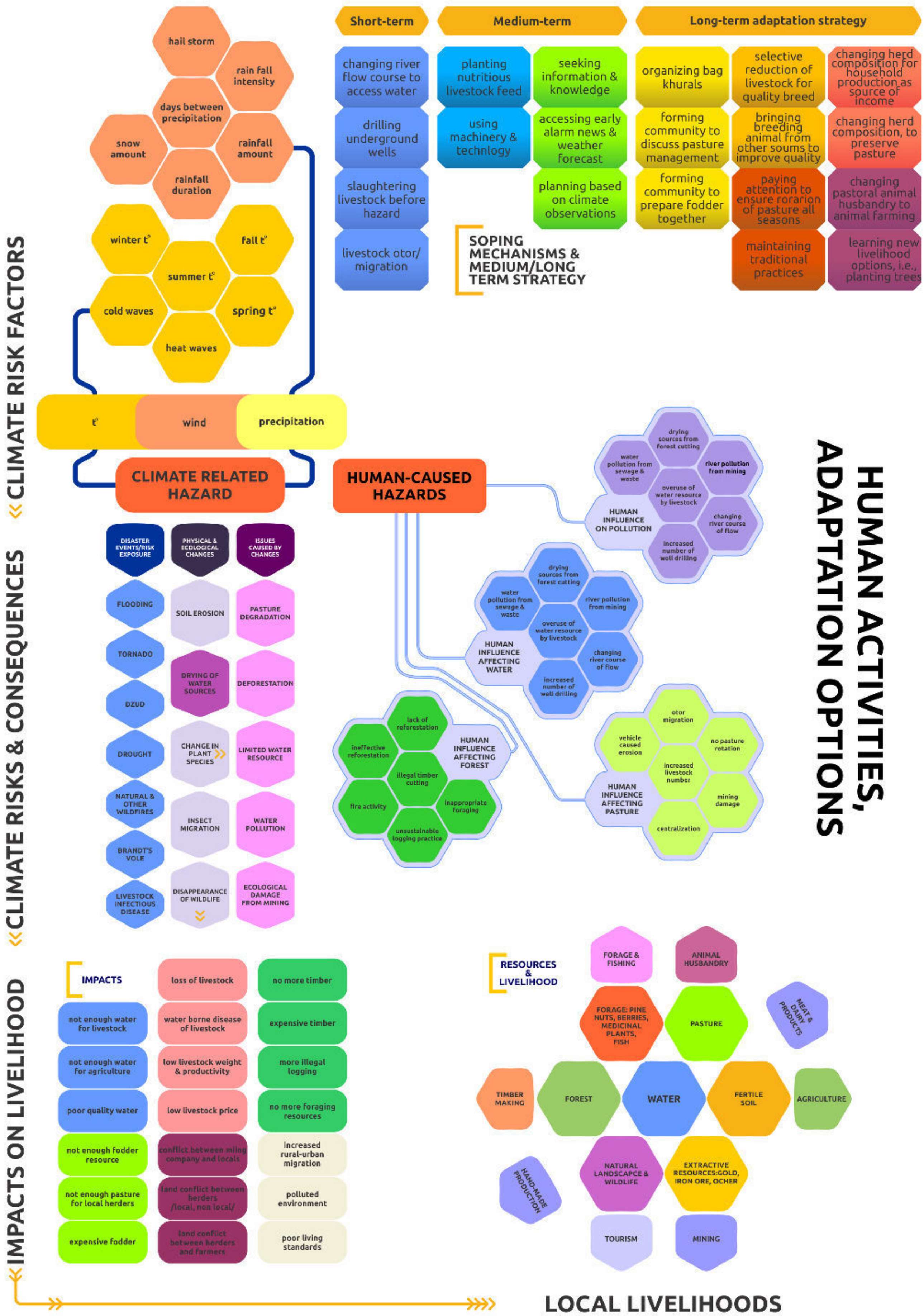
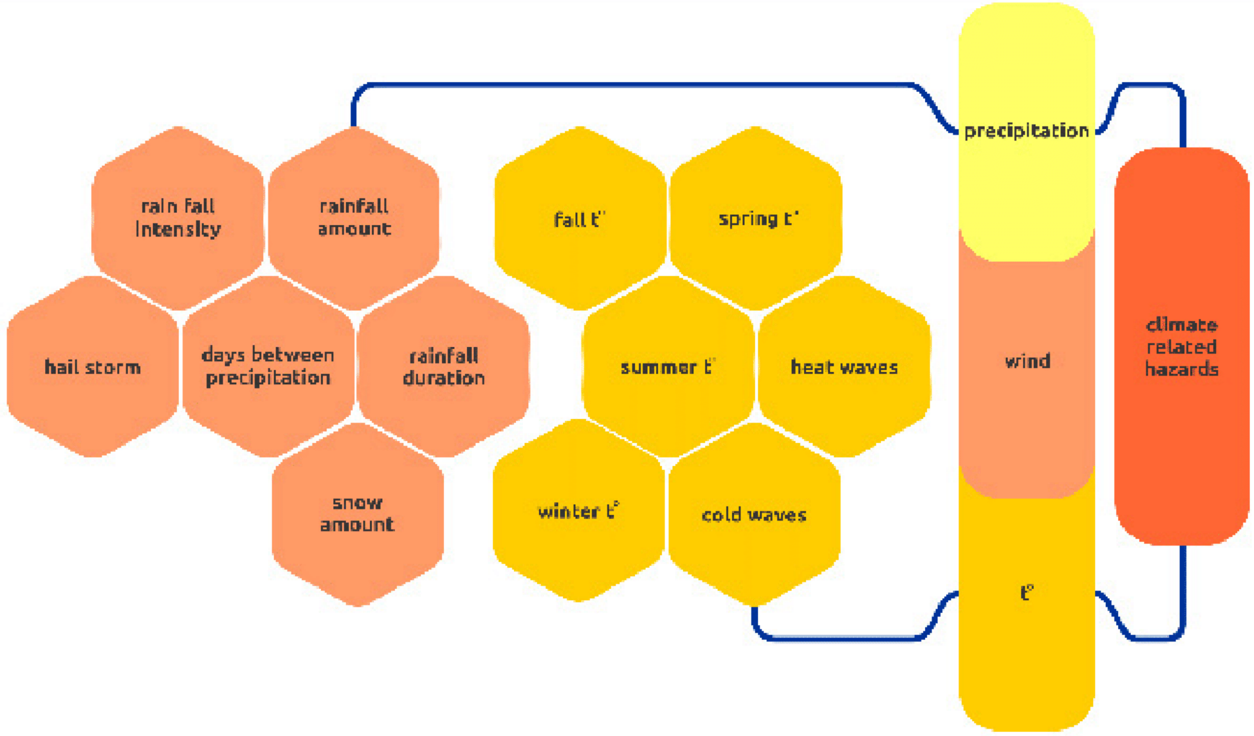


Figure 36: Arkhangai climate change vulnerability scheme

Hazards experienced by locals in Arkhangai are identified as “climate related”, “naturally occurring” and “human-caused”.

