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Socio-economic and climate drivers of land use and land cover changes in Mongolia

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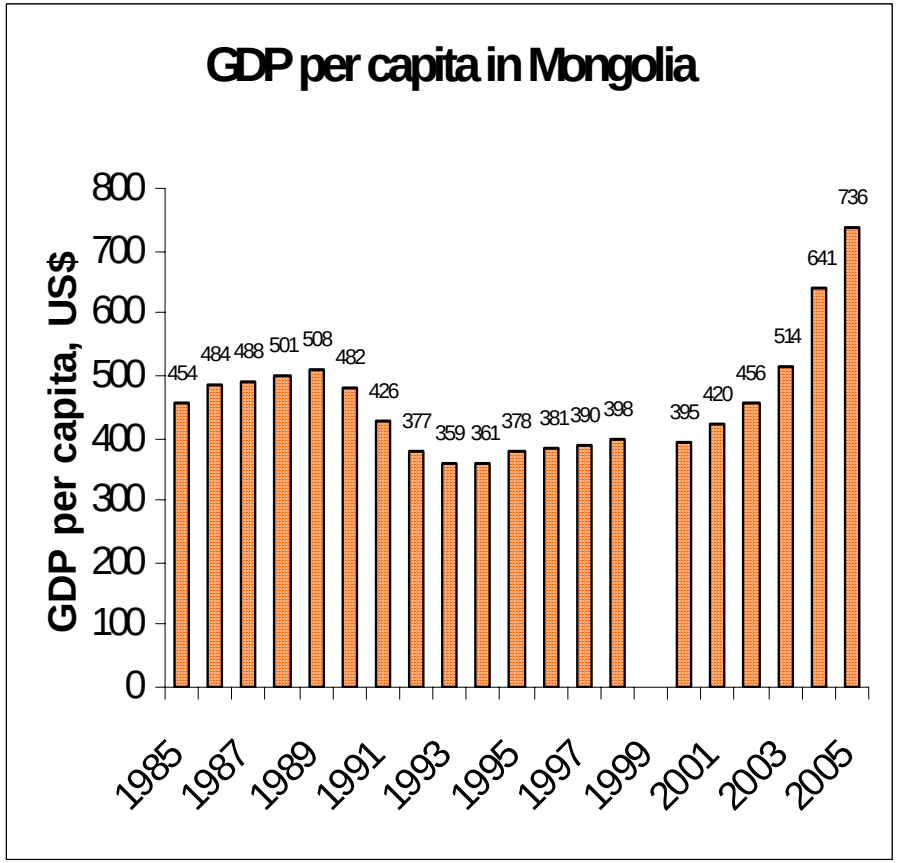
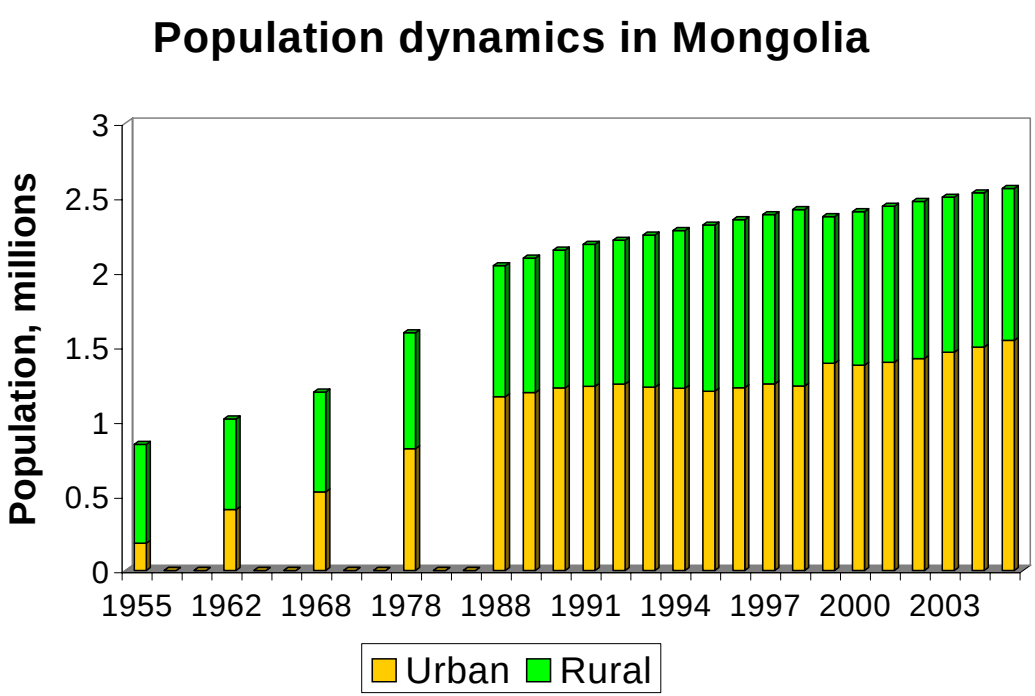
National University of Mongolia

