

Ecosystem-based  
adaptation in Temperate  
East Asia: Development of  
an indicator system for  
evaluating rural  
ecosystem restoration  
programs

CRRP2022-02MY-Shoyama

2024



Project Reference Number:

Project Duration: 2 years

Funding Awarded:

Grant DOI:

Date of Publication:

Project Leader and Contact Details:

Collaborators and Contact Details:

Recommended Citation:



Asia-Pacific Network for Global Change Research (APN)

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Project Reference Number: CRRP2022-02MY-SHOYAMA.

Project Duration: 2 years

Funding Awarded: USD 85,000

Grant DOI: <https://doi.org/10.30852/p.22117>

Date of Publication:

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- Prof. Md. Giashuddin Miah, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh (giash1960@gmail.com)

Recommended Citation:

Shoyama, K., Zhen, L., Nyamtseren, M., Liu, W.Y., Pham, T.D & Miah, M.G. (2025). Ecosystem-based adaptation in Temperate East Asia: Development of an indicator system for evaluating rural ecosystem restoration programs. Technical Report. Asia-Pacific Network for Global Change Research.

## **1. Summary**

Temperate East Asia is strongly affected by climate-related disasters such as droughts and floods, and the effects vary by country and ecosystem type. Ecosystem-based adaptation (EbA) has been implemented in a wide range of approaches to adapt to climate change, but its effectiveness needs to be more clearly tested in a social-ecological context. Ecosystem restoration (ER), the process of helping to restore degraded ecosystems, has been a human intervention to maintain ecosystem services. Many local ER projects have been implemented, particularly in East Asia, but their socioeconomic effects have not been fully quantified due to the lack of scientific evaluation based on locally validated indicator systems. This project will examine the impact of ER on rural livelihoods and ways to reduce vulnerability to climate change risks and climate-induced disasters, by increasing rural resilience in temperate East Asia. It will synthesize indicator systems from case studies of region-specific ecosystems, characterize ER in relation to exogenous and endogenous factors, and derive best practices. This comprehensive examination of ER characteristics will link local policies to international best practices. Furthermore, the evaluation framework developed in this project will contribute to better implementation of the ER process as an EbA strategy.

## **2. Objectives**

The project aims broadly to assess the effects of ER on rural livelihoods and disaster risks, and to identify the key characteristics and processes of ER that will enhance rural resilience in East Asia. Because resilience is defined as the ability of communities to cope with external risks, quantification of the impacts of hazards and exposure and vulnerability to climate-induced disasters enables us to make impact assessments of human interventions (i.e., ER against external risks). Given that ER processes influence socio-ecological systems over time, the analysis should include a comprehensive assessment over time, space and stakeholder level and take into consideration other policy effects and governance systems.

Thus, the specific objectives are to:

- (1) identify significant characteristics of ER that influence ecosystem service, including methods, duration/scales, and stakeholders
- (2) quantify the ecosystem service that are increased by ER
- (3) assess rural livelihoods and disaster risks that are improved by ER
- (4) develop policy recommendations towards better ER as an approach of EbA in East Asia.

In the COVID-19 era, unpredictable external factors (e.g., restrictions in transportation/movement, changing consumer preferences) may also affect rural areas. This concrete analysis of human activities toward EbA will contribute to building a sustainable society in Temperate East Asia, where is threatened by the climate crisis.

### 3. Outputs, Outcomes and Impacts

Outputs	Outcomes	Impacts
Database of characteristics of Ecological Restoration (ER) in East Asia.	The characteristics of ecosystem restoration (ER) in East Asia, including its objectives, methods, duration/scale, and related stakeholders, were clarified.	This project clarified the characteristics of ecosystem restoration (ER) initiatives in East Asia, including their objectives, implementation methods, duration and scale, and related stakeholders, and analyzed social factors related to rural community life, such as agriculture, forestry, fishing, and tourism, on a community-based level, and conducted evaluations using an indicator system. These studies showed how ecosystem restoration can contribute to strengthening the resilience of rural communities in various socio-ecological systems, and provided insights into how such restoration efforts should be evaluated. Furthermore, through the diverse perspectives of the project participants, new insights, knowledge gaps, and areas for future institutional reform were identified. Ecosystem degradation is causing serious economic and environmental damage in many countries, including East Asian countries. As a result, there is an urgent need for long-term efforts to restore ecosystems and maintain and improve the living environment
A community-based analytical framework and indicator systems of rural livelihood.	A community-based analysis of rural livelihoods, including agriculture, forestry, fisheries, and tourism, was conducted and evaluated using an indicator system.	
Package of tools for conducting scientific research as well as building skills/knowledge on ER assessments that contribute to decision-making.	Scientific ER assessment that contributes to decision-making was made possible by using the community-based analytical framework and indicator system.	
A database of project data and methods, peer-reviewed papers and reports, and information on project activities.	The data and results developed by the project were published in international journals so that they could be used in international processes (e.g., IPBES assessments).	
Information on how the results can be used in decision-making at various levels, from local communities to government agencies.	The results of individual projects were extended to the Asian region, and a policy brief was presented that identified priority areas for intervention through the publication of review papers.	
Education of young scholars, who will work on global environmental challenges toward future sustainability.	Young researchers at the master's degree level and above participated in the survey in individual project	

	activities and published papers as first authors and co-authors.	in rural areas. To address this issue, a long-term perspective and a robust monitoring and evaluation framework are needed.
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#### 4. Key facts/figures

