# Terrestrial and Coastal Ecosystem management for Carbon Sequestration using GOSAT satellite

中央大学 CHUO UNIVERSITY — Knowledge into Action —
Yoko Saito

## *Our Research in Mongolia to Eastern Europe and Central Asia*

| Prediction | Intervention | Carbon Monitoring & Finance |
|---|---|---|
| **Early Warning System** | **Solar-Powered Freezing System** | **SOC with satellite-based GHG observation** |
| **Zud Risk Prediction**<br>Model-derived Vulnerability index and Information Dissemination | **Livestock Population Management**<br>Optimize herd size before winter through early shipment and market sales | **GOSAT Satellite-Enhanced SOC Monitoring for Desertification Prevention**<br>Support landscape-scale SOC monitoring beyond the coverage of ground-based measurements |
| **GOSAT Satellite-Enhanced SOC Monitoring for Desertification Prevention**<br>Monitoring SOC to maintain grazing within carrying capacity limits and prevent desertification | **Value-Added Meat Storage**<br>Increase income through frozen meat storage and strategic sales | **Carbon Finance Readiness**<br>Enable future carbon financing by monitoring SOC gains through scalable and transparent observation systems |

## Possible Carbon Sequestration Pathways in Eastern Europa and Central Asia using GOSAT satellite

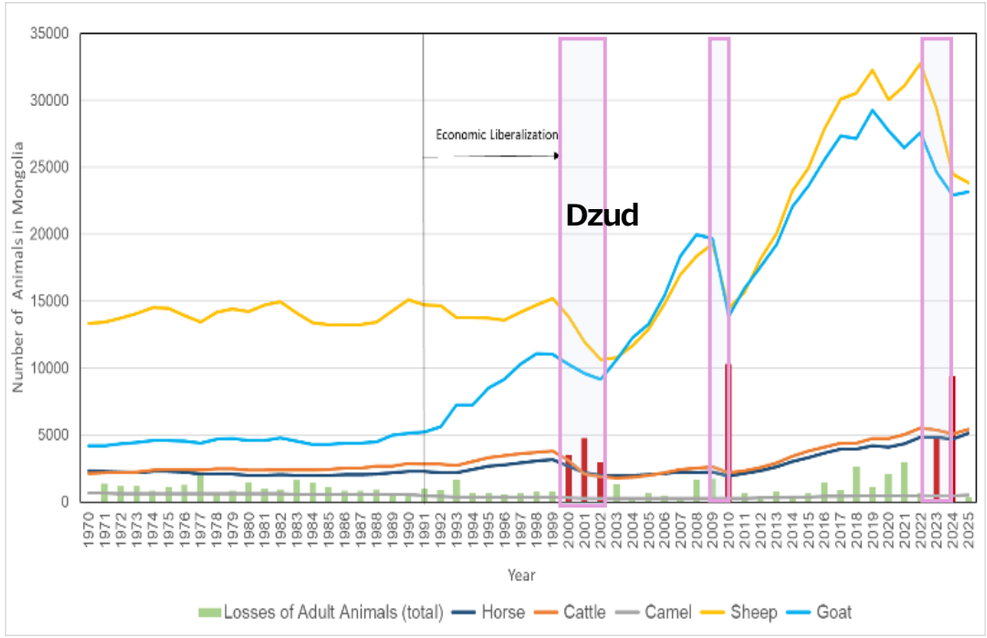
| | | |
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| **Pasture Management**<br>Grazing intensity control<br>Livestock management<br>Prevention of desertification | **Cropland Management**<br>Biochar incorporation | **Caspian Coastal Ecosystems**<br>Sea level restoration<br>Blue carbon enhancement |

# Early Warning System for Dzud

## Dzud in Mongolia

Dzud is a unique disaster in Mongolia that occurs when livestock populations exceed the carrying capacity and summer droughts are followed by extreme winter cold and heavy snowfall. This combination prevents livestock from accessing grazing land, leading to massive animal deaths and devastating the livelihoods of nomadic herders.