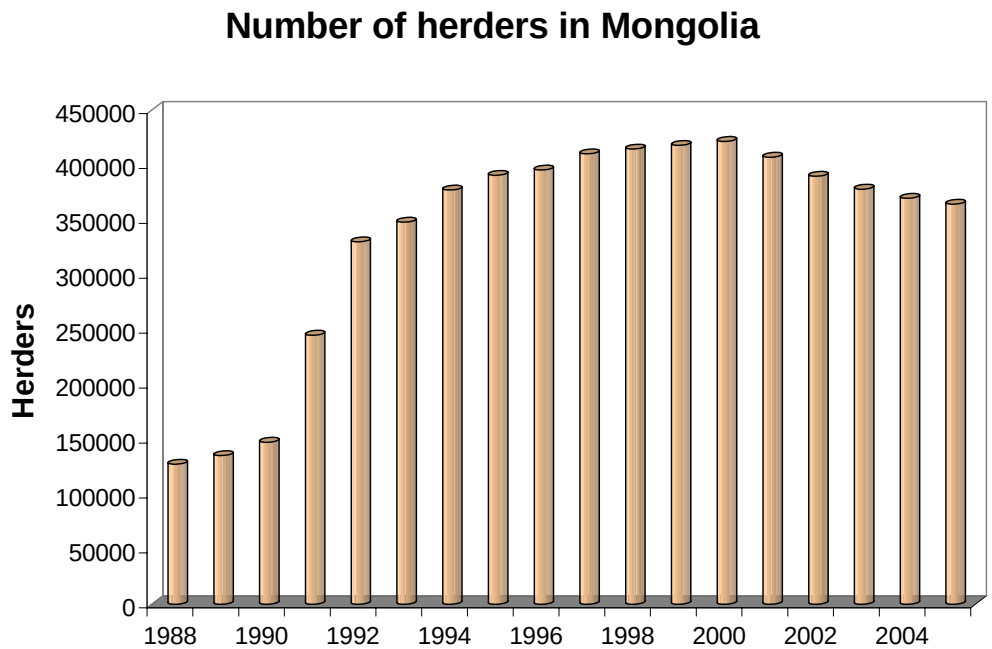
Socio-economic transitional dynamics

Mongolia started its transition to market economy since 1990. GDP per capita dropped during early 1990s, then it started to recover slowly until 2003. Last few years sharp increase of GDP per capita was caused by global market price increase of copper and gold, main exports of Mongolia in addition to cashmere.



Population growth was relatively high until early 1990 (with about 2.8%), however, it decreased by about twice since transition to market economy. The urban population started to over-exceed the rural population in mid 1970s. The rural population slightly increased during early 1990s, when a privatization of livestock occurred. Afterwards, the rural population is decreasing with increased rural to urban migration, which intensified after 1999-2002 *zuds*.



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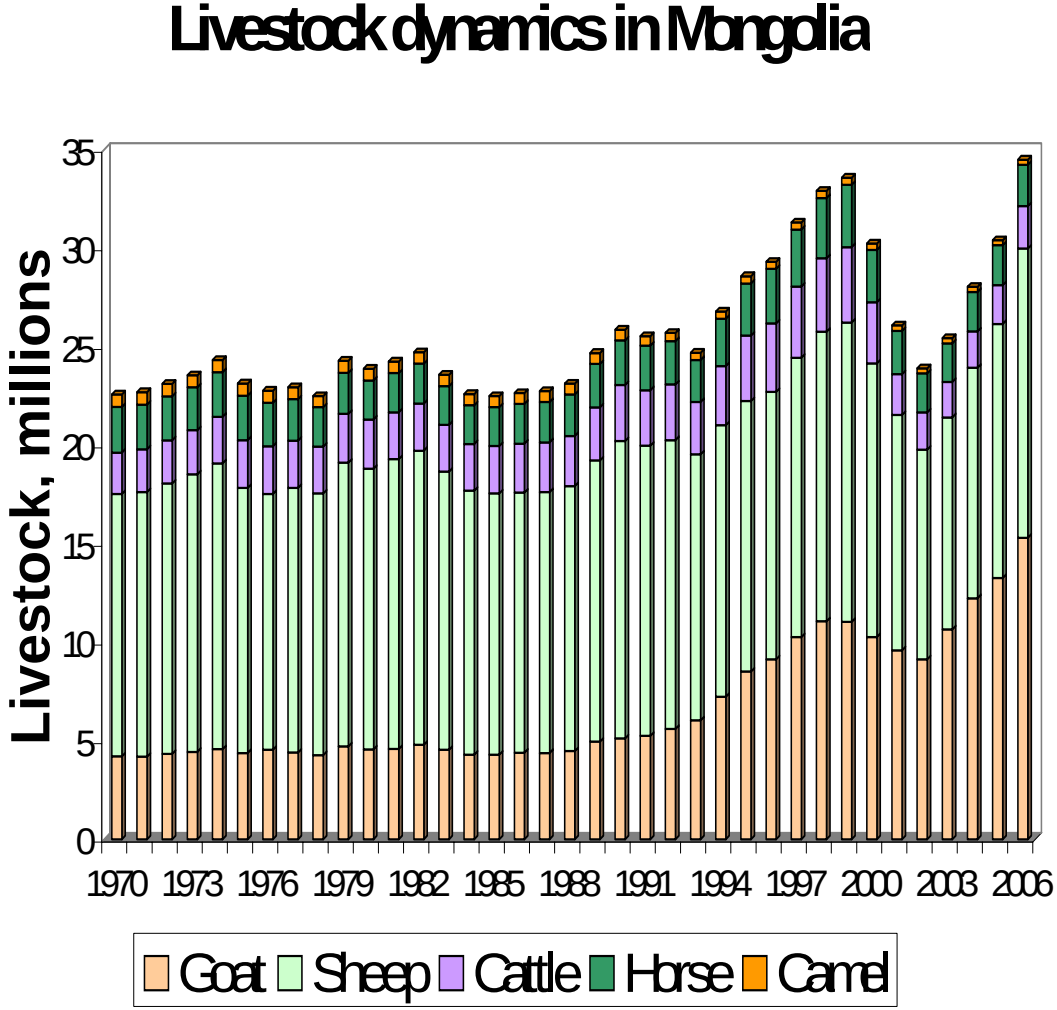
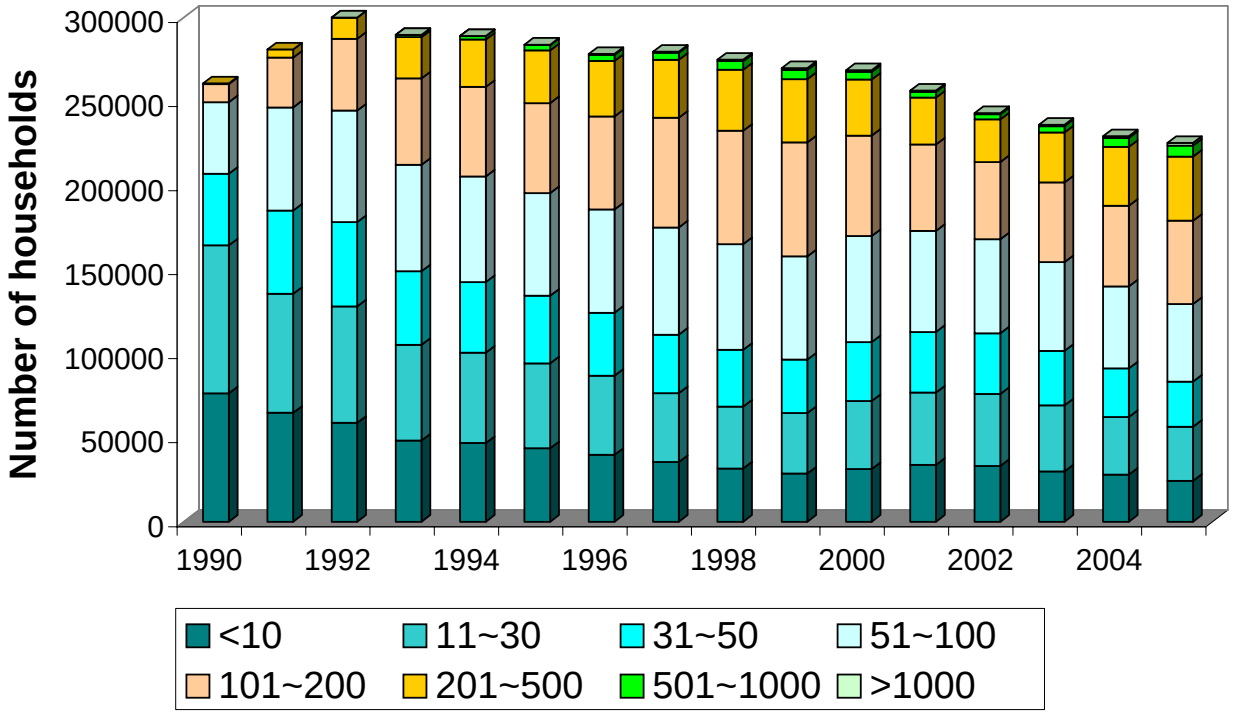
Livestock numbers in Mongolia were relatively stable before the transition to market economy, oscillating around 20-25 million. The goat to sheep ratio was 1:4 as in traditional herding practices. However, the goat number tripled since 1990 due to cashmere value. Livestock reduced back to the stable level after the 1999-2002 *zuds*, however, its number has reached almost 35 million by the end of last year.