- A community-based analytical framework and indicator systems of rural livelihood to assess ecosystem restoration (ER) has been produced.
- Three regional workshop (one online workshop and two in-person workshop) on ER assessment to rural livelihood in East Asia have been held to disseminate the project findings to collaborators and participants.
- 4 journal articles in high quality journal have been published.
- 5 presentations on conference have been done.
- 10 researchers from four different countries (China, Mongolia, and Vietnam) have been trained to assess the ecological restoration in East Asia.

#### 5. Publications

1. Shoyama, K., et al. (under review). Review of indicator system for evaluating rural ecosystem restoration programs in Asia. APN Science Bulletin.
2. Navaandorj, I., Tsogtbayar, E., Tsogtbaatar, S., Dashdondog, G. O., Nyamtseren, M., & Shoyama, K. (2025). Mongolian freshwater ecosystems under climate change and anthropogenic pressure: A case study of Ugii Lake. Land (accepted).
3. Nyamtseren, M., Pham, T. D., Vu, T. T. P., Navaandorj, I., & Shoyama, K. (2025). Mapping vegetation changes in Mongolian grasslands (1990–2024) using Landsat data and advanced machine learning algorithm. Remote Sensing, 17(3), 400. <https://doi.org/10.3390/rs17030400>
4. Shoyama, K., Dasgupta, R., & Estoque, R. C. (2022). Ecosystem service and land-use changes in Asia: Implications for regional sustainability. Sustainability, 14(21), 14263. <https://doi.org/10.3390/su142114263>

#### 6. Media reports, videos and other digital content

1. Project website  
<https://www.apn-gcr.org/project/ecosystem-based-adaptation-in-temperate-east-asia-development-of-an-indicator-system-for-evaluating-rural-ecosystem-restoration-programs/>
2. Video of the policy workshop in Mongolia  
<https://www.facebook.com/reel/852412833463994>

#### 7. Pull quotes

*“A clear understanding of the process from ecosystem degradation to restoration is essential for the effective evaluation of ecosystem restoration initiatives.” - Prof. Md. Giashuddin Miah, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh*

*“Evaluation indicators for ecosystem restoration projects should be carefully selected to capture ecological, economic, and social impacts, while accounting for the unique challenges and characteristics of each site.” - Dr. Lin Zhen, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, China*

*“The hydrology of Lake Ugi is notably sensitive to climate change, underscoring the need to prioritize water resource conservation in future climate adaptation strategies.” - Dr. Mandakh Nyamtseren, Institute of Geography and Geoecology, Mongolian Academy of Sciences, Mongolia*

*“The project activities in Mongolia have been deeply impactful and truly memorable. I extend my heartfelt appreciation to APN for their generous support and to the research team for their meticulous preparations.” Dr. Yunfeng Hu, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, China*

## **8. Acknowledgments**

We would like to express our sincere gratitude to the Asia-Pacific Network for Global Change Research (APN) for funding the project. Our special thanks to several researchers, government officials and nongovernmental organizations, and local farmers who participated in this project directly and indirectly by providing valuable time, experiences, and expertise including being part of the workshops and interviews conducted in this project.

## 9. Appendices

### Appendix 1: Report of the Kick-off Meeting on “Ecosystem-based adaptation in Temperate East Asia: Development of an indicator system for evaluating rural ecosystem restoration programs”

Date: March 16, 2023, 10:00-12:00 Beijing/Ulaanbaatar/11:00-13:00 Tokyo

Venue: Online

#### Participants:

- Kikuko Shoyama (College of Agriculture, Ibaraki University, Japan)
- Lin Zhen (Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences, IGSNRR-CAS)
- Mandakh Nyamtseren (Institute of Geography-Geoecology, Mongolian Academy of Sciences, IGG-MAS)
- Bolortsetseg Erdenee (IGG-MAS)
- Md. Giashuddin Miah (Bangabandhu Sheikh Mujibur Rahman Agricultural University)

#### Objective:

The meeting is organized to share the overall objectives and outline of the project and share information about each research site. In addition, the two-year activity schedule will be confirmed.

