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

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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.
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.
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
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.
### Sums with the most abandoned croplands

<table>
<thead>
<tr>
<th>No.</th>
<th>Aimag</th>
<th>Sum</th>
<th>Territory</th>
<th>Abandoned croplands</th>
<th>Abandoned/territory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tov</td>
<td>Argalant</td>
<td>112,637</td>
<td>9,827</td>
<td>8.7</td>
</tr>
<tr>
<td>2</td>
<td>Tov</td>
<td>Arhust</td>
<td>82,925</td>
<td>11,583</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Tov</td>
<td>Bayanhangai</td>
<td>100,733</td>
<td>13,201</td>
<td>13.1</td>
</tr>
<tr>
<td>4</td>
<td>Tov</td>
<td>Bayantsogt</td>
<td>147,198</td>
<td>17,742</td>
<td>12.1</td>
</tr>
<tr>
<td>5</td>
<td>Tov</td>
<td>Ughtaal</td>
<td>154,789</td>
<td>25,773</td>
<td>16.7</td>
</tr>
<tr>
<td>6</td>
<td>Ovorhangai</td>
<td>Harhorin</td>
<td>224,116</td>
<td>25,080</td>
<td>11.2</td>
</tr>
<tr>
<td>7</td>
<td>Suhbaatar</td>
<td>Tumentsogt</td>
<td>213,456</td>
<td>12,131</td>
<td>5.7</td>
</tr>
<tr>
<td>8</td>
<td>Bulgan</td>
<td>Rashaant</td>
<td>101,212</td>
<td>17,870</td>
<td>17.7</td>
</tr>
<tr>
<td>9</td>
<td>Hentii</td>
<td>Herlen</td>
<td>380,878</td>
<td>19,515</td>
<td>5.1</td>
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<tr>
<td>10</td>
<td>Arhangai</td>
<td>Hairhan</td>
<td>254,430</td>
<td>12,498</td>
<td>4.9</td>
</tr>
<tr>
<td>11</td>
<td>Arhangai</td>
<td>Tovshruuleh</td>
<td>118,958</td>
<td>12,474</td>
<td>10.5</td>
</tr>
</tbody>
</table>
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
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2 - 2.25
- 2.25 - 2.33

0 150 300 450 600 Kilometers
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.
Present administrative-territorial division
Newly proposed division of administrative units

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.
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 Integrated 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