Figure. Livestock Populations and Zud Disasters in Mongolia




## EWS

- Early Observation Network
- Socioeconomic Statistical Data
- MapGIS Data
- Met data
- Weather Forecast NOAA-NCEP
- Satellite Observation Data

→ Dzud Prediction Algorithm

→ **Zud Risk Prediction**
including temperature, precipitation, above biomass, hay preparation and vulnerability index

- Pasture Vegetation
- Snow Cover
- Meat Market

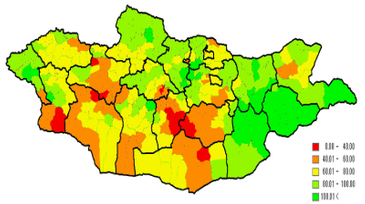
### Providing Information to Herders (Mobile Network)



- Zud-Affected Areas
- Snow-Free Areas
- Vegetation biomass
- Market Prices

### Providing Information to Soum Governors (Web GIS-Based Information)





# Solar-Powered Freezing System

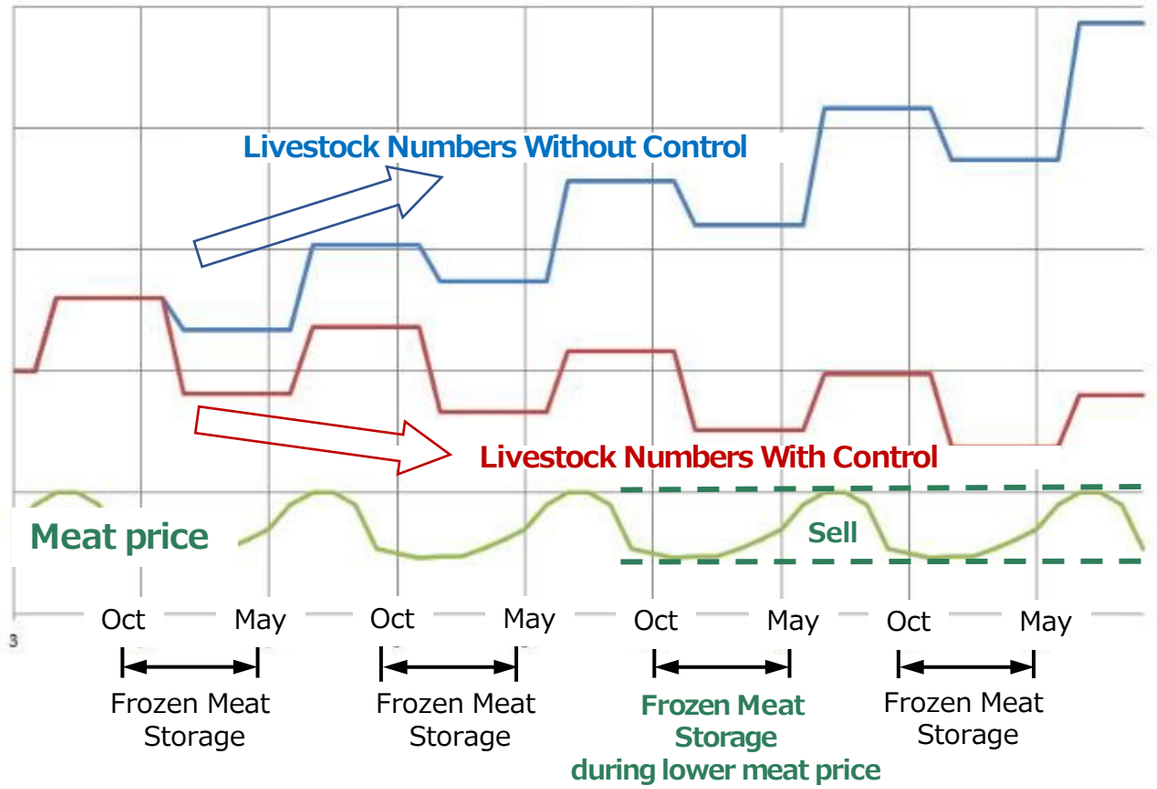
**Solar-Powered Freezing System** is a solution designed to reduce the impacts of zud disasters by enabling herders to adjust livestock numbers in fall and preserve the meat through freezing. Powered by solar energy, the system can operate in remote rural areas, allowing herders to avoid selling large numbers of animals at low prices and instead market the meat in spring when prices are higher. **As a result, the system helps livestock populations converge toward the carrying capacity of rangelands, promotes recovery of degraded grasslands, stabilizes meat prices and quality, and supports more stable incomes for herders.**