4.2.1 Climate-related hazards

The climate-related hazards include changes in temperature, precipitation and wind. The locals have described the changes observed in these climate forces. For example, changes in rain duration, intensity, and frequency have been mentioned in almost all field interviews and community workshops to be one of the main reason causing pasture degradation, drying up of water resources, and forest wildfires (drought and thunder).



The observations about extreme climatic events in general have increased according to locals. This includes the frequency of dzud, snow storms, and dust storms. In some areas, the frequency of tornadoes have increased as well. The extreme climatic events could be linked with the changes observed in temperature, precipitation and the existing vulnerabilities of the locals to such events. As the large majority of the Arkhangai population depend on the livelihood of herding livestock, without significant other livelihood alternatives, the impacts on locals could continue to increase due to the already existing risks and vulnerabilities.

Case snippet

Khotont sum, Sharavnyambuu: "I have been herding for about 30 years. I was affected by dzud three times since 1956, with every 13 years. The dzud of 1990, 2000 and 2010. I lost many of my livestock in 2010 dzud. Families with 1000 was left with 500, and those with 500, left with 250, almost about 50% lost. Since the dzud of 2010, herders began to buy livestock and have been on the trend to increase the number of their herd."

How has the Frequency of DZUD - severe winter conditions - changed in the last 20 years?

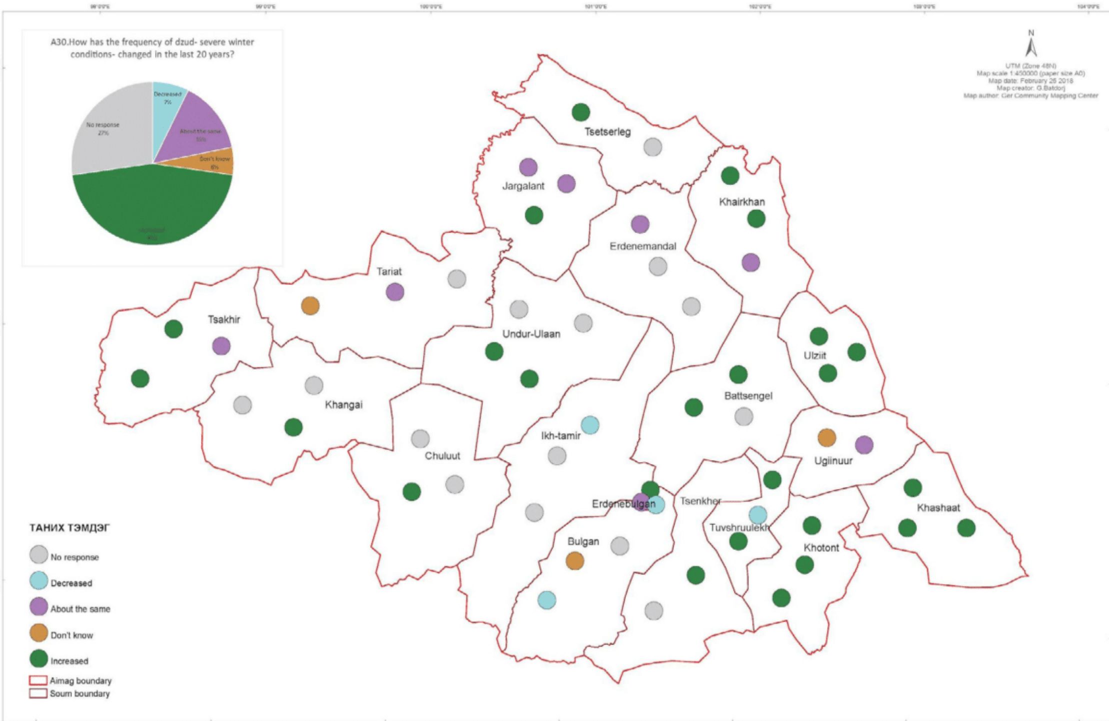


Figure 38: Local perception of change in frequency of dzud in the last 20 years

How has the Frequency of dust and snow storms changed in the last 20 years?

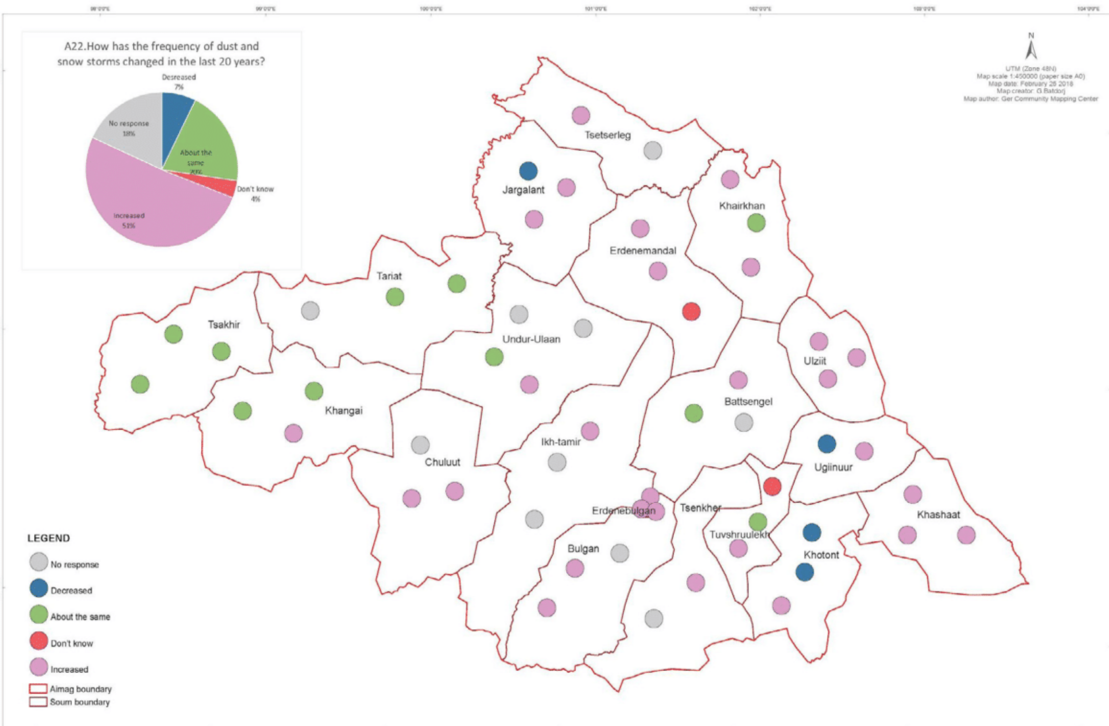


Figure 39: Local perception of change in frequency of dust and snow storms in the last 20 years

How has the Frequency of tornadoes changed in the last 20 years?