#### Agenda:

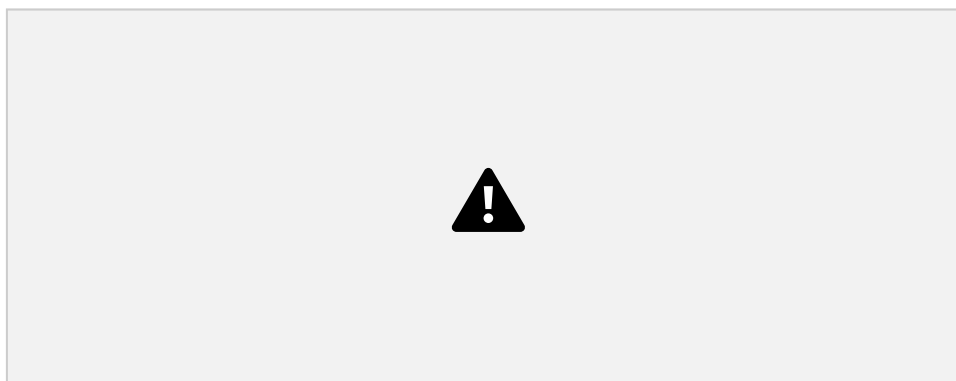
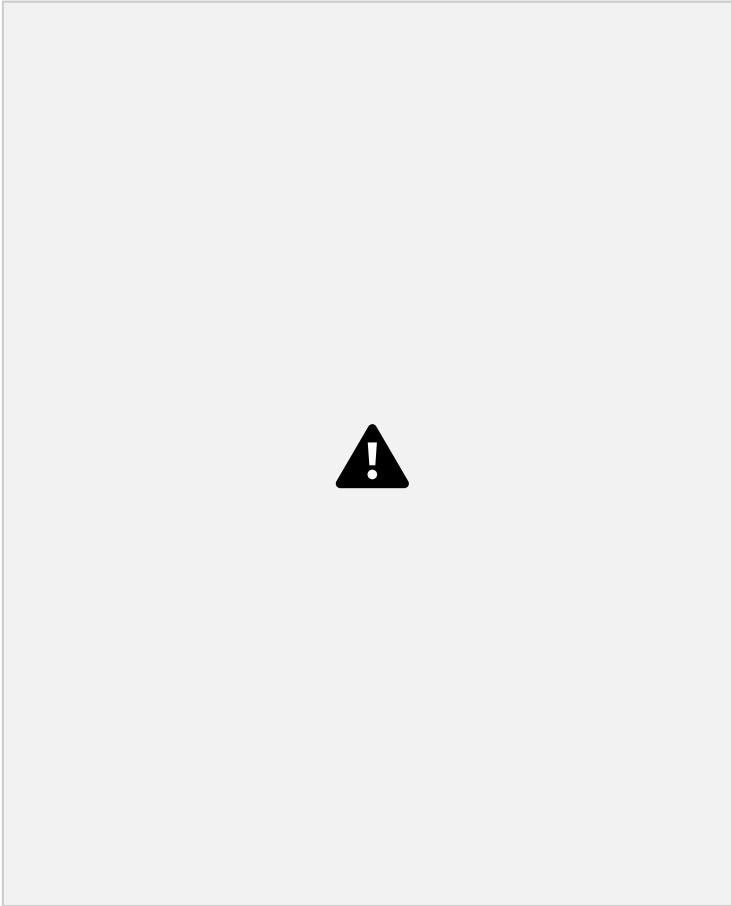
1. General introduction (Dr. Kikuko Shoyama)
2. Introduction of research sites in China (Dr. Lin Zhen)
3. Introduction of research sites in Mongolia (Dr. Mandakh Nyamtseren)
4. Introduction of research sites in Japan (Dr. Kikuko Shoyama)
5. Discussion (activity & budget plan, All participants)
6. Conclusion remarks (Professor Dr. Md. Giashuddin Miah)

#### Abstract:

At the meeting, the participants first introduced themselves and gave an overview of their projects. This was followed by presentations on the research objectives, methods and expected results of each site including (Luoyugou watershed in China's Loess Plateau in China, Lake Ugi in Mongolia, and Aso volcanic zone in Japan). Through the meeting, the participants recognized the similarities and differences between the three sites.

Based on the plenary session, the methods and approaches for ecosystem restoration (ER) and potential evaluation indicators were organized. It was agreed by the participants that effective indicators and evaluation methods for assessing the impact of ER on rural areas should be extracted through project activities. Finally, proposal and agreement were made for a two-year activity schedule.

Ecological Restoration (ER) methods and approaches:



Group photo of the online meeting; Prof.Giash (left), Prof.Zhen and Dr.Shoyama (upper), Dr. Nyamtseren and Ms. Erdenee (lower) (March 16, 2023)

All presentation materials are attached as appendix 1.

## **Appendix 2: Report of the Data Synthesis Workshop on “Ecosystem-based adaptation in Temperate East Asia: Development of an indicator system for evaluating rural ecosystem restoration programs”**

Date: October 18-19, 2023

Venue: Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences, IGSNRR-CAS, Beijing

### Participants:

- Kikuko Shoyama (College of Agriculture, Ibaraki University, Japan)
- Lin Zhen (Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences, IGSNRR-CAS)
- Mandakh Nyamtseren (Institute of Geography-Geoecology, Mongolian Academy of Sciences, IGG-MAS)
- Itgelt Navaandorj (IGG-MAS)
- Md. Giashuddin Miah (Bangabandhu Sheikh Mujibur Rahman Agricultural University)

### Objective:

The purpose of the meeting is to report on the progress at each research site and to organize and integrate evaluation indicators for the ER program.