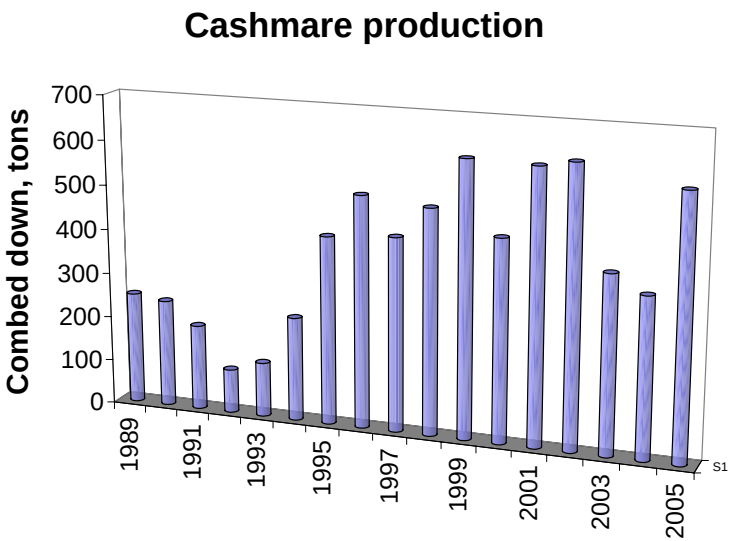


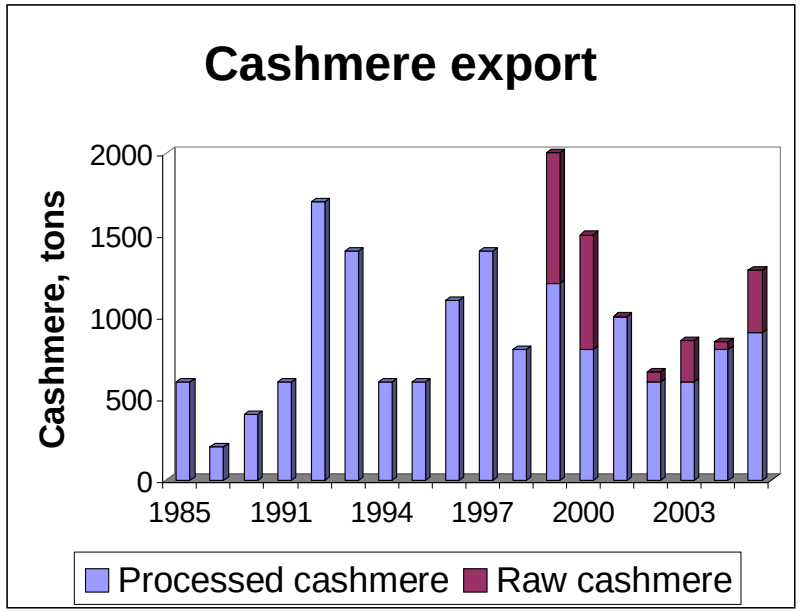
Households with livestock in Mongolia

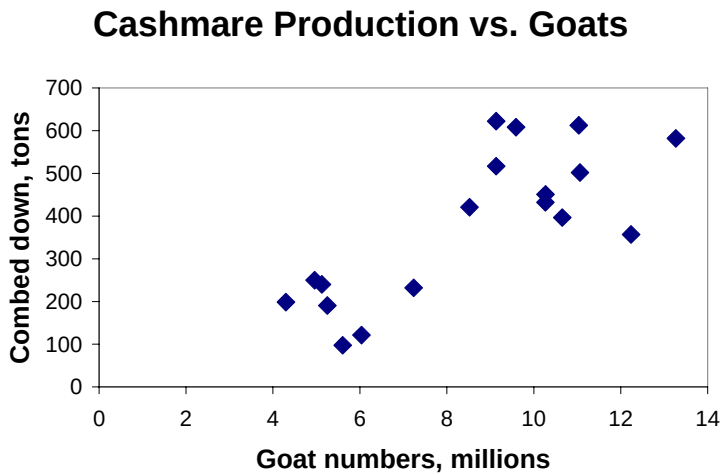


The households with fewer than 100 livestock (poor class) was shrinking since 1990. The middle class with livestock between 200 and 500 is building up, reaching about 20% of all households by 2005. The wealthy class is also growing, reaching almost 5% of the herders' households.