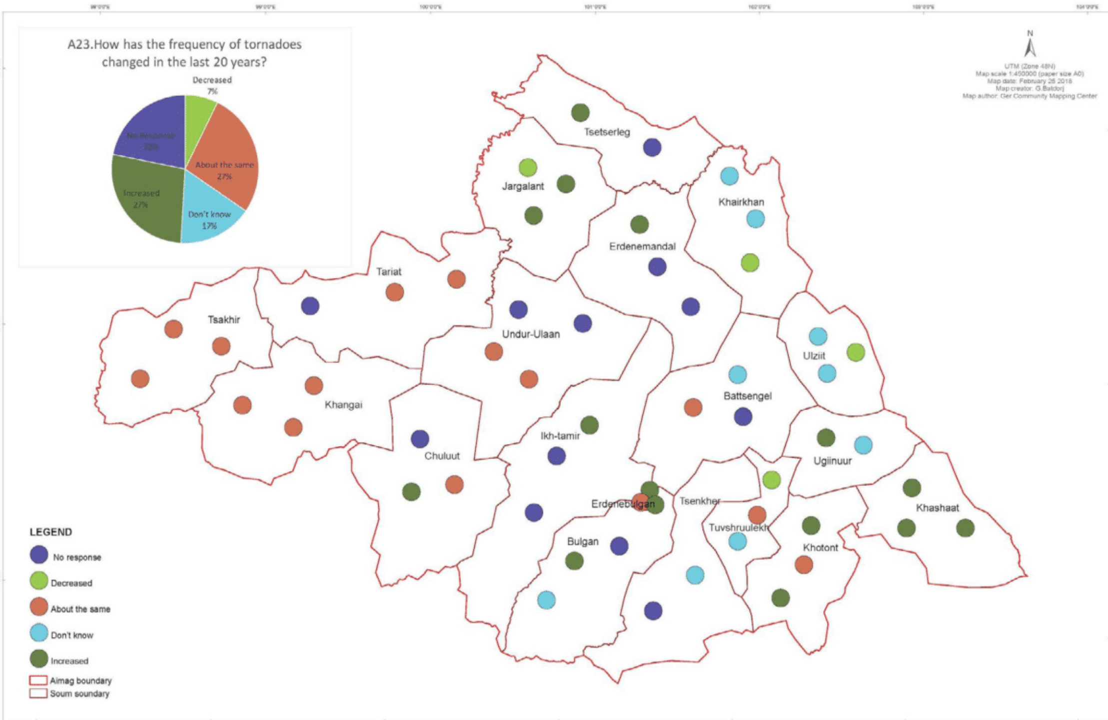


Figure 40: Local perception of change in frequency of tornadoes in the last 20 year

4.2.2 Climate-related hazards

The field work revealed changes and hazards caused by human activity in four main areas, including impacts on forest system, water system, pasture and contribution to pollution of these three main resources. The behaviors in the local community have been identified to contribute to human-caused hazards. Many of these behaviors are of course directly linked to the current livelihoods, and the way these livelihoods are sustained.

Figure 41: Scheme of human-caused hazards in Arkhangai

For example, pasture is affected when herders continue to increase the number of their livestock. In turn the increased number of livestock affect water resource, where too many livestock led to drying and pollution of a local lake. Water resources have been said to decrease or dry out when forests are cut at a level where there are not enough trees to feed the water system. Finally lack of sustainable and effective waste management has been said to cause pollution in water systems as well.

The human activity in the forests including timber making, foraging all increase the risks of forest wildfires caused by humans. The impacts on the main resources sustaining main local livelihoods are highly interdependent, and continued degradation of one further aggravates the impact on livelihoods. For example, water sources dry out when forests are cut at unsustainable rate and method. The herders without enough water move to areas with water, causing overuse and pollution of water resources there. In turn, water resource is again an issue, where locals resort to changing the course of river flow. This change in flow can further lead to drying out of river flow down the stream where pasture in another area is affected. The cycle continues.

4.2.3 Risk exposure

These are the results of the hazards described before. This includes climatic events such as drought, dzud, flooding - episodes of disasters. On a more long-term, continual spectrum, it also includes changes that are happening in the natural landscape, both physical and ecological changes, over time, such as changes in soil composition, water resource changes, and changes in biological indicators of the natural environment such as plant and wildlife variety.

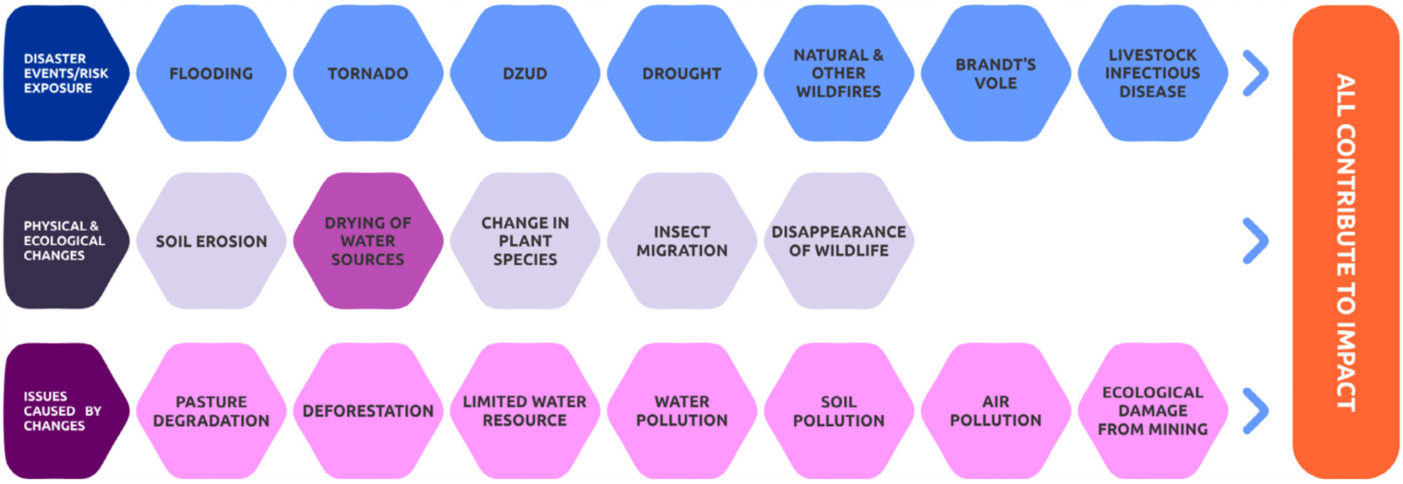


Figure 42: Risks caused from climate and human-caused hazards

On the level, where local livelihoods are affected, we identified issues arising from these changes and disasters. This includes, pollution, pasture degradation and deforestation, as discussed by local communities. The combination of these exposure to climatic events, changes, and resulting issues, lead to actual impact on local livelihoods, which is described in the next section.