### Agenda:

<Day1>

1. General introduction (Dr. Kikuko Shoyama)
2. Progress report from China (Dr. Lin Zhen) and Q&A
3. Progress report from Mongolia (Dr. Mandakh Nyamtseren) and Q&A
4. Progress report from Japan (Dr. Kikuko Shoyama) and Q&A
5. Data synthesis (All participants)
6. Work plan for next year (Dr. Kikuko Shoyama)

<Day2>

1. Review report status (Dr. Kikuko Shoyama) and Q&A
2. Data synthesis (Continue)
3. Discussion toward co-design and co-development of the indicator system with the stakeholders for ER assessment (activity & budget plan, All participants)
4. Overall comment and recommendations (Prof. Md. Giashuddin Miah)
5. Others (e.g., Individual consultation, Accounting)

### Abstract:

At the meeting, the objectives, activities, outputs/findings, and policy recommendations were listed based on the progress of each research case study. In the discussion, it was emphasized that a distinction should be made between environmental restoration and economic restoration, and that evaluations should reflect local issues and conditions. Furthermore, the evaluation indicators from the three sites were organized and integrated into a unified evaluation framework.

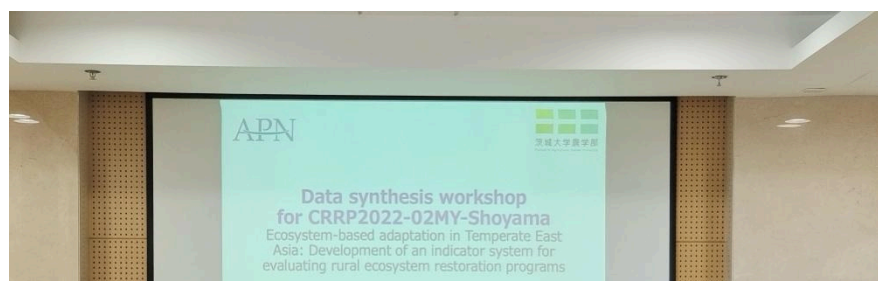
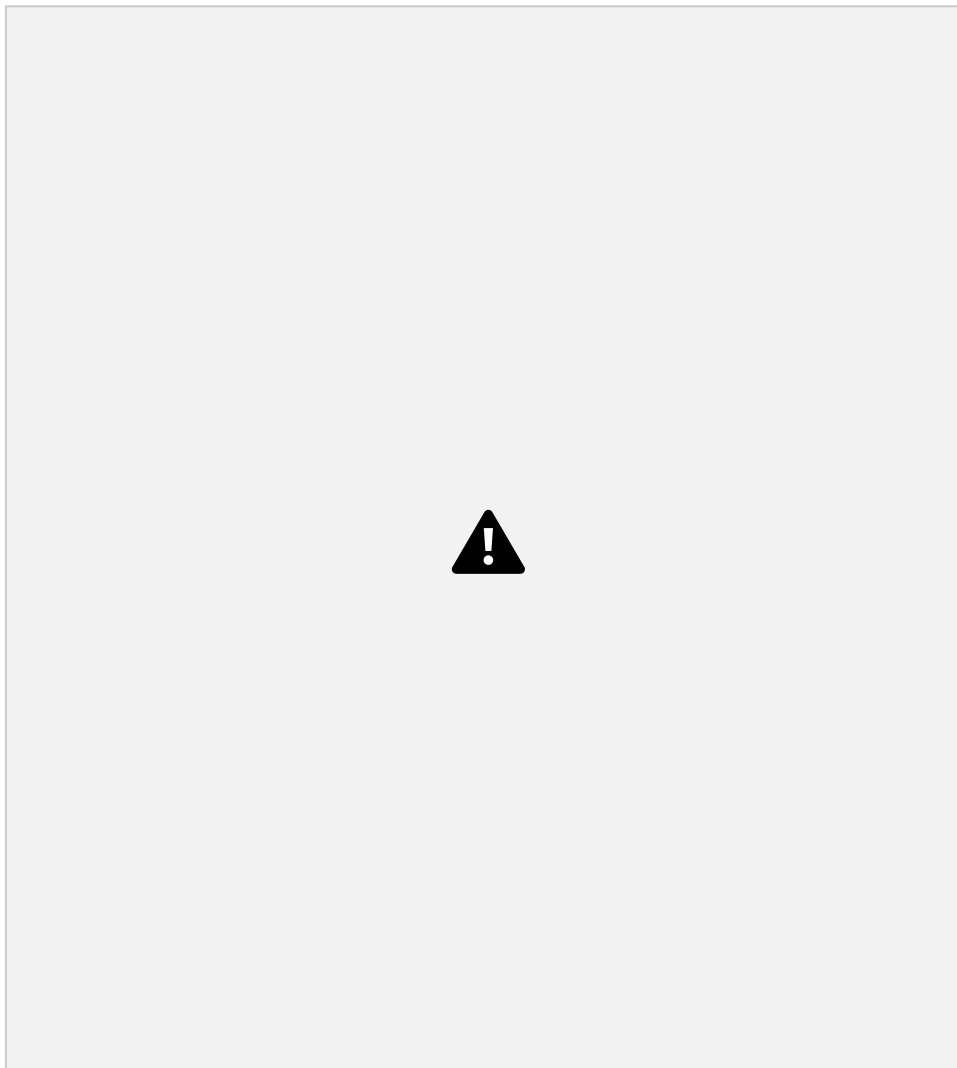
1. Indicators should be selected to reflect ecological, economic, and social effects, based on site-specific issues.
2. Climate parameters should be included to assess the impacts of climate change.
3. Pre- and post-intervention evaluations (temporal changes) should be considered.

