

Integrating Household and Community Data with Remote Sensing Applications to Detect Land-use and Land-cover Change in Lamjung, Nepal

Milan Shrestha

Department of Anthropology, the University of Georgia, Athens

This study is based on a growing recognition that land-use and land-cover change (LULCC) researchers must look beyond the primary area of transition (i.e., conversion of forests) to properly understand the global land-cover dynamics (Lambin et al., 2000). Of particular significance is studying the impact of agricultural 'modification activities' on land-cover, mainly the changes in agricultural land-use strategies resulting in different agricultural intensification levels, which happen to be more dynamic to be detected from remotely sensed data alone. This emerging research theme, however, lacks sufficient knowledge regarding the extent to which land-use strategies contribute to LULCC and vice versa. The need of such knowledge is even greater for the mountains, where agricultural practices depend heavily on forests and other common pool resources, livestock, and cultural-ecological adaptation (Netting 1981, Rhoades 1997).

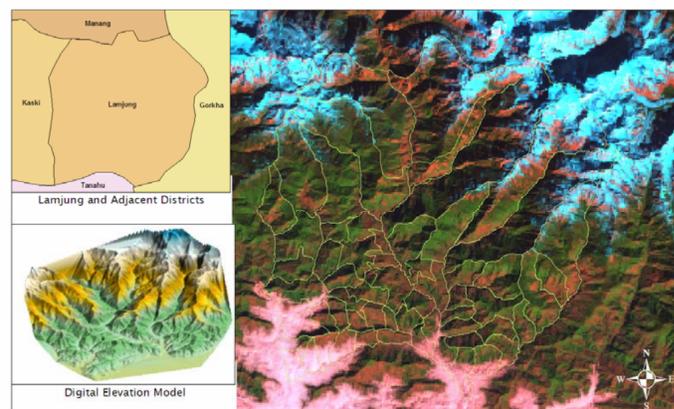
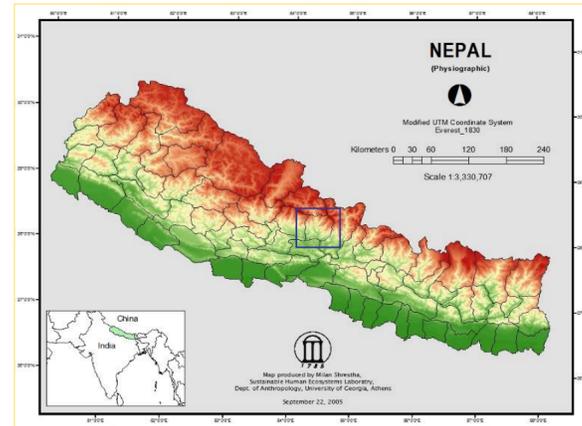
Such in-depth knowledge requires a cross-disciplinary, multi-scale approach that integrates household and community ethnography with spatial data and remote sensing (Conklin 1980, Guyer and Lambin 1993, Fox et al. 2003, Boucek and Moran 2004), as their integration provides more accurate explanations of the LULCC patterns and their driving forces.

This study proposes a cross-disciplinary, multi-level approach that integrates household and community data with remote sensing analysis to investigate land-use strategies of mountain smallholders in Lamjung district, Nepal and examine how changes in their land-use strategies can be linked to broader land-cover change trajectories of the last 40 years (i.e., 1976 through 2003).

RESEARCH QUESTIONS

- Under what household and community contexts do smallholders change their agricultural land-use strategies?
- How and to what degree are land-use strategies associated with the broader patterns of land-cover?

After participant observations, household surveys of 66 households were followed by in-depth interviews of key respondents, collection of training samples, elicitation of land history, and remote sensing analysis to detect 40 years' (i.e., between 1976 and 2003) land-cover change. These data help assess the extent to which shared cultural knowledge and rules of agricultural land-use strategies contribute to land-cover change. This research also captures how an important cross-section of actors perceive, manage, and change land resources in the Nepal Himalaya—one of the environmentally critical regions of the world.