Cashmere production

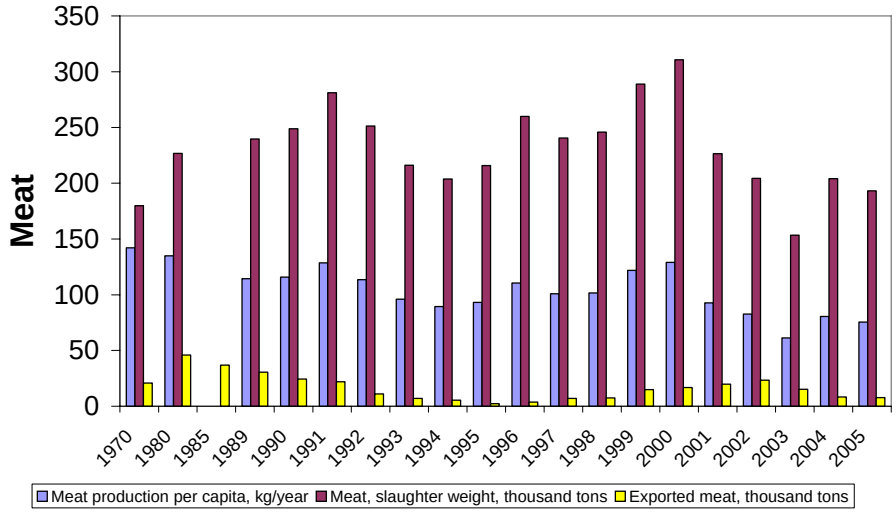






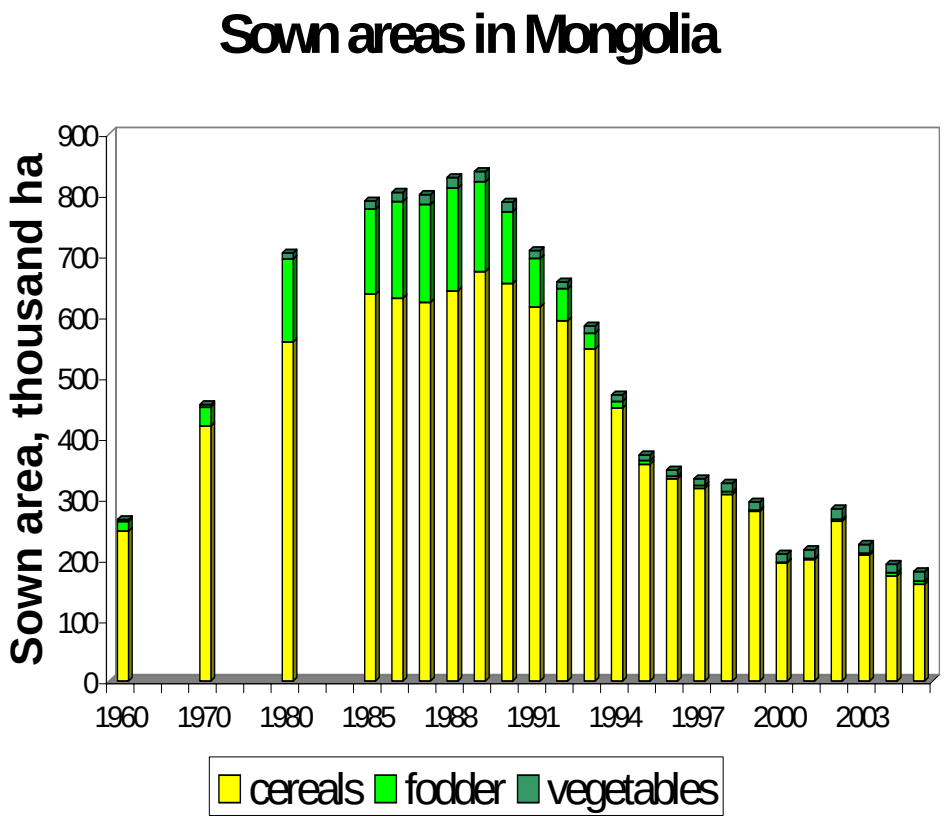
- Cashmere production increased after privatization of livestock during 1992-1996
- However, cashmere production and exported cashmere don't have any correlation with continued goat increase after it's number reached 9 million in 1996

Meat production and export

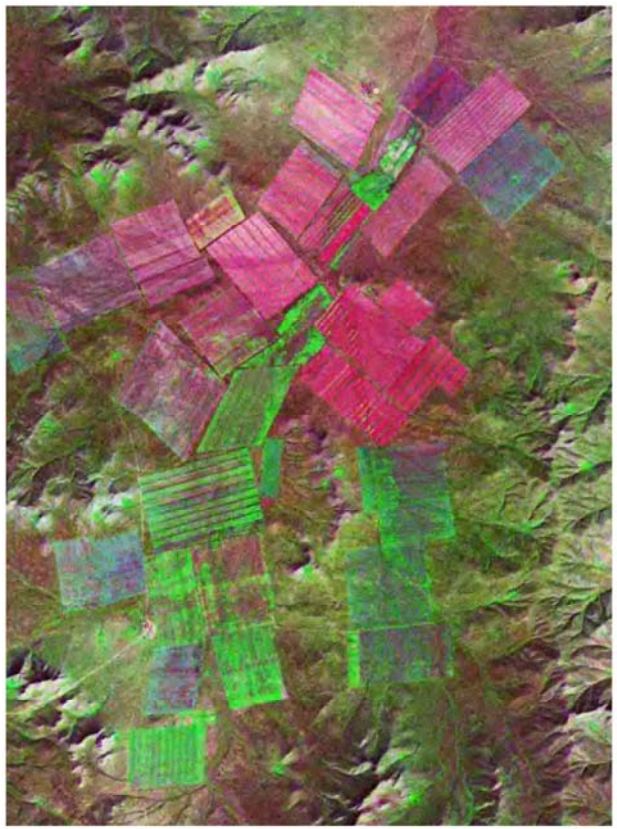


The meat production per capita has decreasing trend although the meat is only food item which we provide by ourselves. The total meat production had increasing trend with livestock numbers during 1994-2000 period, however, it was reduced until 2003 and it didn't recover yet even to 1994 level. The meat export substantially reduced during early transition to market economy. We still need to increase meat export in order to reach the pre-market economy level.