Figure. Demonstration of a Solar-Powered Freezing System in Mongolia



Figure. Sheep Meat Freezing Storage Test in Mongolia



# Inversion Analysis to Estimate CO2 Emissions and Absorptions

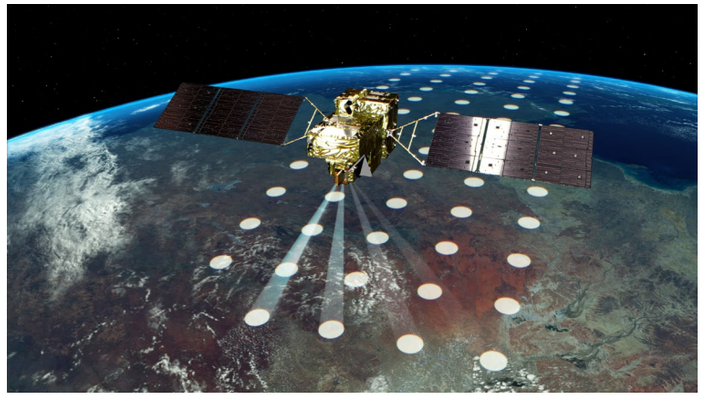
## Approach

We developed the model to estimate posterior emissions volumes of a GHG emissions inventory by inverse analysis based on the Green Function using GOSAT-series satellite observation results

## Satellite-based observations

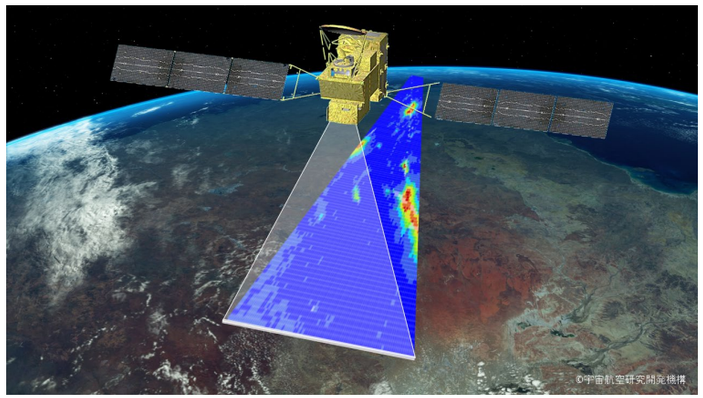
**GOSAT-1&2**

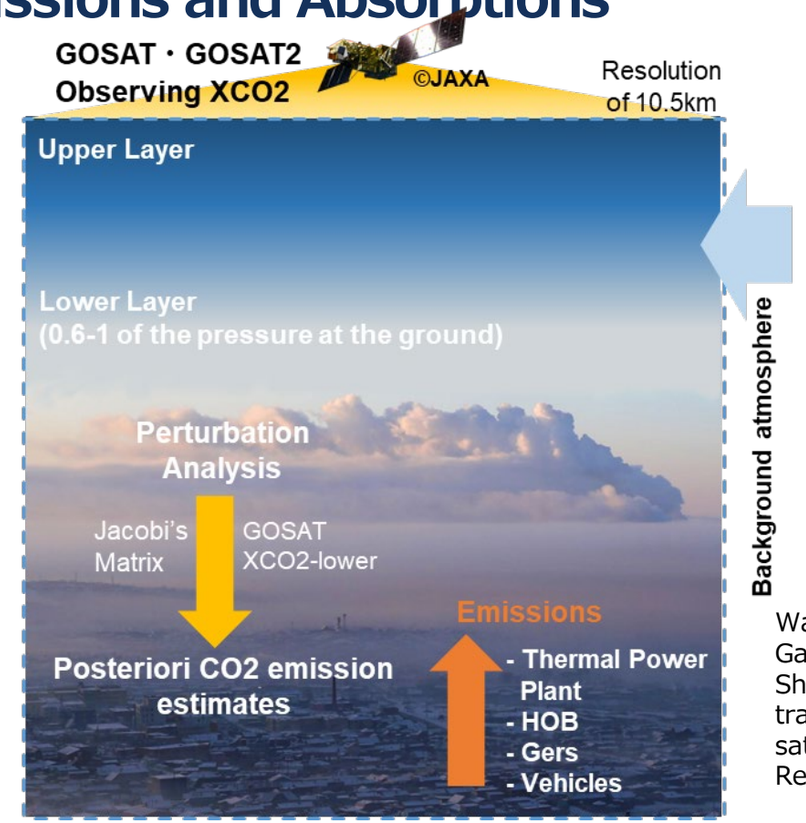
Point-based observation with 10km resolution