Indicators are categorized as follows:

- (1) Ecosystem Services, including provisioning, regulating, cultural, and supporting functions; and
- (2) Livelihood Indicators, assessed at both the community and household levels, covering aspects such as education, participation, health, accessibility to social services, and multiple dimensions of security — namely food, economic, health, educational, social, and institutional security.

At the end of the meeting, it was agreed that survey activities to calculate the indicators at each site would continue, and that the schedule for the policy workshop at the Mongolian site would be confirmed.

(Example of indicators)



Group photo of the Data Synthesis Workshop (October 18-19, 2023)

All presentation materials are attached as appendix 2.

### **Appendix 3: Report of the Ugii Lake Multistakeholder Policy Workshop in Mongolia**

Date: June 5-10, 2024

Venue: Mongolia, Institute of Geography Geoecology, Mongolian Academy of Sciences (IGG-MAS) & Ugii lake information center

Participants:

- Local Herders around the Ugii Lake Watershed
- Arkhangai aimag (EPA officer from Ugii soum)
- Ch. Erdenetuya (Ugii Lake Information Center)
- Kikuko Shoyama (College of Agriculture, Ibaraki University, Japan)
- Lin Zhen (Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences, IGSNRR-CAS)
- Hu Yunfeng (IGSNRR-CAS)
- Mandakh Nyamtseren (Institute of Geography-Geoecology, Mongolian Academy of Sciences, IGG-MAS)
- Itgelt Navaandorj (IGG-MAS)
- Gerelt-Od Dashdondog (IGG-MAS)
- Md. Giashuddin Miah (Bangabandhu Sheikh Mujibur Rahman Agricultural University)

Objective: The objective is to present research findings and synthesize key outputs, as well as to develop policy briefs. A policy workshop will also be conducted with stakeholders at the study site in Mongolia.

Schedule:

June 4-5: Arrival & Pre-meetings in Ulaanbaatar  
June 6: From Ulaanbaatar to UGII lake  
June 7: Policy workshop and Project meeting  
June 8: From UGII lake to Ulaanbaatar  
June 9-10: Post-meeting & Departure from Ulaanbaatar

Abstract:

The Ugii Lake Multistakeholder Policy Workshop will be held on 7 June 2024, starting at 9:00 AM (Mongolian time) at the Ugii Lake Information Center. The workshop was conducted in English with a local interpreter and aims to bring together various stakeholders to discuss the environmental and socio-economic issues surrounding the Ugii Lake watershed.

The agenda was as follows:

- 09:20–09:40 – Project Introduction
- 09:40–10:20 – Ugii Lake and Its Environmental Issues  
(Presented by an EPA officer from Ugii soum, Arkhangai aimag)
- 10:20–10:40 – Ugii Lake Watershed Management Plan: Implementation, Progress, and Issues to Be Considered  
(Presented by Ch. Erdenetuya, Manager of Ugii Lake Information Center)
- 10:40–11:00 – Herder Livelihood and Rangeland Management in and Around the Ugii Lake Watershed  
(Presented by a representative of local herders)
- 11:00–11:30 – State of the Environment in the Ugii Lake Watershed  
(Presented by N. Mandakh, N. Itgelt, and D. Gerelt-Od)

- 11:30–12:00 – Discussion

This workshop provided an opportunity for participants to exchange views on the current challenges and strategies for sustainable watershed management in the Ugii Lake area.

Following the policy workshop, a project meeting was held in the afternoon of the day. The agenda was as follows:

- 14:00-14:10 General introduction (Dr. Kikuko Shoyama)
- 14:10-14:30 Progress report from China (Dr. Lin Zhen) and Q&A
- 14:30-14:50 Progress report from Mongolia (Dr.Mandakh Nyamtseren) and Q&A
- 14:50-15:10 Progress report from Japan and status of the review paper (Dr.Kikuko Shoyama) and Q&A
- 15:30-15:50 Short presentation by Dr. Hu Yunfeng
- 15:50-16:00 Policy brief and work plans (Dr. Kikuko Shoyama)
- 16:00-16:10 Overall comment and recommendations (Prof. Md. Giashuddin Miah)



A joint survey in the pastureland around Ugii lake (upper), and group photo and discussion session (lower) in the Multistakeholder Policy Workshop (June 7, 2024)

Workshop materials (Environmental survey results on Ugii lake) are attached as appendix 3.