4.2.1 Communities identified impacts on posture, water and forest

How has pasture quility changed in the last 20 years ?

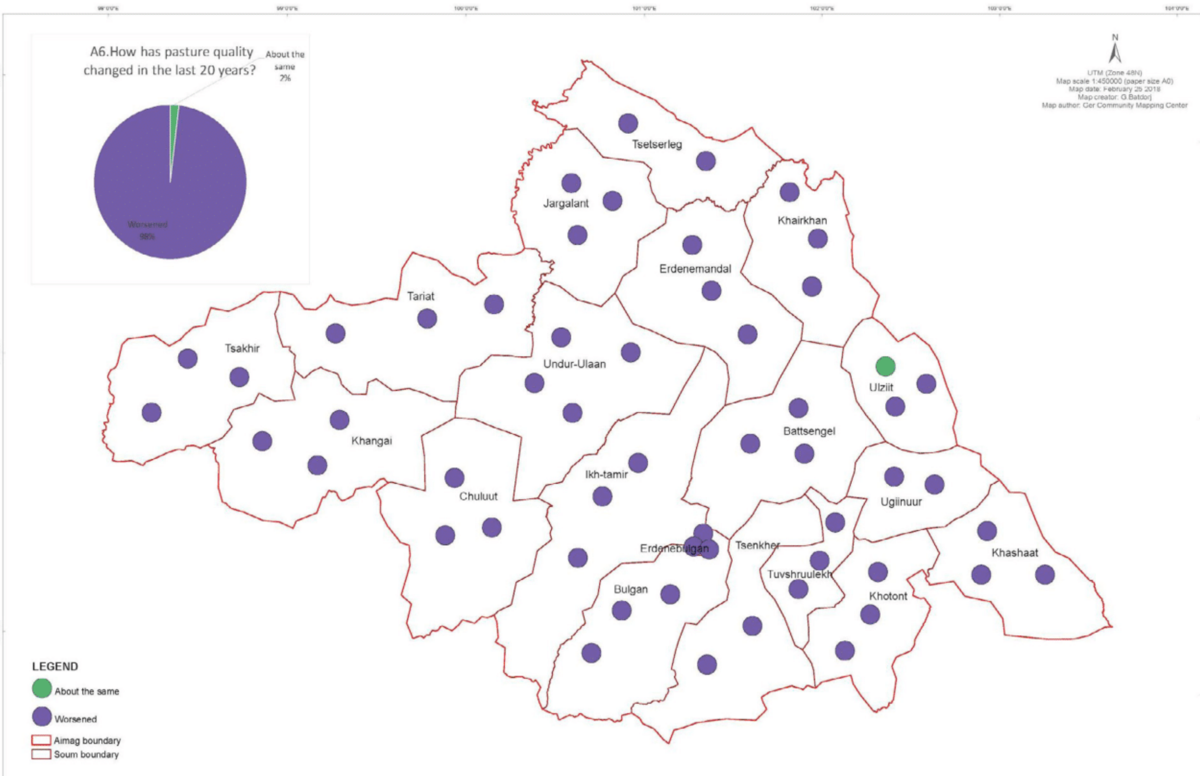


Figure 43: Local perception of change in crop quality and yield in the last 20 years

The locals observed at large that the pasture quality has worsened over the last two decades. In addition, locals also observe that crop yield in agricultural fields have decreased.

How has crops quality and yield changed in the last 20 years?

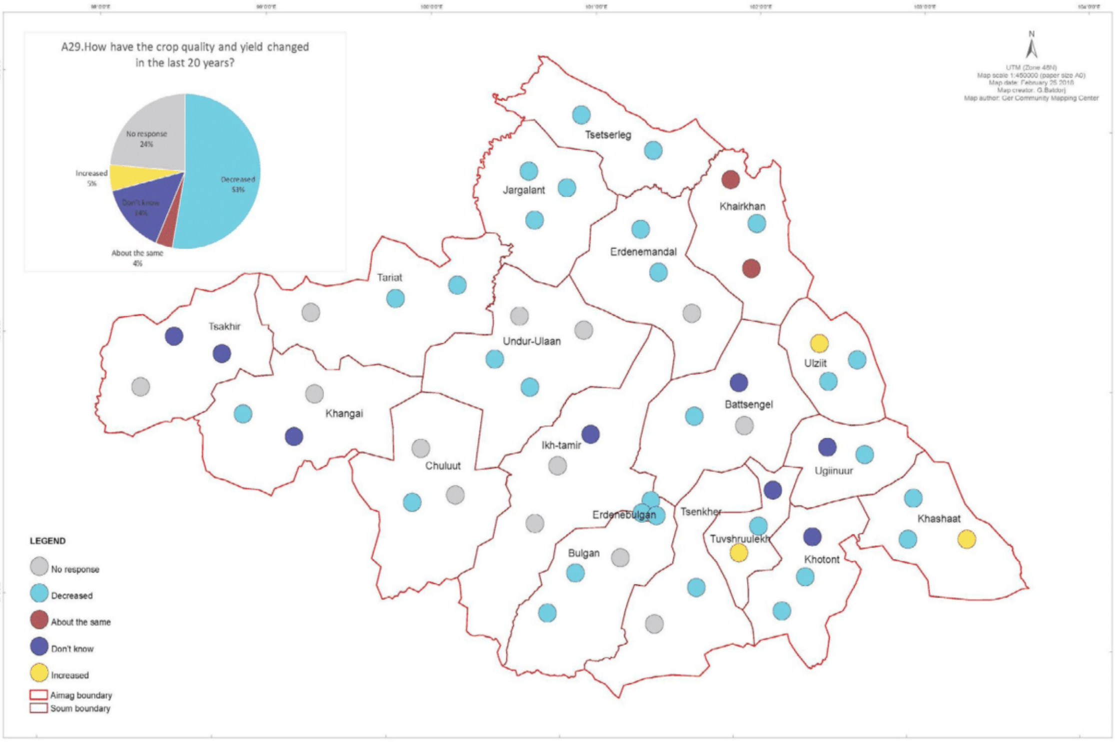


Figure 44: Local perception of change in plant varieties in the last 20 years

One of the main factors that herders continue to raise the number of their livestock is low market price for raw livestock products including meat, leather, and milk. In addition, small or medium industries are lacking to enable value-added production. Another significant factor to maintain a large number of animals is to increase the number of livestock survival due to climatic events such as drought and dzud. The tendency among herders to keep growing number of livestock is resulting in pasture overuse, and thus leading to increased conflicts between local and non-local[5] herders on sharing natural resources such as water, pasture, and hay.

