Session proposal

Theme: Analyzing and promoting change and transformation

Session title: Resilience to drought in Monsoon-dominated semi-arid environments: analysis through computer simulation

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Keywords: adaptation to climate change; cross-scale; disturbance; local knowledge; long term dynamics; modelling; path dependency; population dynamics; regime shift; resilience; reversibility; simulation; social-ecological systems; threshold; trap

Type of session: traditional (60 minutes):

Synopsis and structure of the session

Papers presented in this session are set in N Gujarat, a semi-arid region of NW India. The region is one the most exposed to drought within the Indian continent. In spite of that, human settlement is attested in the region throughout the Holocene. Over time, local populations have adapted to these specific environmental settings, developing specific socio-ecological strategies for resilience and sustainability. Works presented in this session explores how computer simulation and Agent Based Modelling can be used to analyse long-term trajectories for hazard-mitigation and resilience to drought in Monsoon-dominated semi-arid environments.

Three papers will be presented (10 minutes each). Papers will have been previously circulated among participants (at least those presenting) to ease discussion. Discussion will be open to the public and last for 30 minutes following presentations. Starting from results presented in the different case studies, discussion will focus on the following key concepts:

Challenges for analyzing resilience to drought in Monsoon-dominated semi-arid environments using computer simulation:

1. Backstage: degree of abstraction and labor behind the models
2. Utility of proposed models for resilience to drought in Monsoon-dominated semi-arid environments
   a. Insight into the effects of integrating traditional strategies and new technologies
   b. Knowledge transmission, adaptation and transformation relative to drought recurrence
   c. Usefulness of long-term trajectories, archaeology and anthropology

Contributions

Papers in this session explore changes in social-ecological systems (i.e. hunter-gatherer and agro-pastoral communities, past and present) in tropical semi-arid environments. Works presented here explore resilience in terms of population performance in an environment characterized by high short-term variability in precipitation. Adaptive strategies explored in this session include reversibility between strategies of resource use and the effects of the
integration of new technologies and traditional knowledge. These changes are analysed at different spatial and temporal scales.

Contributions to the session are coherent in terms of geographical contexts and methodology, leading to a degree of overlap between presented works. Although interlinked, the three papers present different perspectives on the core topics explored in this session. This session is meant for resilience scientists and policy makers to discuss and provide feedback on the quality and relevance of the long-term integrated approach proposed in the three contributions:

1. Balbo, Andrea et al. (balbo@imf.csic.es)
   Complexity and Socio-Ecological dynamics (CaSEs, www.cases-bcn.net) and SimulPast
   (http://simulpast.imf.csic.es/sp/), Istitució Milà i Fontanals, Spanish National Research Council (IMF-CSIC),
   C/Ejipciaques 15, 08001 Barcelona, Spain
   **Resilience to precipitation variability in tropical semi-arid environments. An Agent-Based Modelling approach to Holocene population dynamics in Kutch-Saurashtra, Gujarat, India**
   Based on archaeological evidence from Kutch-Saurashtra (N Gujarat, NW India), we use Agent-Based Modelling (ABM) to explore resilience to precipitation variability for hunter-gatherer (HG) groups in semi-arid environments dominated by the monsoon in the mid and late Holocene. Precipitation trends are modelled from instrumental records (1871 - 2008) calibrated with existing models for the Asian monsoon in the Holocene (c. 12 ka - present). Experiments explore dependencies between population dynamics and changes in precipitation trends (i.e. affecting resource availability) at the local, regional and continental scales. Average yearly precipitation (AYP) and variance in yearly precipitation (VYP) are the main parameters affecting resource availability in the simulations.
   We assess the effects of environmental change on HG populations at different time-scales: (1) Patterns of seasonal (inter-annual) resource availability, (2) Effects of long-term (Pleistocene-Holocene) and mid-term (Holocene, millennial) precipitation trends, and (3) Effects of short-term intra-annual (annual, decadal) precipitation variability. Simulations show that: (1) Mid and late Holocene HG populations in India were adapted to strong seasonality, (2) Mid-term (Holocene) changes in AYP can hardly explain the extinction of HG populations in Kutch-Saurashtra 4 ka, (3) Short-term (annual to decadal) variance in precipitation is the main parameter affecting HG resilience in terms of population performance and overall ecosystem dynamics.