#### **Appendix 4: Journal Articles**

1. Shoyama, K., et al. (under review). Review of indicator system for evaluating rural ecosystem restoration programs in Asia. APN Science Bulletin.

##### Abstract:

This study investigates the hydrological, ecological, and socio-economic re-sponses of Ugii Lake—a freshwater body in semi-arid central Mongolia—to climate variability and anthropogenic pressures. Seasonal field surveys conducted during the spring, summer, and fall of 2023–2024 revealed notable spatial and temporal variation in water quality, with pH ranging from 7.54 to 8.87, EC from 316 to 645  $\mu\text{S}/\text{cm}$ , and turbidity between 0.36 and 5.76 NTU. Total dissolved solids (TDS) values and ionic compositions indicated increased salinization in some zones, particularly those exposed to high evaporation and shoreline disturbance. Heavy metal analysis identified elevated levels of aluminum, manganese, and zinc at several sampling points; however, concentrations generally remained within national environmental standards. Vegetation surveys showed that disturbed areas—especially those affected by grazing and tourism—exhibited reduced native plant diversity and dominance of invasive species. Socio-economic interviews with local herders and stakeholders indicated that 67.3% of households experienced declining livestock productivity, and 37.1% reported increased allergies or respiratory symptoms linked to deteriorating environmental conditions. Despite some ongoing conservation efforts, respondents expressed dissatisfaction with enforcement and impact. These findings highlight the need for community-driven, integrated lake management strategies that address environmental degradation, climate adaptation, and rural livelihood security.

##### Keywords:

Ugii lake; climate change; interaction; water quality; public perception

2. Navaandorj, I., Tsogtbayar, E., Tsogtbaatar, S., Dashdondog, G. O., Nyamtseren, M., & Shoyama, K. (2025). Mongolian freshwater ecosystems under climate change and anthropogenic pressure: A case study of Ugii Lake. *Land* (accepted).

##### Abstract:

This study investigates the hydrological, ecological, and socio-economic responses of Ugii Lake—a freshwater body in semi-arid central Mongolia—to climate variability and anthropogenic pressures. Seasonal field surveys conducted during the spring, summer, and fall of 2023–2024 revealed notable spatial and temporal variation in water quality, with pH ranging from 7.54 to 8.87, EC from 316 to 645  $\mu\text{S}/\text{cm}$ , and turbidity between 0.36 and 5.76 NTU. Total dissolved solids (TDS) values and ionic compositions indicated increased salinization in some zones, particularly those exposed to high evaporation and shoreline disturbance. Heavy metal analysis identified elevated levels of aluminum, manganese, and zinc at several sampling

points; however, concentrations generally remained within national environmental standards. Vegetation surveys showed that disturbed areas—especially those affected by grazing and tourism—exhibited reduced native plant diversity and dominance of invasive species. Socio-economic interviews with local herders and stakeholders indicated that 67.3% of households experienced declining livestock productivity, and 37.1% reported increased allergies or respiratory symptoms linked to deteriorating environmental conditions. Despite some ongoing conservation efforts, respondents expressed dissatisfaction with enforcement and impact. These findings highlight the need for community-driven, integrated lake management strategies that address environmental degradation, climate adaptation, and rural livelihood security.

Keywords:

Ugii lake; climate change; interaction; water quality; public perception

3. Nyamtseren, M., Pham, T. D., Vu, T. T. P., Navaandorj, I., & Shoyama, K. (2025). Mapping vegetation changes in Mongolian grasslands (1990–2024) using Landsat data and advanced machine learning algorithm. *Remote Sensing*, 17(3), 400. <https://doi.org/10.3390/rs17030400>

Abstract:

Grassland ecosystems provide a range of services in semi-arid and arid regions. However, they have significantly declined due to overgrazing and desertification. In the current study, we employed Landsat time series data (TM, OLI, OLI-2) spanning from 1990 to 2024, combined with vegetation indices such as NDVI and SAVI, along with NDWI and digital elevation models (DEMs), to analyze land cover dynamics in the Ugii Lake watershed area, Mongolia. By integrating multisource remote sensing data into the advanced XGBoost (extreme gradient boosting) machine learning algorithm, we achieved high classification accuracy, with overall accuracies exceeding 94% and Kappa coefficients greater than 0.92. The results revealed a decline in montane grasslands (−6.2%) and an increase in other grassland types, suggesting ecosystem redistribution influenced by climatic and anthropogenic factors. Cropland exhibited resilience, recovering from a significant decline in the 1990s to moderate growth by 2024. Our findings highlight the stability of barren land and underscore pressures from ecological degradation and human activities. This study provides up-to-date statistical data to support decision-making in the conservation and sustainable management of grassland ecosystems in Mongolia under changing climatic conditions.