The following illustration describes the vicious circle in which the impacts are only magnified with each coping mechanism that puts more stress on the pasture and other essential natural sources.

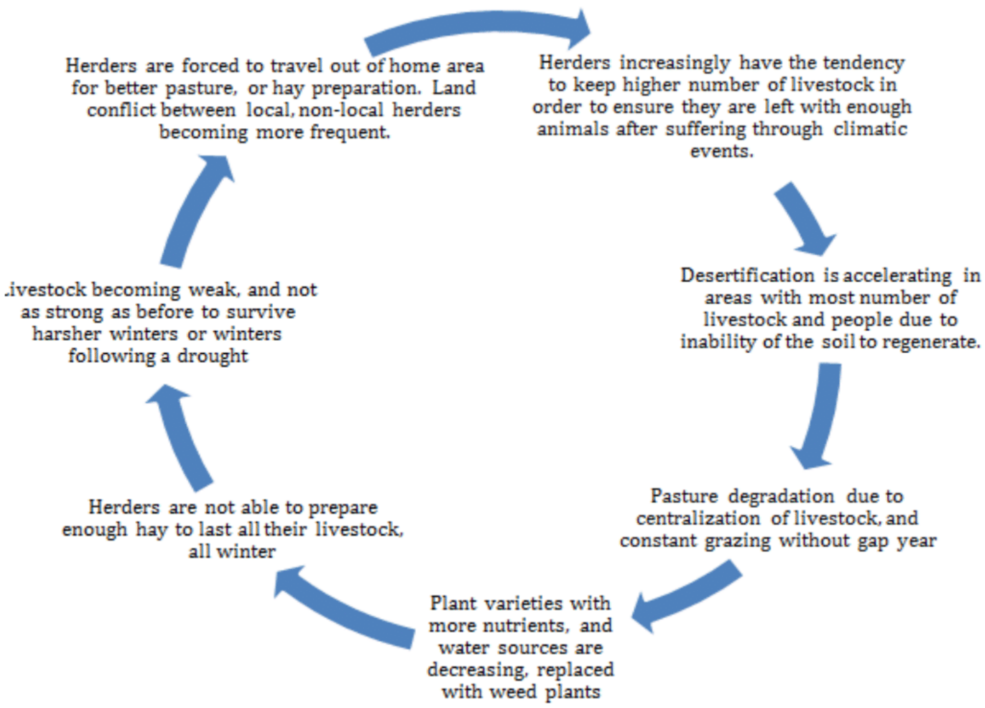


Figure 45: Pasture degradation cycle, Arkhangai

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5 Non-locals refer to herders from other aimags, sometimes having travelled long distances over from a few aimag boundaries away.

How has volume of river flow changed in the last 20 years ?

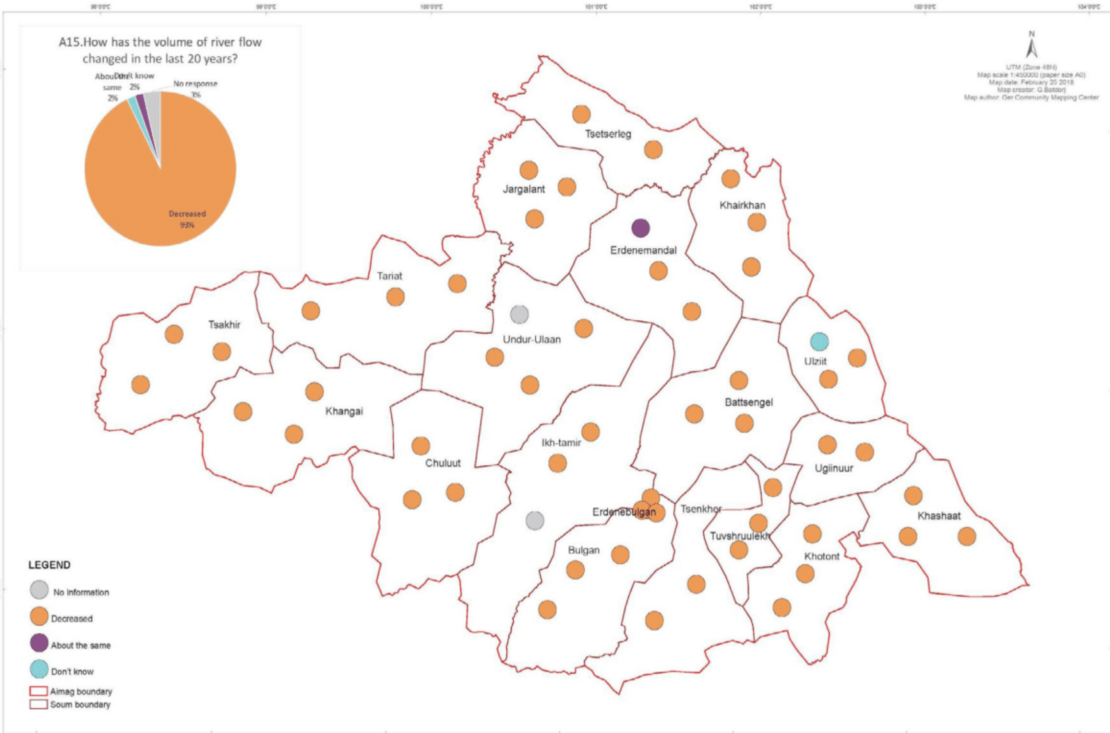

Figure 46: Local perception of change in volume of river flow in the last 20 years

How has water level in springs and lakes changed in the last 20 years ?