2. Crema, Enrico et al. (e.crema@ucl.ac.uk).
   ERC EUROEVOL, UCL Institute of Archaeology, 31-34 Gordon Square, WC1H 0PY, London
   **Modelling Cultural Transmission of Subsistence Strategies in Monsoon dominated semi-arid environments**
   This paper models the dynamics of cultural transmission underpinning bi-directional transitions between two socio-ecological systems, namely hunting-gathering and agropastoralism. Shifts in subsistence strategies have been traditionally explored unidirectionally and restrained within the theoretical framework of the optimal foraging theory (OFT). OFT seeks to identify equilibrium conditions for a variety of scenarios given the core assumption of a perfect knowledge amongst the actors of the system. This approach has an important shortcoming in that it does not consider the role of path-dependence in a dynamic environment, where optimal solutions are temporal and constantly changing. In OFT, decision-making is driven by short-term benefits (myopic optimality), where dynamics of inheritance and transmission of knowledge can lead to increased specialisation and loss of alternative beneficial traits, resulting in a brittle system, unable to flexibly adapt to a subsequent change in the environment.
   We examine the role played by the conservation of ‘obsolete’ knowledge to enable episodes of ‘cultural reversion’, whereby a previously abandoned strategy is re-adopted given an environmental transition to a stage for which it is more adaptive than the new one. We create an agent-based simulation to examine how modelling the transmission, inheritance, and conservation of knowledge related to subsistence strategy is paramount for understanding long-term equilibria in a changing environment. We focus on the adaptive
history of northern Gujarat, where hunting-gathering and agro-pastoralism coexisted for several centuries within an ecotone dominated by exceptional short-term variability in precipitation. We ultimately seek to identify expected equilibria for different socio-ecological systems under specific environmental conditions, and determine how resilient they may be to disturbance events.

3. Rubio-Campillo, Xavier et al. (xavier.rubio@bsc.es) 
Barcelona Supercomputing Centre (BSC), Nexus II Building, C/Jordi Girona, 29, 08034 Barcelona, Spain

Mobile phones for mobile people: The effects of affordable cellular communication technology on the resilience of traditional shepherds in Gujarat, India

The focus of this work is on the impact of cell phones for the exchange of environmental information among traditional shepherd communities. Using computer simulation, we examine how an increased flow of information may affect the resilience of these groups to environmental variability. Previous studies suggest that the way individuals share knowledge about the environment is partly the consequence of adaptive processes related to natural resource management and therefore to the potential variability of environmental conditions. Depending on these parameters, the optimal strategy for the community to maximize resource exploitation could be defined by a varying frequency of information sharing. In terms of evaluating the resilience of a given socio-ecological setting, a full understanding of the effects of changes in the frequency of information sharing should take into account not only currently available resources but also potential future scenarios with reduced resource availability.

We present an Agent-Based Model designed to explore the relationship between the intensity of communication amongst shepherds and the exploitation of natural resources (i.e. knowledge of the seasonal distribution patterns of pasture across the landscape over a number of years). We aim at understanding how an increase in the rate of information exchange among traditional groups of shepherds, as a result of the widespread diffusion of cell phone communication, affects the resilience of the system to short and mid-term environmental change. Parameters underlying the computer simulation are calibrated to the specific settings of North Gujarat (India), a monsoon-dominated region characterized by a climate with high intra- and inter-annual variability.

For centuries, local shepherds have left their villages at the start of the dry season (i.e. beginning of the year) looking for suitable grazing areas to maintain their herds. Their seasonal migrations could extend over tens and hundreds of kilometers, before coming back home at the end of the dry season (late Spring). In the past, communication between groups of shepherds was much reduced during the migration season, as their routes seldom overlapped. The recent introduction and fast spreading of cell phones has radically changed this situation. Shepherds are now able to instantly share information about the quality of the areas they are exploring for grazing. This implies a higher capacity for the exploitation of available resources in the short-term. However, due to the short time elapsed since the introduction of this technology, it is difficult at present to foresee its effects on resource maintenance, and ultimately on the resilience of this particular socio-ecological setting, in the mid- and long-term. Our simulations suggest that the introduction of telecommunications among these communities has the potential to sharply decrease in the mid-term the resilience of the system to climatic variability.

Involved institutions include:
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