Keywords:

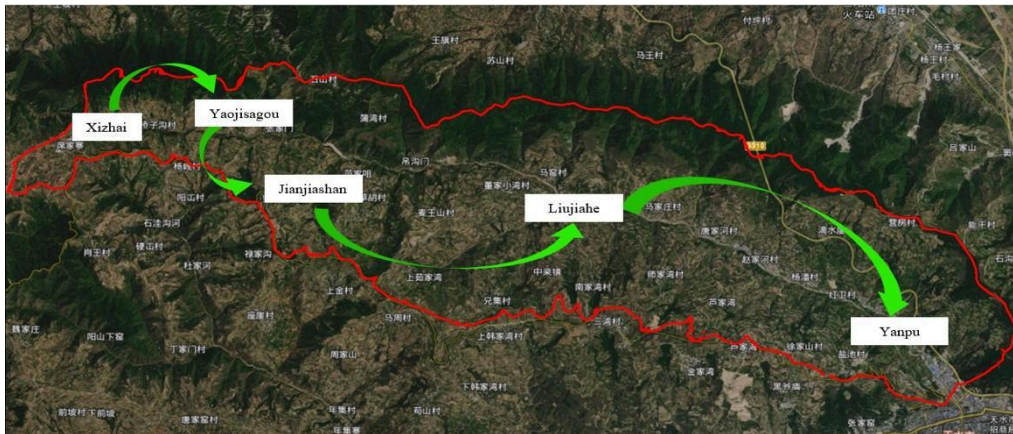
grassland; remote sensing; Landsat; XGBoost; Mongolia; vegetation change

Publications are attached as appendix 4.

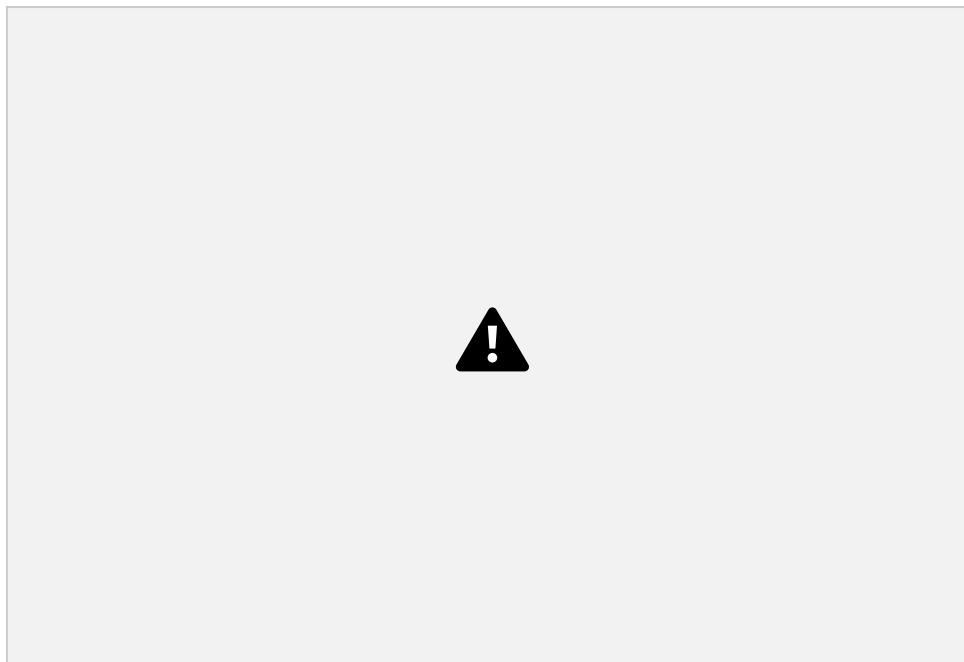
Appendix 5: Photos of field surveys in Luoyugou watershed in China