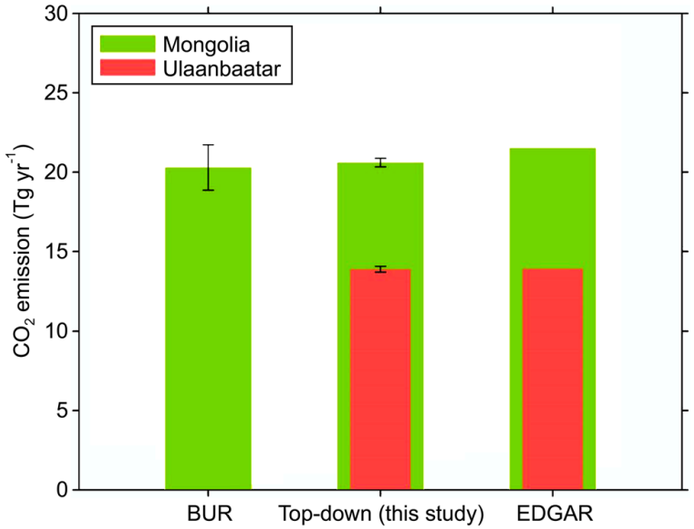
**GOSAT-GW**

Surface-based observation over 90km swath with 3km resolution






Watanabe, M., Oba, A., Saito, Y., Purevjav, G., Gankhuyag, B., Byamba-Ochir, M., Zamba, B., & Shishime, T. (2023). Enhancing scientific transparency in national $CO_2$ emissions reports via satellite-based a posteriori estimates. Scientific Reports, 13, 15427.




## Comparison of Mongolia's GHG inventory and satellite-based estimation

Comparison of Mongolia's bottom-up and top-down energy sector CO2 emissions in 2018.
Mongolia's CO2 emissions
(in Tg yr−1) for BUR, top-down estimates, and EDGAR.

# GOSAT satellite-based GHG emission estimation in Central Asia

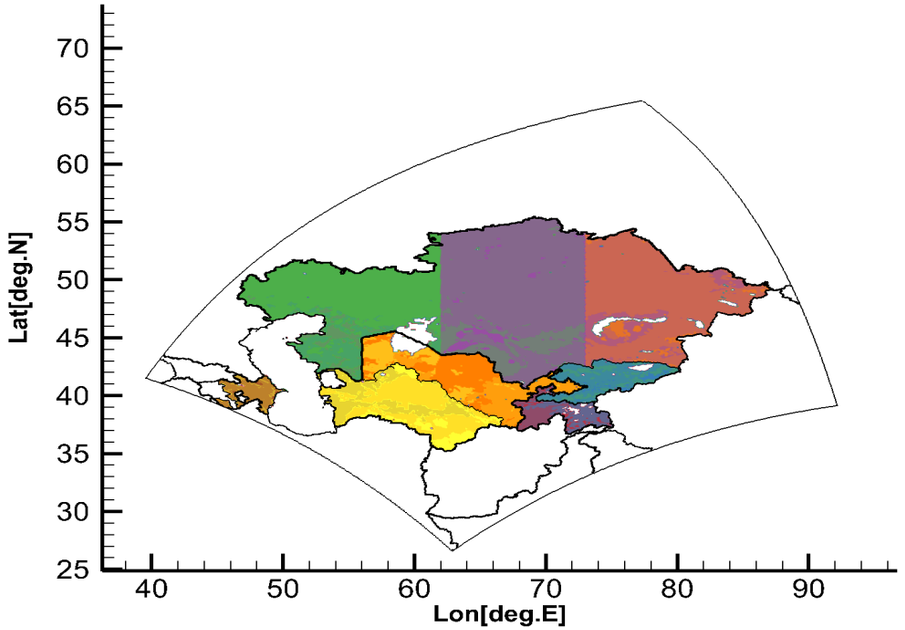
Under the MoU, Chuo University supports Central Asian countries in BTR preparation by providing GHG emission estimates derived from GOSAT observations.

