

A POLICY CONTRIBUTION-ORIENTED RESEARCH PROJECT
“VULNERABILITY ASSESSMENT AND ADAPTATION STRATEGIES FOR
PERMAFROST REGIONS IN MONGOLIA”

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Abstract: Climate warming has caused the degradation of the permafrost in Mongolia, which has considered accelerating reduction of water resources and put a negative effect on terrestrial ecosystems and pastoral productivity. Policies and processes to mitigate for these effects are urgently required. In response to these requirements, a policy contribution-oriented research project “Vulnerability Assessment and Adaptation Strategies for Permafrost Regions in Mongolia” has been approved by Ministry of the Environment, Government of Japan. The project will try to develop two evaluation systems: one is the evaluation system for environmental vulnerabilities caused by permafrost degradation, and other is that for environmental capacity and climate change adaptive policies. The first priority is to determine the extent of permafrost degradation and the associated effects on terrestrial ecosystems. Analyzing the various factors that make the ecosystem vulnerable is the next priority. The effects of these factors on the environmental capacity will be measured. Finally, adaptive policies will be recommended for sustainable development, preservation of the environment, and maintenance of the pastoral economy.

Key words: Vulnerability assessment, environmental capacity, permafrost degradation, climate change adaptation, Mongolia

RESEARCH BACKGROUND AND NECESSITIES

According to the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), the effects of climate change from CO₂ emissions cannot be avoided. Policies and processes that adapt to these effects are thus required. Efforts to put in place such policies must be included as a major part of the next international framework for the Kyoto Protocol. In developing countries, particularly where there are areas vulnerable to the effects of climate change; pressure on food and water supplies may increase due to climate change. Specific emergency policies and countermeasures must be established for these areas on the basis of

scientific assessment.

One of these vulnerable developing countries is Mongolia. Two thirds of the land area of Mongolia was underlain by permafrost. Since 1940, the air temperature in the area has risen as much as 1.8°C, and this change has caused shrinkage in the area and depth of permafrost (Wu et al., 2009, Wu et al., 2011). The degradation of the permafrost has considered accelerating reduction of water resources and desertification of grassland in Mongolia, which has had a negative effect on terrestrial ecosystems and pastoral productivity. Degradation of grassland and a decline in economic productivity based on pastoral agriculture are feared consequences of the permafrost degradation. On the other hand, since the adoption of a market-based economy in the 1990s, the political systems, economy, and society in Mongolia have changed greatly. The nomadic lifestyle in balance with nature that sustained the Mongolian people for many years is disintegrating and changing. The poverty of the nomadic people and their lack of income have resulted in overgrazed pastures, degradation of pasture lands, and accompanying social and environmental issues (Fig.1). Policies and processes to mitigate these effects are urgently required.

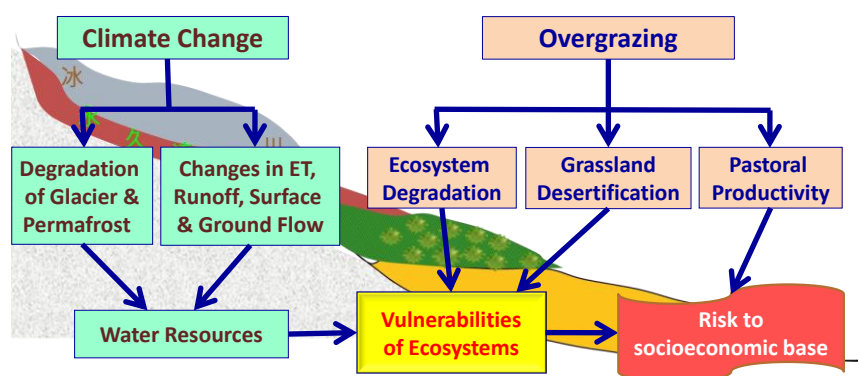


Fig.1 Research background and necessities

RESEARCH OBJECTIVES AND FRAMEWORK

In response to the need to develop these policies, this study will focus on the high-latitude permafrost regions, particularly vulnerable to climate change. The susceptibility of the terrestrial ecosystems to damage by climate change will be evaluated, and appropriate policy recommendations will be put forward. The first priority is to detect the extent of permafrost degradation and the associated effects on terrestrial ecosystems. Analyzing the various factors that make the ecosystem vulnerable and their effects on the natural, economic, and social environment is the next priority. The effects of these factors on the environmental capacity of the grasslands region will be measured. At last, a system will then be developed to determine various policies on climate change adaptation, and adaptive policies will be recommended for sustainable development, preservation of the environment, and maintenance of the pastoral economy (Fig.2).