Photos of key informant interview



The route of household survey



Household questionnaire surveys

Appendix 6: Photos of field surveys in Ugii lake in Mongolia



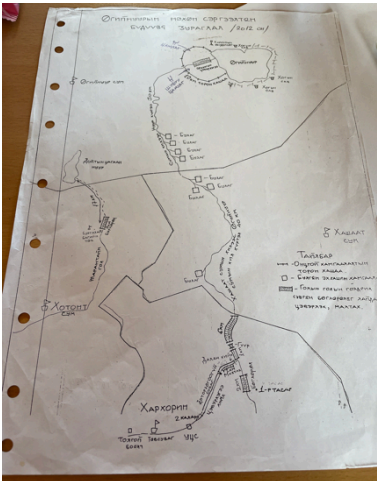
Location of the site



Fencing to limit road impact to the lake



Water channel to divert water flow

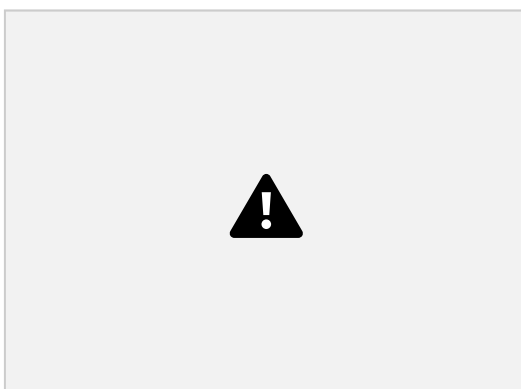


Ecosystem Restoration Plan Map

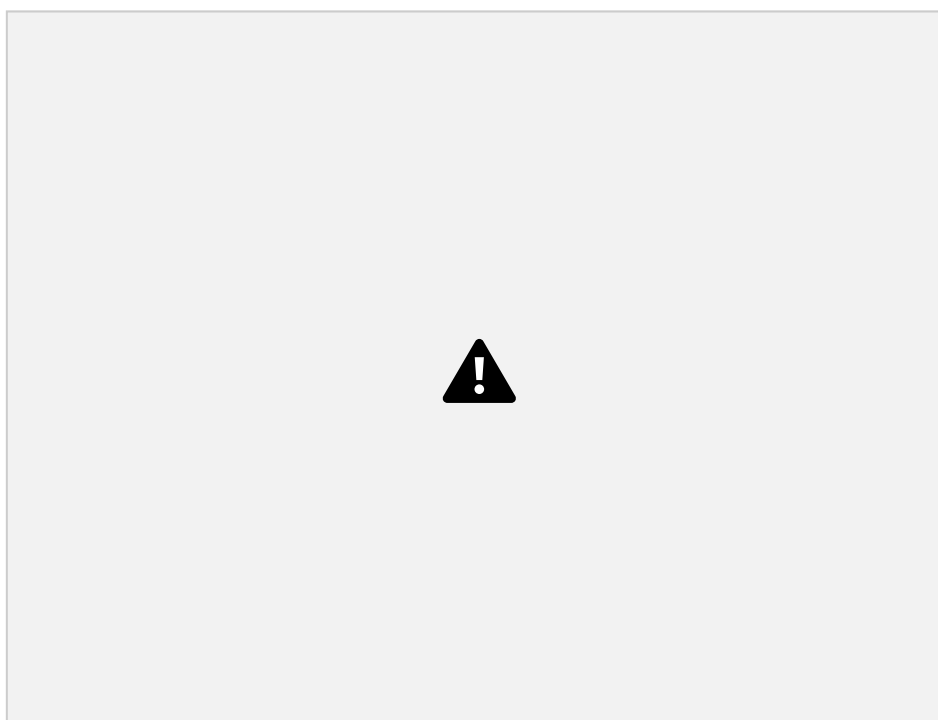


Household questionnaire surveys

**Appendix 7: Photos of field surveys in Aso volcano in Japan**



Land conversion from grassland to crop field (left) and geographical environment (right)



Photos of Grassland management workshop in May 2024

## **Appendix 8: List of young researchers**

1. Young researchers and students involved in the China case study
  - Dr. Shuang Wang (PhD student in IGSNRR-CAS, China)
  - Dr. Yexuan Liu (PhD student in IGSNRR-CAS, China)
  - Associate Prof., Dr. Zhichao Xue (Expert on soil erosion model application training in IGSNRR-CAS, China)
  - Ms. Xintao Liu (PhD student in IGSNRR-CAS, China)
  - Mr. Saw Yan Naing (PhD student in IGSNRR-CAS, China)
  
2. Young researchers and students involved in the Mongolia case study
  - Ms. Itgelt Navaandorj (Botanist, Research staff in IGG-MAS, Mongolia)
  - Ms. Erdenetsetseg Tsogtbayar (Chemist, Research staff in IGG-MAS, Mongolia)
  - Ms. Solongo Tsogtbaatar (Economist, Research staff in IGG-MAS, Mongolia)
  - Ms. Gerelt-Od Dashdondog, (Hydro-chemist, Research staff in IGG-MAS, Mongolia)
  
3. Young researcher involved for Synthesis Analysis
  - Dr. Thuy Thi Phuong Vu (Researcher in Forest Inventory and Planning Institute (FIPI), Ministry of Agricultural and Rural Development (MARD), Vietnam)

## Appendix 9: List of conference presentation

1. Title: Land use scenario analysis for disaster risk reduction with the protective action decision process  
Presenter: Kikuko Shoyama  
Conference name: EcoSummit 2023  
Venue and time: Gold Coast, Australia, June 2023
2. Title: Application of ecological restoration technologies and assessment of the effects in Luoyugou watershed of the Loess Plateau  
Presenter: Ms Yexuan Liu  
Conference name: China Natural Resources Science Conference.  
Venue and time: Nanning city of Guangxi Province, November 2023
3. Title: Land Degredation and Water Use Controversy  
Presenter: Mandakh N, Solongo Ts, Itgelt N.  
Conference name: 3th Asia International Water Week Enhancing Our Future Water Security  
Venue and time: Beijing, China, September 2024
4. Title: Water chemistry of Ugii Lake  
Presenter: Gerelt-Od D., Erdenetsetseg Ts., Mandakh N., Byambasuren Z., Erdenetuya Ch.  
Conference name: Water science and engineering 2024  
Proceedings of the conference., pp. 117-122.
5. Title: Pastoralism in Mongolia and challenges in rangeland governance  
Presenter: N.Mandakh, Ts.Solongo, B.Uyanga  
Conference name: Environmental science and technology 4th International conference  
Venue and time: Ulaanbaatar, Mongolia, August, 2023