## Comparison with the National GHG Inventory in BTR1

| Gg-$CO_2$ [2021] | Kazakhstan | | Kyrgyzstan | | Tajikistan | | Turkmenistan | | Uzbekistan | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NI [BTR1] | Our Study | NI [BTR1] | Our Study | NI [BTR1] | Our Study | NI [BTR1] | Our Study | NI [BTR1] | Our Study |
| **Anthropogenic Emissions** | **244,904** | **221,877** | **11,164** | **11,232** | **9,713** | **9,771** | **69,489** | **36,033** | **139,235** | **127,255** |
| Agreement (%) | 90.6 | | 100.6 | | 100.6 | | 51.9 | | 91.4 | |

### Approach

We applied the same satellite-based inverse modeling framework as used in Mongolian case study, Watanabe et al. (2023) to estimate national anthropogenic $CO_2$ emissions in Central Asia. Kazakhstan was divided into three inversion domains, whereas Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan were each treated as a single domain. Posterior emission estimates were then compared with the National GHG Inventories reported in BTR1.




Estimation domain

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# Blue Carbon in the Caspian Sea

Figure. Global averages for carbon pools (soil organic carbon and living biomass) of focal coastal habitats. Tropical forests are included for comparison. Only the top meter of soil is included in the soil carbon estimates (Murray et al., 2011)

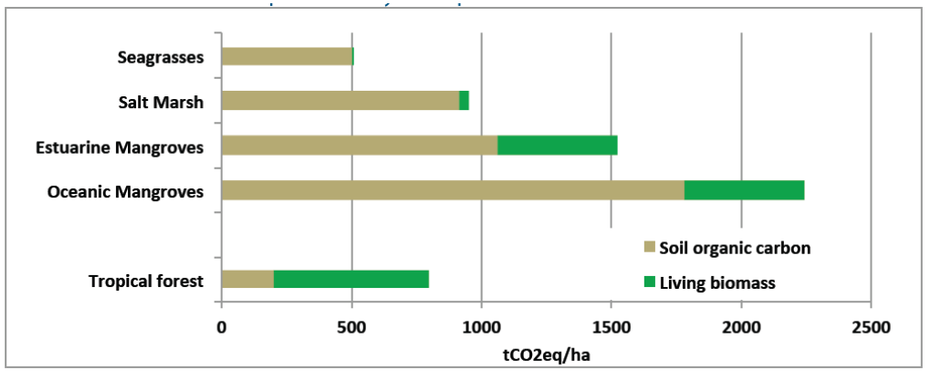
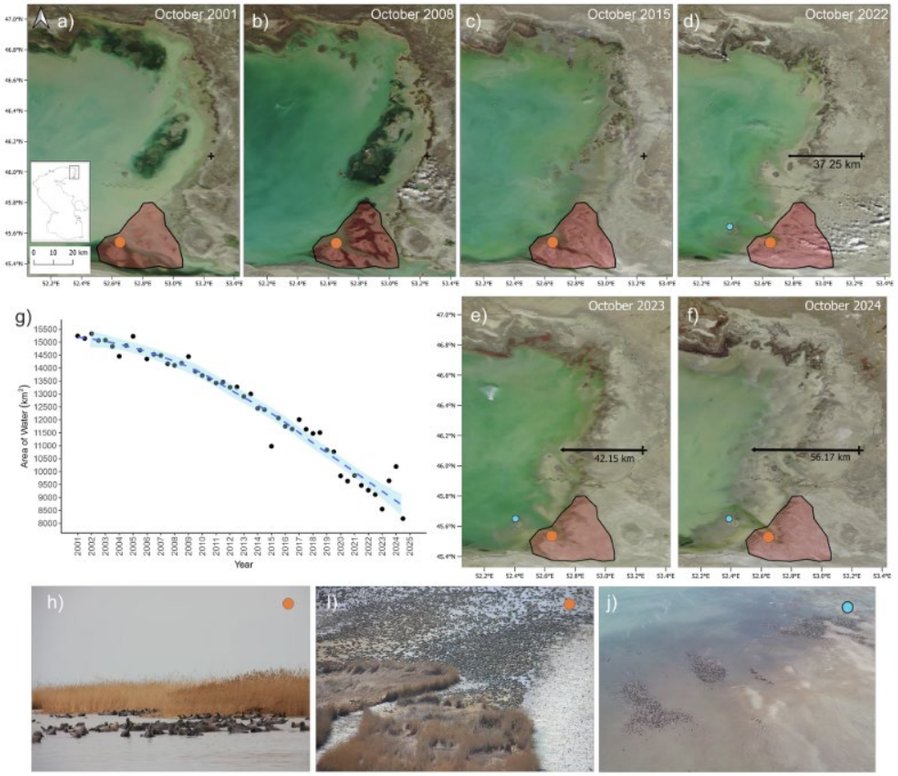