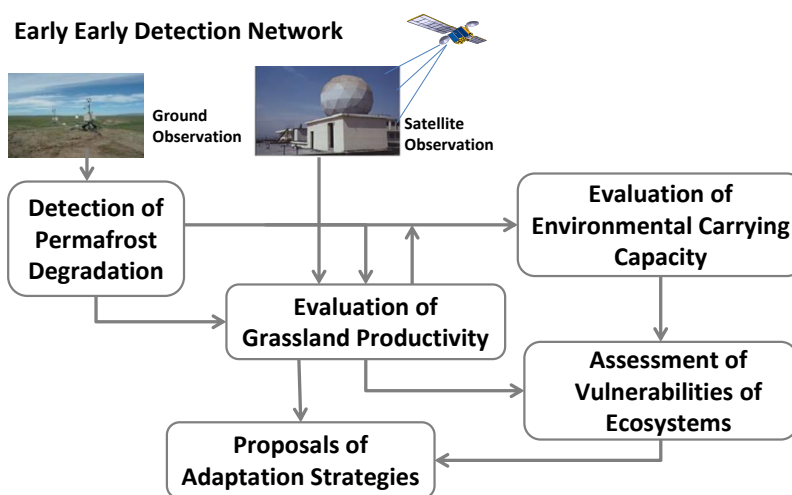


Fig.2 Research Objectives and framework

RESEARCH CONTENTS AND EXPECTED RESULTS

Two evaluation systems will be developed to achieve these research goals. One is the evaluation system for environmental vulnerabilities caused by permafrost degradation, and other is that for environmental capacity and climate change adaptive policies.

(1) Evaluation System for Environmental Vulnerabilities Caused by Permafrost Degradation

The evaluation system for environmental vulnerabilities caused by permafrost degradation consists of three parts: detection of permafrost degradation and distribution, assessment of grassland production and evaluation of environmental vulnerabilities (Fig.3).