Mongolia was self-sufficient in providing its population with flour before the transition to market economy. Agriculture is collapsed with decrease of sown areas four times since 1990. There isn't almost any fodder cropping. Vegetable growth has recovered. The most abandoned croplands are located in central parts of Mongolia. We study these land use and land cover changes using the Multi-Spectral Image Differencing method.



Landsat ETM+ Mosaic circa September 1994



0 1 2 3 Kilometers
Universal Transverse Mercator Projection

N
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Landsat ETM+ Mosaic circa September 2000

0 1 2 3 Kilometers
Universal Transverse Mercator Projection

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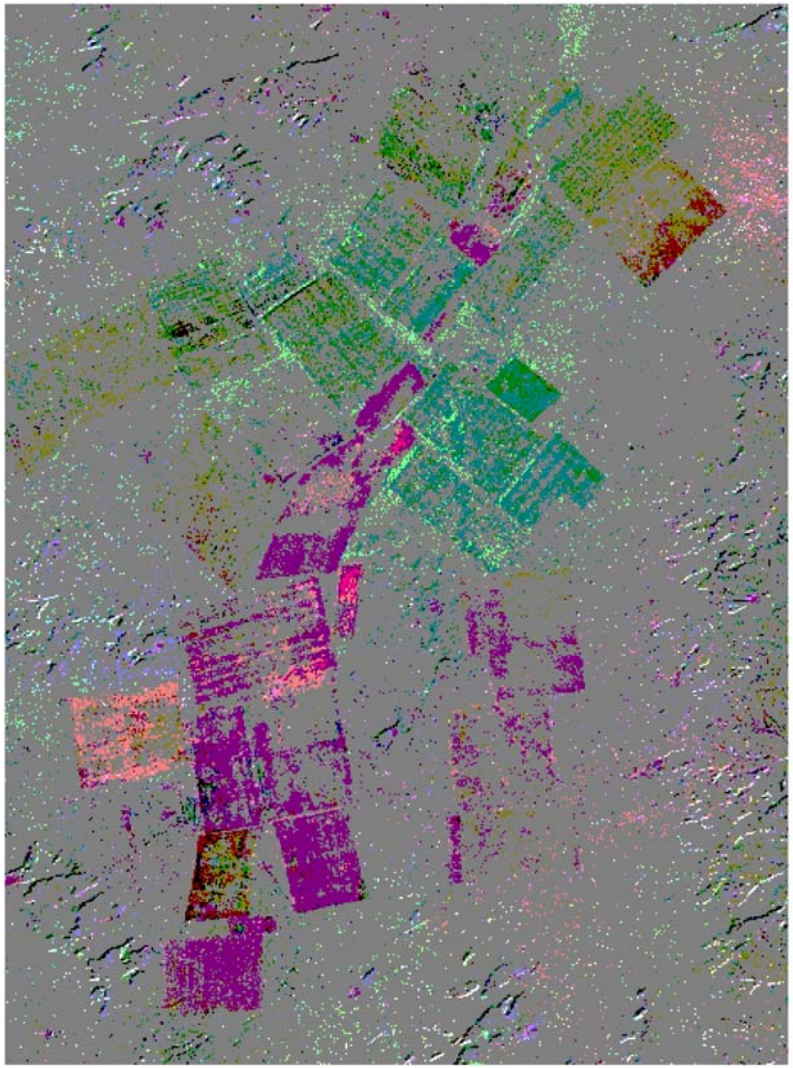
Multi-Spectral Image Differencing



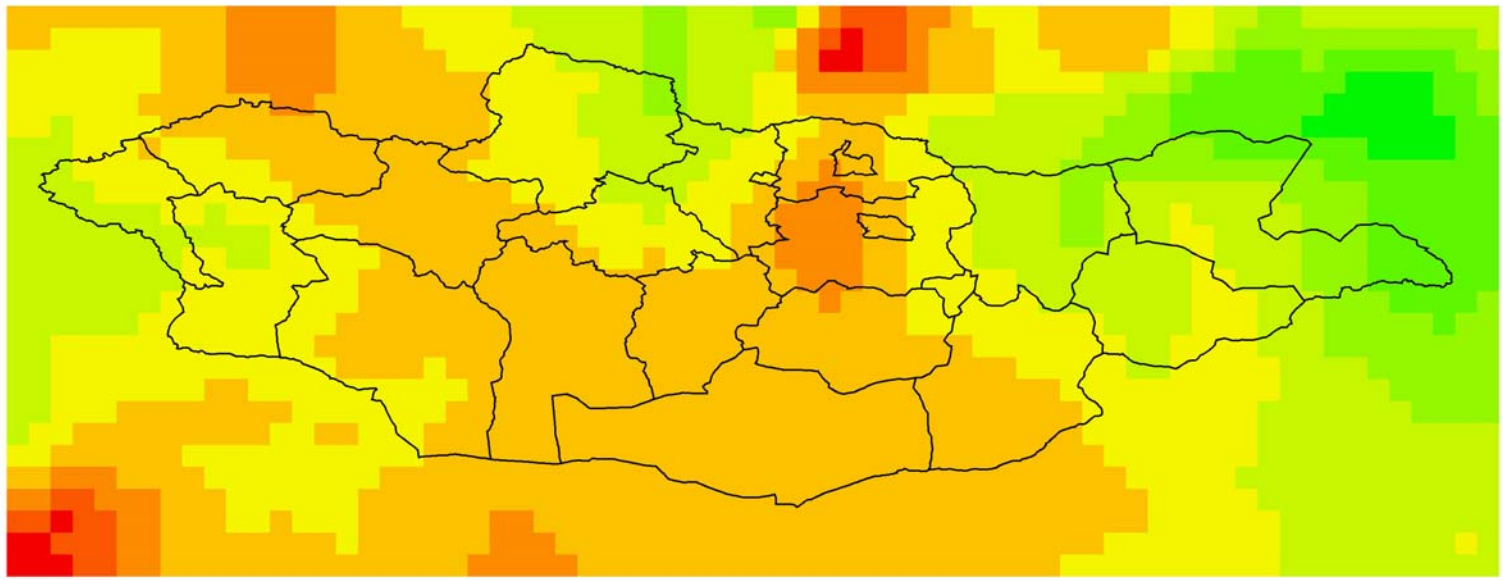
Sums with the most abandoned croplands

No.	Aimag	Sum	Territory	Abandoned croplands	Abandoned/ territory
			ha	ha	%
1	Tov	Argalant	112,637	9,827	8.7
2	Tov	Arhust	82,925	11,583	14
3	Tov	Bayanhangai	100,733	13,201	13.1
4	Tov	Bayantsogt	147,198	17,742	12.1
5	Tov	Ugtaal	154,789	25,773	16.7
6	Ovorhangai	Harhorin	224,116	25,080	11.2
7	Suhbaatar	Tumentsogt	213,456	12,131	5.7
8	Bulgan	Rashaant	101,212	17,870	17.7
9	Hentii	Herlen	380,878	19,515	5.1
10	Arhangai	Hairhan	254,430	12,498	4.9
11	Arhangai	Tovshruuleh	118,958	12,474	10.5