Figure. Coastal regression in the northeastern Caspian Sea (Court et al., 2025)




## Coastal vegetated habitats store substantially more soil carbon than tropical forests

Blue carbon, the carbon captured and stored by coastal marine vegetation such as mangroves, seagrasses, and salt marshes, is known to constitute a carbon sink comparable in magnitude to that of terrestrial ecosystems. In particular, shallow coastal waters where sunlight reaches the seafloor and supports the growth of seagrasses and macroalgae serve as important sinks for atmospheric $CO_2$. These ecosystems continuously accumulate carbon in both biomass and sediments, thereby contributing to long-term carbon sequestration. **Soil organic carbon represents by far the largest carbon pool in coastal ecosystems** (Murray et al., 2011; see figure above).

## Caspian Sea level decline

In the northeastern Caspian Sea along the coast of Kazakhstan, the extent of surface water has decreased by approximately **7,000 km² (46%) between 2001 and 2024**, resulting in the shrinkage and loss of coastal reed beds, salt marshes, lagoons, and shallow wetlands (see figure bottom). As these ecosystems become exposed and transition into steppe or desert habitats due to ongoing water-level decline, not only is their capacity for carbon sequestration and storage reduced, but organic carbon that has accumulated in sediments over long periods may also be released back into the atmosphere. Consequently, **efforts to halt or mitigate the shrinking of the Caspian Sea are important not only for conserving biodiversity and maintaining ecosystem functions, but also for preserving and restoring valuable blue carbon resources.**

# GCF FP154 in Mongolia

## Mongolia: Aimags and Soums Green Regional Development Investment Program (ASDIP)

Portfolio and impact / Projects

### Mongolia: Aimags and Soums Green Regional Development Investment Program (ASDIP)

Cross-cutting | Under implementation

| | |
|---|---|
| Date approved | 19 Mar 2021 › |
| Est. completion | 23 Jan 2035 |
| ESS Category | Category B |
| Financing | Public sector |
| Entity | Asian Development Bank › |




Total project value

**$735m**

In Mongolia average temperatures have risen by 2.1°C over the past 70 years. Average rainfall is declining, and extreme weather events are more frequent. This poses challenges to livestock production and managing the country's vast pasturelands, which are already fragile due to decades of unsustainable herding practices.

This project addresses Mongolia's rangeland degradation and overgrazing. It will do this by building climate-resilient and low-carbon cities that provide adequate services to attract private sector investments to support local agribusiness. Other measures include supporting herder groups to manage the rangelands sustainably by limiting the number of grazing animals, and strengthening agribusiness value chains.

*https://www.greenclimate.fund/portfolio/projects/fp154*