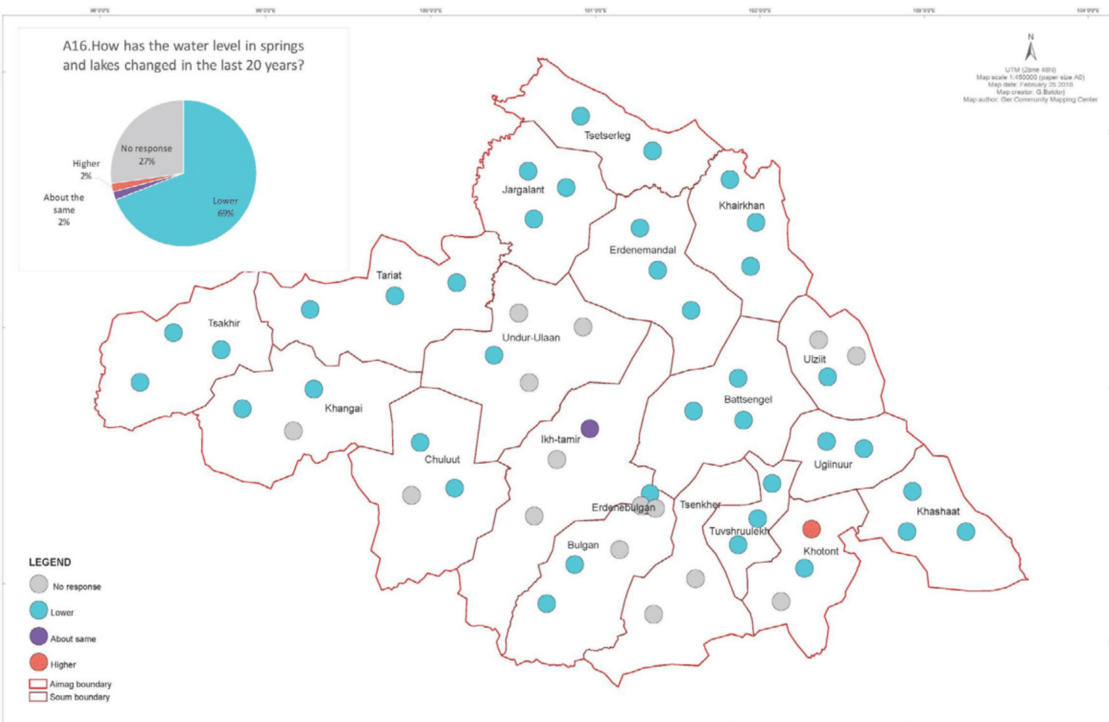

Figure 47: Local perception of change in water level in springs and lake in the last 20 years

The locals observe changes in the patterns of precipitation. The decrease in rainfall amount, duration, and frequency have resulted in the decreasing water resources in rivers, wells, and lakes. The locals observe not only the lack of water availability in natural water resources, but also poorer quality of water resources. The decrease in water availability and quality is increasingly an important vulnerability to the natural ecosystems and livelihoods of locals who depend on them.

Related to the receding forest line, springs and rivers flowing from the forest springs are drying. Lack of water sources for livestock forces herders to move in search for other water sources outside their home area, often to an already centralized zone where pasture overuse and degradation, land conflict between herders are increasingly an issue.

Centralization surrounding available water sources further lead to pollution and degradation of water quality which can cause livestock diseases. Apart from livestock health, access to clean water for local population in areas with water issues will only worsen over the years without appropriate action.

Water resources have been discussed in relation to lack of precipitation and deforestation either due to pest problems, wildfires (remarked to be usually man-made fires), and logging activities. Issues of water resource and quality are also directly linked to movement and often centralization of population and livestock.

How has the forest cover changed in the last 20 years ?

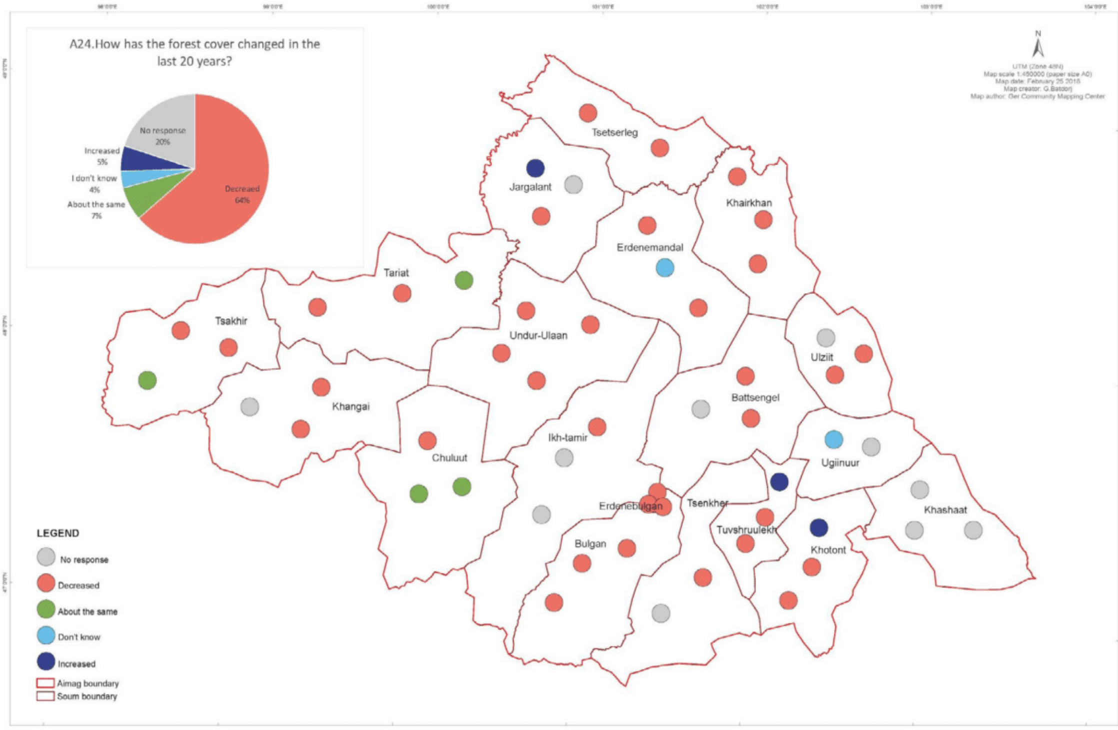

Figure 48: Local perception of change in forest cover in the last 20 years

Locals have observed a receding forest cover in the last 20 years. The decrease in forest cover are perceived to be attributed to the increase in pest attacks, and illegal logging. The wildfires affecting the forest are perceived to have remained about the same in the last 20 years. This means, the forests have been suffering from more damage and the results are decrease in resources such as wild nuts and berries which play an important seasonal, additional source of income for some locals.

The forest degradation observed by the locals align with the negative changes observed previously in pasture and water resources. Forests are also an important source of fuel, as a resource for locals to provide as an economic products for non-locals. The decrease in these important resources related to the forest, in addition to degradation in pasture and water resources could bring climate vulnerabilities as well as energy crisis when the prices of wood going up with increasingly limited supply.

Photo credit: Batdorj Gongor

Forest has been one of key issues discussed during the field work, illustrating a general perception of forest degradation due to human activity, in addition to natural causes. Locals feel, at the same time, that illegal timbering has been better monitored in the recent years, even though neighboring aimags and other sums of Arkhangai without forest reserve continue to supply their wood/fuel needs from forested sums. The need for better planning, monitoring, and forest resource management has been expressed across all discussions.

The locals identified direct link between forest resources to availability of water resource. Forests cover have been perceived to be declining. Participants noted the increased frequency of forest fires, mostly caused by human activity and pest attacks. In particular, timber workers and seasonal berry and nut harvest groups have caused large majority of forest fires.