Climate change and its impact

•Mongolia is in a region that is experiencing the greatest warming on our Earth during the past century. It has warmed by the 1.80C since 1940, with the greatest warming occurring during the winter months (approximately a 3.60C increase) and in the spring (approximately 1.80C increase).
•The Gobi region became warmer by 0.75-1.50C, the northern central part - by 1.75-20C, and the north-eastern part of Mongolia - by 1.75-2.250C during the last century according the CRU-2 data;
•Precipitation decreased up to 5% in the Central aimag west from Ulaanbaatar city, increased up to 10% in the most of country. Only the eastern, the most western and northern parts had precipitation increase by more than 10%.

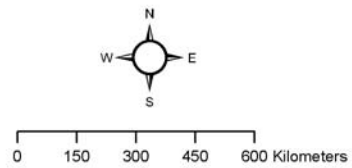
Relative Annual Precipitation Change (1901 - 2000)



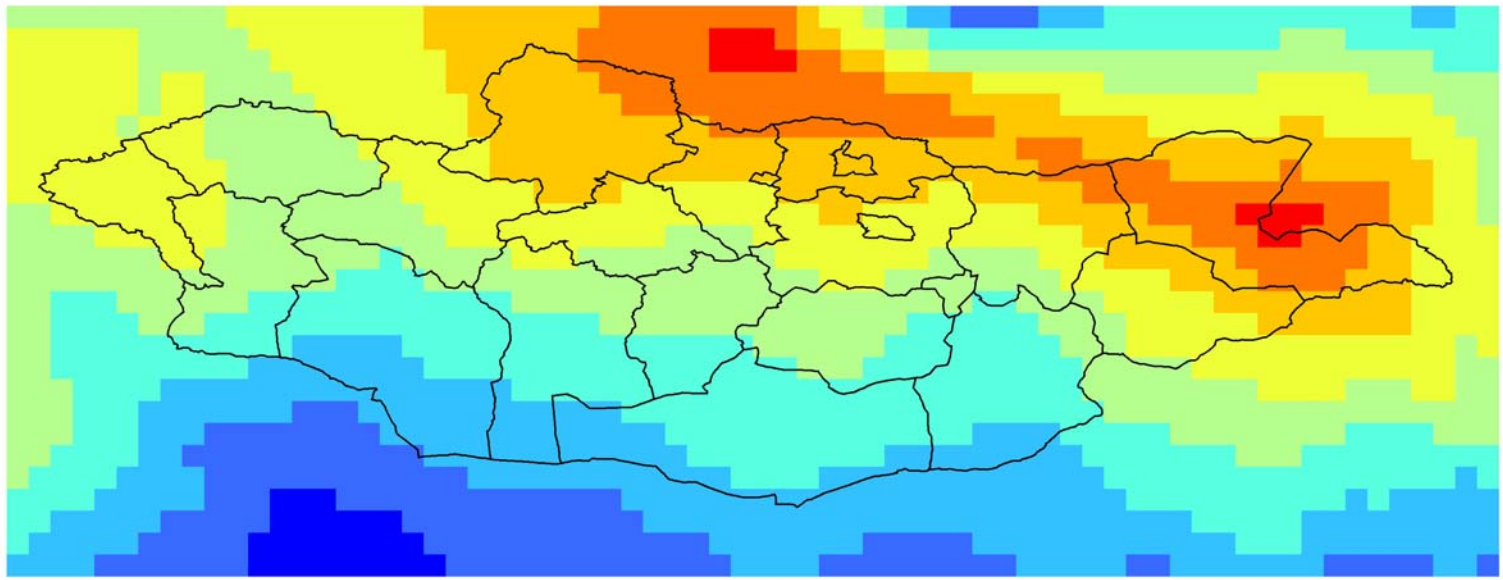
CRU-2 Data

Percent Change

-13.5 - -10	0 - 5	15 - 20
-10 - -5	5 - 10	20 - 25
-5 - 0	10 - 15	25 - 25.25



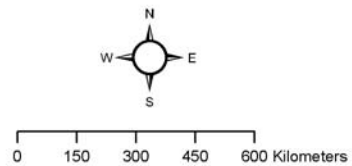
Relative Annual Average Temperature Change (1901 - 2000)



CRU-2 Data

Degrees Celsius

0.36 - 0.5	1 - 1.25	1.75 - 2
0.5 - 0.75	1.25 - 1.5	2 - 2.25
0.75 - 1	1.5 - 1.75	2.25 - 2.33

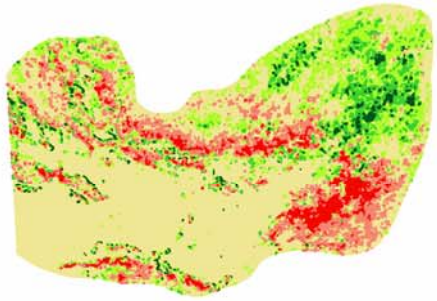


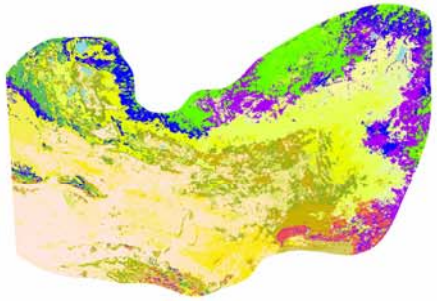
Climate change impact on ecosystems

- Central part of Mongolia has decreasing NPP trend over last two decades (Ojima et al., 2004).
- Plant onset trends of grassland ecosystems of the Mongolian Steppe have been analyzed using a long-term RS data identifying the zones with delayed or advanced plant onset trends in the Mongolian rangelands (Ellis et al., 2002). The delayed green-up zone forms band along the boundary area of the dry steppe and the Gobi desert steppe and covers the desert steppes located in the southern slopes of high mountains.