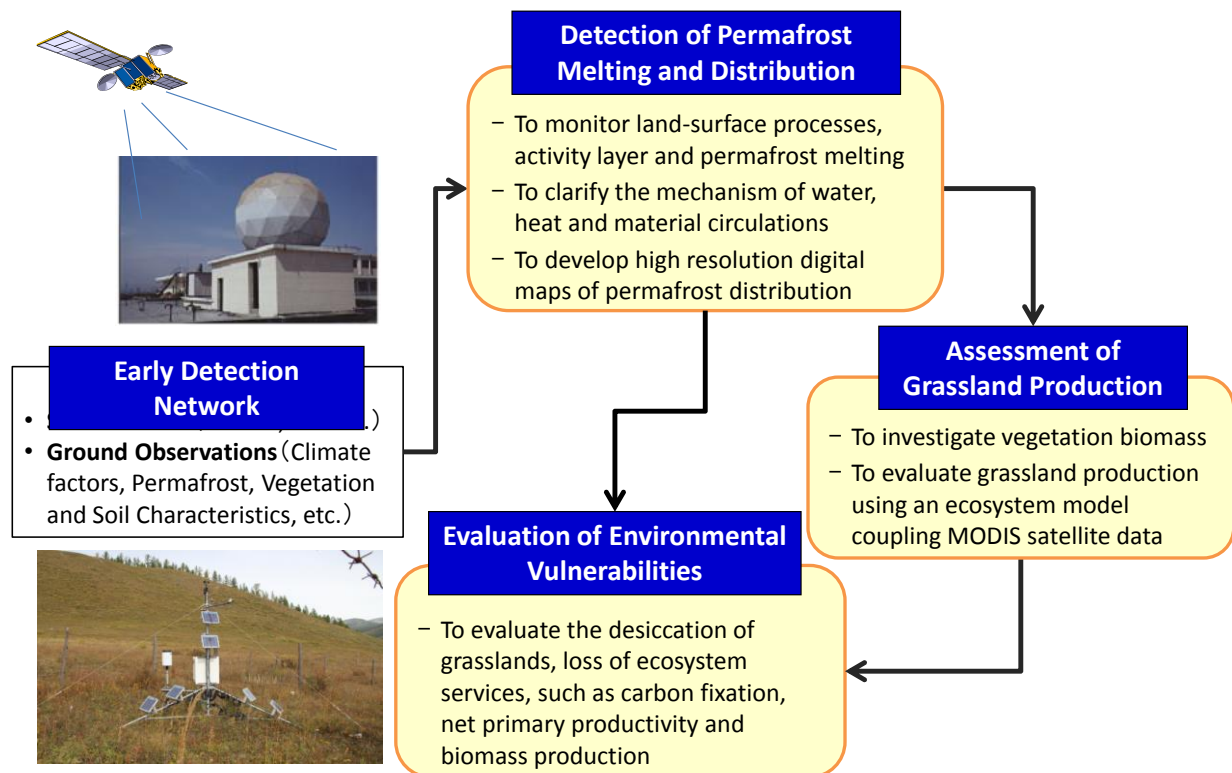


Fig.3 An evaluation system for environmental vulnerabilities caused by permafrost degradation

The data used for this system includes both satellite and field data, which will be obtained from projects (the Early Detection Network of the Global Warming Impacts) supported by the Ministry of the Environment, Japan (MOEJ). Using those data, the extent and location of permafrost degradation and accompanying environmental degradation on the Mongolian plateaus will be determined early. This early detection network consists of a combination of a satellite receiver based in the suburbs of Ürümqi, data analysis system by an independent agency known as the National Institute of Environmental Studies (NIES), and ground-based observation points in representative ecosystems. Data from this network will be used to elucidate the circulation of heat and water in the active layer above permafrost. This information will aid in the formulation of an ecosystem model on these processes.

Detection of the extent of permafrost degradation will be the first purpose of the early detection network. Satellite data from satellites such as MODIS is received by the satellite receiving station near Ürümqi. This

data is then transmitted to NIES, where it is stored in high-capacity storage devices. The ground observation stations can monitor data on meteorological factors, permafrost profiles as well as changes in land cover, biomass production, and other relevant on-site data. From these observations and site data, water and heat exchanging processes in the active layer above permafrost can be determined, and then the causes of permafrost degradation can be identified.

Mapping of the distribution of the permafrost is important in the process of determining the extent of degradation. High-capacity satellite data on land surface temperature (LST), land cover, and vegetation indices can be combined to a model to produce maps of permafrost distribution. The accuracy of the permafrost distribution map will be verified by directly testing, such as surface boring and ground-penetrating radar.

Vulnerability to permafrost degradation will be examined based on an ecosystem model. Environmental vulnerability is usually caused by the breakdown of water and heat exchanging processes. Breakdown of these cycles might affect the water storage in soil, carbon and nitrogen fixation in grassland, and the productivities in ecosystems. The ecosystem model will examine factors affecting heat, water and material circulation in the permafrost layer and evaluates the risk in different regions by simulating desiccation of grasslands, loss of ecosystem services, such as carbon fixation, net primary productivity as well as biomass production.

(2) Evaluation System for Environmental Capacity and Climate Change Adaptive Policies

The evaluation system for environmental capacity and climate change adaptive policies also consists of three parts: evaluation of environmental capacity, assessment of adaptive policies and finally policy recommendations based on these evaluations (Fig. 4). The environmental capacity of grassland will be investigated using the data collected by early detection network in addition to statistical data of social and economic factors from each municipality. The amount by which the number of cattle exceeds the carrying capacity for each municipality will be estimated, and the required efforts to reduce livestock numbers to acceptable levels will be made. The efficiency of various adaptive technologies and policies in promoting both environmental and economic sustainability will be evaluated and recommended for each municipality. The following three areas will be of particular interest: water circulation, environmental capacity, and policy recommendations for the adaptation of climate change. These areas are described in more detail as follows.