Area affected by forest fire and pest, as identified by local communities

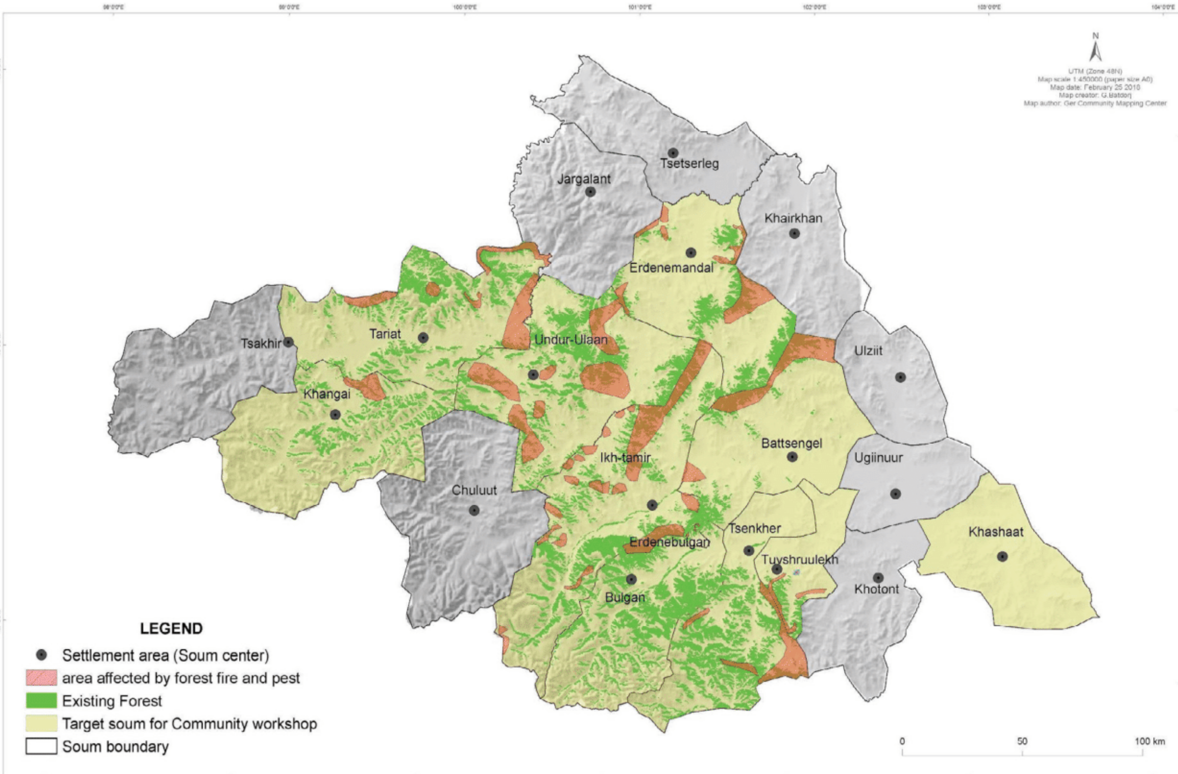

Figure 49: Areas of forest affected by wildfires and pests, as identified by local communities Arkhangai

Across all the community workshops, it was confirmed that all the households rely on the surrounding forest for energy and fuel needs.

The participants highlighted the urgency and severity of deforestation in each their respective soums. Participants have also highlighted that Arkhangai locals are not of the habit of using other sources of fuel, such as dried manure, or even decomposing timber cleared from forests. This means the energy needs are likely to continue to be sourced from forests. The issue of deforestation means increased prices for energy in the near future.

4.2.5 Impacts on local livelihood

These include indicators on how existing local livelihoods are becoming more challenging to sustain. The impacts on different elements of livelihoods have been identified in different colors. The impacts are also interdependent, and work in a chain effect.

Negative changes in pasture, forest, and water resources means limited resources, with ever increasing need. Land dispute is increasingly an issue between herders, farmers, locals and non-locals. For example, pasture degradation can lead to land disputes, and also result in lack of fodder for the winter for herders. This leads to either loss of livestock, or low quality livestock, leading to drop in market price for livestock products, and poor living standards for the herder family as a result.

Furthermore, unemployment, migration from home area to urban areas, younger generation no longer continuing the herding practices, as well as psychological distress for herders during harsh droughts and dzuds have been described. Herders who lost all of their livestock often migrate to aimag center, and to greater urban areas in search for better economic opportunities.

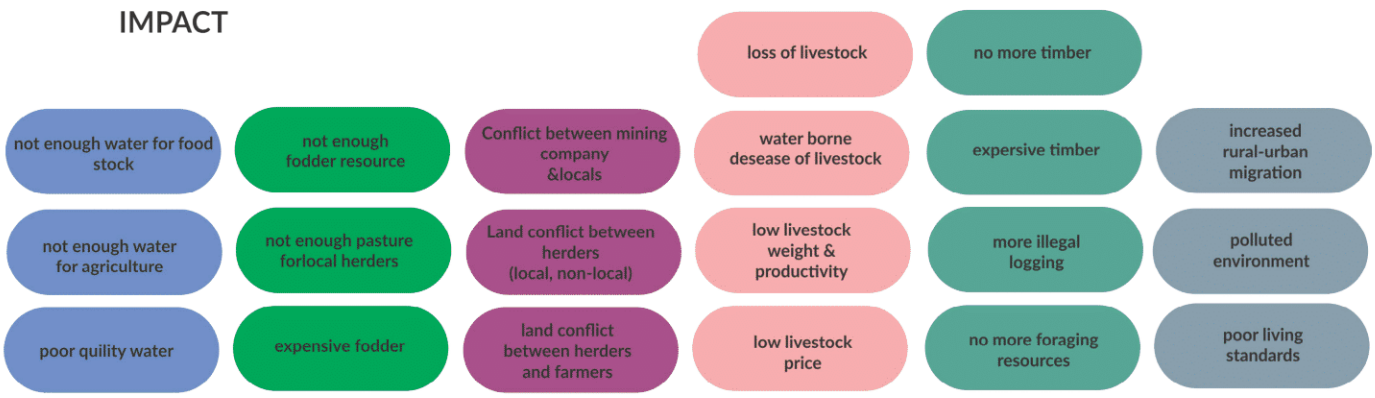

Figure 50: Impacts on local livelihoods

4.2.6 Locals`narrative on impacts of climates changes

The locals discussed climate and livelihood significant events from memory during their lifetime. The following lists some examples of the events, place, impacts and given timeline. These memories are made into an online map where any user can access the information on climate change event and its impacts in Arkhangai. The timeline of climatic events memory was developed based on the field interviews. The timeline is developed as an online map[6] to illustrate events with their corresponding years.

It is intended to provide overall information on the local evidence of climate change and its impacts as spoken by locals. Where GPS coordinates are available, the recounted events are geo-located within the aimag. The user to the online platform will be able to see where, what happened, who was impacted and what was done at the time of the event.