Applications of the RS study for policy making

Seasonal land cover map and plant onset trends defined using RS technique were used for the proposal on new administrative-territorial division of Mongolia. Newly proposed administrative units (below map) have larger territory than current units (above map) and incorporate several ecological zones. Adaptive capacity of the rangelands to climate change can be improved in newly proposed administrative unit because vulnerable to climate change rangelands with delayed green-up zones (red) take smaller portion of the unit's territory compared with some previous administrative units being all in red zone.





Asian Seasonal Land Cover

overlaid by

Regions with Changes in Green-up Dates

James Ellis and Chuluun Togtohyn

Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado, USA

In recent analyses (see Yu et al. 1999) our research team found that some regions of Mongolia, northern China, and surrounding areas are exhibiting changes in the dates when the onset of green-up of local vegetation occurs. Some areas, such as those dominated by Meadow Steppe, are showing earlier green-up over the period from 1982 to 1991. In other areas, such as portions of the Desert Steppe, the onset of green-up occurred later in the later years of that same period (see description, far left). Areas of Typical Steppe show varied responses, with much of that region not showing marked changes in the dates of the onset of green-up. Changed in green-up dates may have profound effects upon local pastoral production systems. To help identify finer-scaled responses, we will be making field visits to selected sites to ground-truth vegetation and local conditions.

Vegetation green-up dates were discerned from AVHRR Normalized Difference Vegetation Indices (NDVI) from 1982 to 1991 (see Yu et al. 1999). A green-up profile of dates was created for each of the 4.2 x 4.2 km NDVI pixels in the area. A regression compared Julian date and green-up dates for each pixel. Pixels with positive slopes from their regression equation are shown in shades of red (see key, below). They represent areas where green-up has occurred later in the year in later parts of the study period (1982 to 1991). Pixels with negative slopes are in green and represent areas where green-up occurred earlier in the year. Areas shown in tan either did not have marked changes in green-up date, or are from areas such as the Gobi Desert where green-ups were not evident from NDVI.

The vegetation map used is a portion of one refined by experts in a major workshop in July of 1997 at the EROS Data Center, South Dakota. Prior to the workshop, a set of NDVI images from 1992 and 1993 had been used to create a global 1 x 1 km vegetation map. Experts participating in the workshop used existing high resolution land cover maps from Mongolia, China, and Russia to refine and assess the draft map. The resulting map has 98 land cover types. A portion of the map was extracted and is shown at left. The boundary defined by areas bordering barren and steppe lands, and shown in changes in green-up dates (see map at left).

Land Cover Type

TUNDRA
- High Mountain Tundra, Shrub, Meadow (Cladonia, Betula, Salix, Kobresia, Carex)

FORESTS
- Mountain Forest (Pinus, Larix)
- Mountain Forest (Larix)
- Boreal Forest (Pinus sylvestris)
- Boreal Forest (Abies, Picea, Pinus, Larix)
- Mountain Boreal Forest/Shrubland (Picea, Abies, Pinus pumila)
- Mixed Forest (Betula, Pinus, Ulmus)
- Deciduous Mixed Forest (Betula, Populus, Larix)
- Woodland/Shrubland (Quercus, Betula, Populus, Oxytropsis)

MEADOW STEPPE
- Mountain Steppe (Festuca, Poa)
- Meadow Steppe (Festuca, Bromus)
- Meadow Steppe (Filifolium)
- Meadow/Steppe with Shrubs (Festuca, Stipa)
- Semi-Humid Grasslands with Shrubs (Artemisia, Caragana, Ulmus)
- Moderately Dry Steppe (Stipa, Koeleria)/cropland
- Moderately Dry Steppe (Stipa)

DRY STEPPE
- Dry Steppe (Stipa klemenzii)
- Dry Steppe (Stipa, Cleistogenes, Leymus)
- Dry Steppe (Stipa, Leymus, Koeleria)
- Dry Steppe (Stipa, Filifolium, Cleistogenes)
- Dry Steppe (Caragana, Cleistogenes, Stipa)
- Grassland/Shrubland (Stipa)
- Steppe Desert (Stipa, Cleistogenes, Agropyron)

DESERT STEPPE/DESERT
- Semi-Desert Steppe (Stipa, Allium, Salsola)
- Desert Steppe with Shrubs (Stipa, Caragana, Cleistogenes)
- Desert Steppe (Artemisia)
- Desert Steppe (Anabasis, Stipa, Allium, Salsola)
- Desert (Sympegma, Haloxylon, Anabasis)
- Desert (Anabasis, Haloxylon)
- Desert Sandy (Artemisia, Calligonum)

CROPLANDS
- Irrigated Fields and Planted Trees
- Cropland/Grassland (Festuca, Poa)
- Cropland

OTHER
- Barren
- Water

Changes in Vegetation Green-up

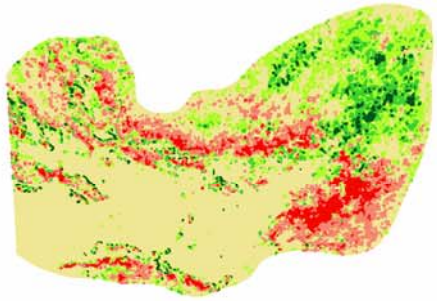
Slope of regression of Julian dates with green-up dates discerned from NDVI profiles from 1982 to 1991

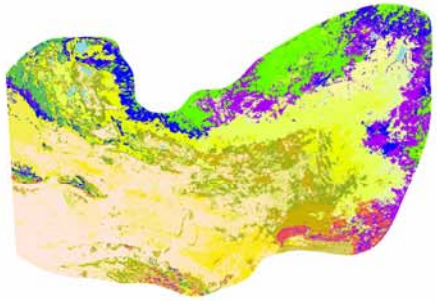
- > 3.8 - Late green-up
- 3.7 to 2.3
- -0.8 to -2.2
- -2.3 to -3.7
- < -3.8 - Early green-up
- Green-up cannot be regularly calculated (desert), or green-up has not changed markedly