Quantifying the relationship between permafrost degradation and variations in water circulation will be accomplished using observational data on ground, satellite data from MODIS, and information from socioeconomic statistic data. A pastoral management model will be developed to analyze interactions between climatic factors, pasture conditions, and pastoral management. It will be combined with the model on permafrost degradation described earlier to evaluate the influence on pastoral productivity of variations in water circulation caused by permafrost degradation.

The next step is to estimate environmental capacity of sites in permafrost regions using the data from the combined model to calculate the variation in pastoral productivity for each municipality, taking into account the natural effects of climate change (droughts, snow damage) and socioeconomic effects (e.g., pastoral management, overgrazing). The average environmental capacity and changes in that capacity over the last 10 years can then be estimated for each region, together with the number of cows in excess of the carrying capacity.

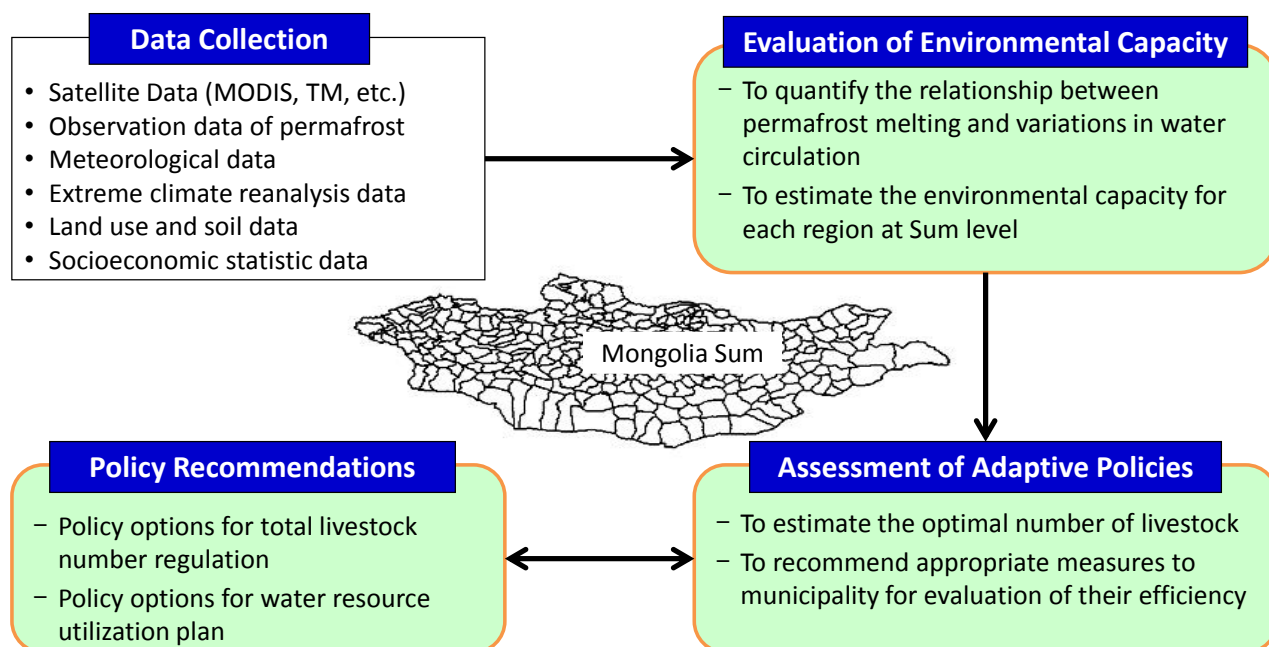


Fig.4 An evaluation system for environmental capacity and climate change adaptive policies

The last step is to develop adaptive policies for recommendation to policy makers. The environmental capacity will be estimated for each municipality. For each region, particularly the more vulnerable regions, the optimal number of cattle will be estimated, and appropriate measures will be recommended to reduce the numbers to the required density in places where the carrying capacity has been exceeded. The appropriate measures could include restrictions on introduction of cattle to certain areas, control of sales, and movement of cattle based on the amount of precipitation, expansion of grazing areas, or transfer of cattle out of the region. Economic incentives may be offered, such as early shipment, refrigerated storage, and water use technologies (e.g., ground water wells). The effectiveness of adaptive policies for each region will be determined and these policies will be amended as appropriate.

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