The online platform also includes portraits of interviewees (where release form was signed) and photograph of the area when possible. As a result, the online timeline will be presented in a visually compelling manner, where users can learn about lo

cal narratives related to climate change.

5 Part IV – ADAPTATION OPTIONS& CONCLUSION

5.1 Community-based adaptation options

The result of the impacts' analysis then lead to adaptation options. These can be short-term coping mechanisms, or medium and long-term adaptation strategies. The following chart shows the adaptation options identified through field interviews and community workshops.

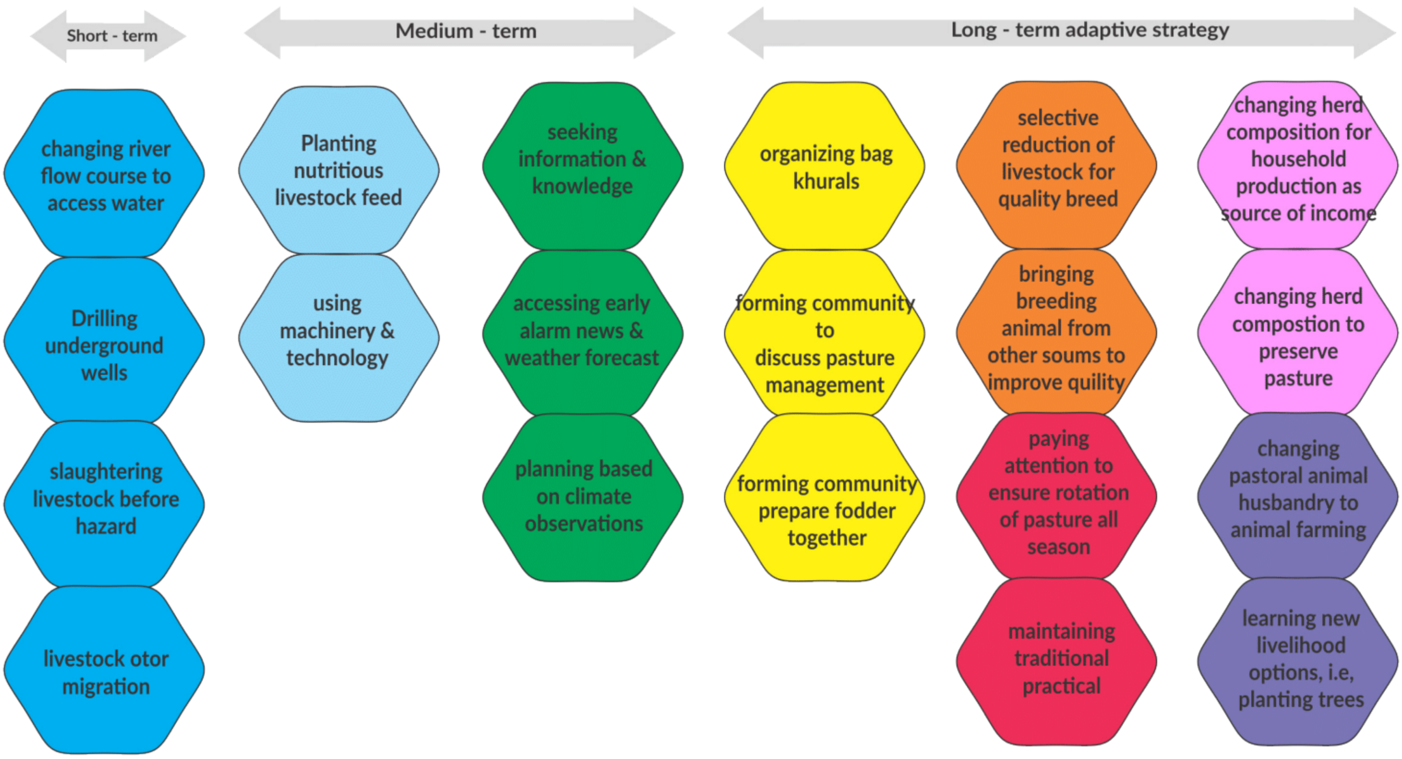

Figure 51: Short, medium and long-term adaptation option

The issues identified through the interviews illustrate the vicious circle of decreasing natural resources coupled with increasing demand to maintain animal husbandry. The interviewers discussed the following options as **possible coping mechanisms**:

- ✓ Some herders are beginning to pay attention to pasture management;
- ✓ Some herders are focusing on livestock health/quality and decreasing the number;
- ✓ Buying livestock feed and hay in advance;
- ✓ Herders are prioritizing weaker of the herd to sell;
- ✓ Some herders prevent their livestock going into the forest to prevent receding of forest line;
- ✓ Some herders are still practicing seasonal nomadism to allow gap year for pasture;
- ✓ Some herders are beginning to employ home production of value-added products and thus changing the composition of their herd;
- ✓ Some locals form a community, often based on family ties to collectively prepare for their upcoming needs such as preparing livestock feed;
- ✓ Some locals in agriculture redirected river flow to provide water to the crop field;
- ✓ More people are beginning to work as a community to better prepare.
- ✓

The following recommendations are proposed as potential solutions to prevent further aggravations of the identified issues, and mitigate the risks for local communities:

- ✓ Capacity building and awareness raising for local community members and relevant officials on climate change and its impacts;
- ✓ Introducing and implementing pasture allocation system at the local level (subsequently at national level);
- ✓ Revisiting and developing policies to address the increasing land conflicts;
- ✓ Supporting value-added production of livestock produce;
- ✓ Strengthening the implementation of rehabilitation activities, legally budgeted from profits made from natural resource exploitation such as mining, and forests;

- ✓ Constructing watershed to better provide and manage water resource for livestock.

5.2 CONCLUSIVE REMARKS

The present community-based climate vulnerability risk assessment constitutes is a pillar of the territorial approach to climate and energy issues developed by Geres in collaboration with Arkhangai governorate through CEMAATERR program.

It has been conducted in an inclusive and iterative approach giving community members the opportunity to bring their contribution, as far as they are concerned, to the assessment of past and futures vulnerabilities and the identification of adaptation options to address those challenges.

This analysis, combining scientific climate data analysis with local communities' perception of climate change effects and impacts (will) supports the development of specific training and awareness material in order to raise awareness and understanding of local stakeholders (aimag and soum decision makers, civil society, citizens, private sector, etc.) about climate current and futures challenge.

It results in the identification of priority orientations to address climate change adaptation and mitigation challenges meeting community needs and consistent with national commitments and policies; that could be mainstreamed into policy making process at aimag and sum levels.

Geres continues to offer its technical and institutional support to local authorities and civil society of the Arkhangai for improving their understating of past and futures challenges and develop more relevant and effective public energy-climate interventions at local level.

COMMUNITY-BASED CLIMATE VULNERABILITY RISK ASSESSMENT OF ARKHANGAI

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