0 100 200 300 Kilometers

Map production: Randall B. Boone

Present administrative-territorial division





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Newly proposed division of administrative units

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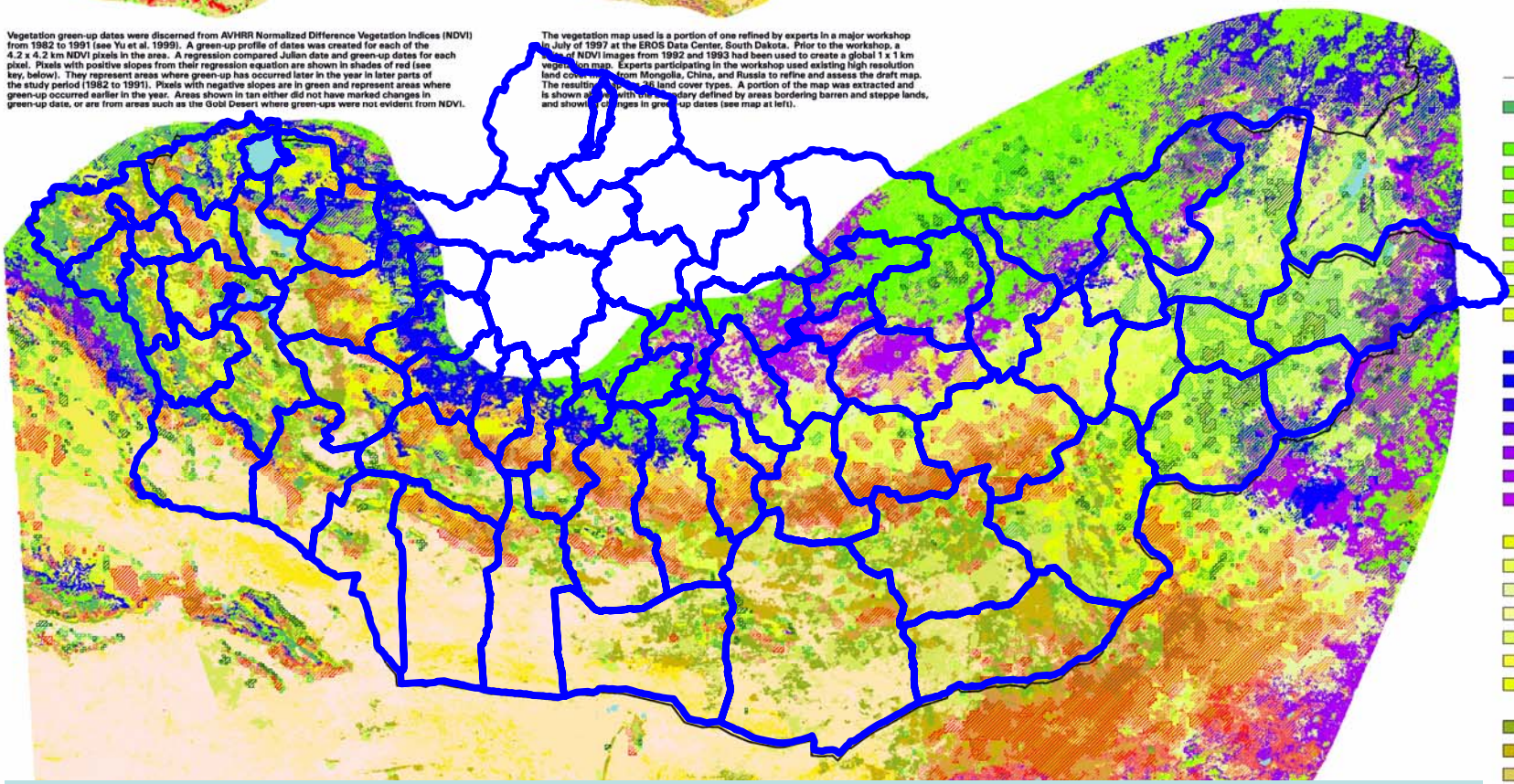

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- Cropland

OTHER
- Barren
- Water

Territory vulnerable to climate change comprises a small part of the entire territory of *hoshuus*, thus enlarging administrative and territorial units will serve as a factor to reduce the vulnerability of the rangelands to climate change.

Map production: Randall B. Boone

Critical environmental issues for Mongolia

- Vulnerability of transitional ecosystems in Mongolia to CC
  - Steppe/Gobi boundary area
  - Forest steppe and southern boundary of the boreal forests
  - Reindeer herders
- How water resources and riparian zones are affected by CC?
  - Springs, small rivers and glaciers
- How biodiversity is affected with open market economy?
  - Elk & forest decrease due to market demand of China
  - Marmot decrease due to market demand of Russia
- How human (food, water and health) security of the Mongolian people is changing due to global changes?
- What policy actions should be taken to reduce vulnerability and increase adaptive capacity of the coupled socio-environmental systems in Mongolia in response to global and regional changes such as emerging China and Russia?

Land[scape] Vulnerability & Resilience

- Resilience/Coping capacity
- Emerging Sustainability science
- Vulnerability of coupled social-ecological or human-environmental systems
- How to make win-win ecology at all spatial scales (community, administrative unit, country, regional and global)?
- Sustainable Land Architecture (Bill Turner)
  - Cultural landscapes as examples of SLA: Ecological landscape shaped with land use (grazing, hunting and worshipping) by traditional nomadic community

Partnership: Science and policy linkage

- ESSP (Earth System Science Partnership)
  - NEESPI (North Eurasian Earth System Partnership Initiative)
  - MAIRS (Monsoon Asia Intregrated Regional Study)
  - START/TEACOM/Regional office (ACCCA)
  - Joint Sustainability Projects
    - Carbon (Air pollution in UB)
    - Food security (Mongolia is a nutrient deficient nation, FAO)
    - Water (snow) scarcity, sensitivity and security
    - Global Land Project
- NASA: Land-Cover and Land-Use Change Program
- NSF: NEON (National Ecological Observatory Network)
- Colorado State University (Natural Resource Ecology Laboratory)
- The Heinz Center for Science, Economics and the Environment