Vulnerability on the Roof of the World: Building Resilience to Climate Change, Extreme Weather Events and Rangeland Policies on the Tibetan Plateau

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Multi-method, multi-scaled approach

Detailed ecological experiment

Detailed socio-economic studies of vulnerability, indigenous knowledge, social networks

Broad ecological observations and socio-economic surveys, remote sensing

Coupled ecological and household decision-making model (SAVANNA-DECUMA)

Future Scenarios
Main system components

Ecosystem
- Alpine rangelands
  - Vegetation
  - Animals (wild, domestic)
  - Glaciers/water
  - Soil resources

Social system
- Pastoral livelihoods
  - Indigenous knowledge
  - Cultural practices
  - Moral economy
  - Political economy
  - Traditional institutions

Ecosystem Services

Decisions & Actions
Ecosystem Services

- Forage
- Medicinal plants/animals
- Livestock products (livelihoods)
- Wildlife
- Tourism opportunities
- Knowledge & Stewardship
- Aesthetic & Cultural value
- Local & downstream water supply
- Carbon sequestration & storage
- Climate regulation

Local

Global
External Drivers, Shocks, Stressors

**Climate**

*Drivers*
- Temperature
  - Warming
- Precipitation

*Shocks*
- Extreme weather
  - Severe snowstorms

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**Ecosystem**

Alpine grasslands

**Social system**

Pastoral livelihoods
External Drivers, Shocks, Stressors

Climate

- Temperature
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Drivers

- Extreme weather
  - Severe snowstorms

Shocks

Policies

- Fencing
- Privatization
- Sedentarization
- Herd limits
- Grazing bans
- Restocking

Ecosystem

Social system

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Pastoral livelihoods
**External Drivers, Shocks, Stressors**

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**Economy**
- Market integration
- ↑ need for cash income
- Tourism

**Ecosystem**
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External Drivers, Shocks, Stressors

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Economy
- Market integration
- Tourism
- Pressure for cash income

Ecology
- Δ Species composition
- Δ Glaciers
- Δ Wildlife populations
  - grazers (pikas)
  - predators
- Δ Pests
  - toxic plants
  - parasites

Internal Dynamics and Stressors
External Drivers, Shocks, Stressors

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Ecosystem
- Alpine grasslands

Social system
- Pastoral livelihoods

Infrastructure
- Houses
- Radio
- Vehicles
- Fences
- Roads
- Cell phones

Internal Dynamics and Stressors
External Drivers, Shocks, Stressors

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Internal Dynamics and Stressors

Institutions
- Land tenure
- Village committees
- Private lending/credit

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- Alpine grasslands
System features that confer resilience

Drivers & Shocks
- Climate change
- Policies
- Economic pressure

Sensitivity:
- ecosystem
- grazing resources

Adaptive capacity:
- diversity (species, livelihoods, knowledge)
- leadership
- innovation
- social capital
- legal/political rights

Chapin et al. 2009
System features that confer resilience

Drivers & Shocks
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Constraints on traditional coping and adaptation strategies
- Reduced:
  - mobility
  - herd sizes
  - ecosystem health

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Persistence:
- Traditional livelihood practices, herding
- Healthy ecosystems

Navigated transformation:
- Alternative livelihoods

Unintended transformation:
- Ecosystem degradation
- Flooded grazing land
- Shift from cooperative to privatized grazing mentality

Chapin et al. 2009
Modeling a Coupled Natural and Human System

The linked SAVANNA and DECUMA models
Agent-based Household Decision Making

Agent-based household model

Household $m$

- Quality of grazing
- Conflicts
- Social status
- Relatedness
- Networks
- Gifts made

Household $n$

Distributions of livestock by species considering forage quality, quantity, distance to water, etc., plus restrictions on use due to land tenure and status

Distribution of crops

Ecosystem model

- Habitat suitability for livestock, by species
- Suitability of lands for cultivation
- Suitability for other types of diversification
- Other attributes reflecting ecosystem services (water quantity, quality for cultivation, soil quality)
Example spatial distributions in DECUMA

Mean Response variables

Output for selected individual households is produced as well.
Chyulu Hills are treated as a grazing reserve, with little use until the dry season (i.e., August-October).

Chyulu Hills have been discussed as an area for rain-fed agriculture.

If the Chyulus were unavailable to mobile Maasai herders and their livestock, what would be the effects on populations?
The Value of a Grazing Reserve
Progress on Tibetan Application
Some Policy Questions that may be addressed with DECUMA & SAVANNA

- Climate change and drought responses
- Changes in herbivore access
- Livestock stocking rates
- Livestock survival through veterinary care
- Changes in water supplies
- Effects of cultivation
- Effects of human population growth
- Land tenure changes and subdivision
An Example Suite of Scenarios

In Samburu, Kenya, we are addressing:

- Changes in animal health associated with changes in veterinary care
- Effects of subdivision on livestock capacity and pastoralist wellbeing
- Commercial cropping in Siambu and fencing in Mbaringon
- Increased livestock use during drought
- Tradeoffs between support for livestock and support for wildlife in Mbaringon
- Enhanced goat breeds and milk production
- Effects of increased crop yields on pastoralist wellbeing
Other Approaches and Tools

DECUMA is weakly linked to the ecosystem model, and may be joined with many different models.

In an NSF-supported project in Mali, we are using DECUMA with the African Carbon Exchange (ACE) model and the Soil and Water Assessment Tool (SWAT) to understand how pastoralists and hydrology are linked.

In an effort supported by the International Livestock Research Institute, we have constructed a global ecosystem model of moderate complexity called G-Range.

G-Range may be used to look at mountain habitats across the globe simultaneously.
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