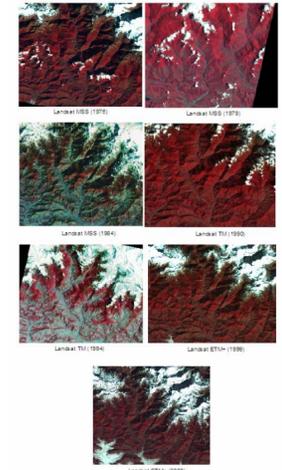


METHODOLOGY

This research combines ethnography and household surveys with GIS and remote sensing. Ethnographic methods included were participant observations, freelistings, pilesorts, interviews with key participants, elicitation of land-use history, and cognitive mapping. Ethnographic data together with household and community surveys provide, among other socio-cultural, demographic, and economic data, exhaustive listings of agricultural land-use strategies (i.e., modification activities of land-cover change) and their frequency distributions in each of the two research sites. A multi-scale analysis of the proximate causes and their driving forces of broader land-cover can be understood by relating these modification activities with the trade-off percentage change among land-cover categories for 40 years. While the processes of LULCC can be understood in the light of dominant modification activities, the patterns can be inferred by detecting spatial and temporal change in land-cover percentage. By doing so, it is now possible to establish the linkages of micro-level land-use modification activities with the patterns of land-cover change for district and regional levels.

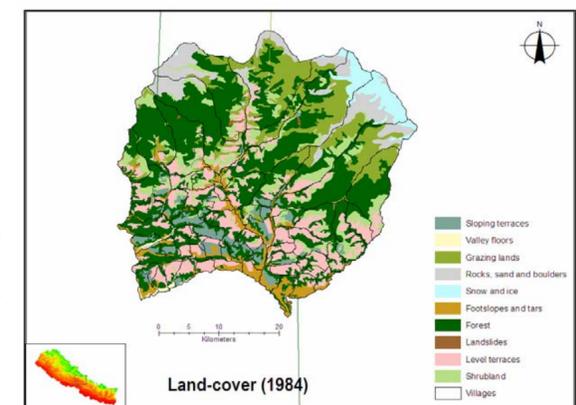
The specific steps are:

- Determine household and demographic processes affecting land-use intensification practices
- Assess ethnoecological knowledge on agricultural land-use practices and elicit land history
- Document community contexts of rules/institutions, labor exchange network, and cultural "agencies"
- Collect "training" samples of cultivated lands and forest plots.
- Detect and quantify percent changes in land-cover over time and space with the use and interpretation of aerial photographs (of 1979 and 1996), multi-date satellite images (i.e., 1976, 1979, 1984, 1990, 1999, and 2003), and spatial data layers. Each image is classified using a hybrid of unsupervised and supervised classification method (Walsh et al. 2001, Yang and Lo 2002). I also calculate NDVI and quantify spatially significant land-cover change information with the help of spatial autocorrelation technique, which allows comparison of the corresponding values of locations and attributes of cropped land, forest patches, and settlements with their spatial distance from the select markets seen on the satellite images of 1976 and 2003. The thematic accuracy of the land-cover change maps is also tested by creating an error matrix with both *Kappa* and *Tau* coefficients (Congalton 1991, Ma and Redmond 1995).
- Link the relationships of local agricultural land-use strategies with broader, district level land-cover change trajectories. In so doing, consider the significance of scales and the modifiable area unit problem (MAUP) issues.



SIGNIFICANCE

This study attempts to fill theoretical and methodological gaps in agricultural and environmental anthropology, agricultural change theory, global LULCC research, and ethnoecology of mountain resources and environments. While this research targeted a particular culture and place, my ultimate interest is in establishing general relationships underlying subsistence behavior of mountain smallholders, their dependence on land and forest resources, and the extent to which their behaviors are historically influenced by changing local demography, institutional arrangements, increasing accessibility, and socio-economic change. The particular contribution of this research will be a set of spatially and temporally explicit accounts of agricultural land-use strategies and their association with broader level land-cover changes. By exploring the proposed research questions through the lens of smallholders and community institutions, this research also captures how an important cross-section of actors and institutions perceive, manage, and change land resources in the Nepali Himalaya. Most importantly, the results of the research will be spatially and historically informed knowledge of human impact on the Himalayan environment, which is a critical part of the earth system.



REFERENCES

- Becker, A. and H. Bugmann. 1999. *Global Change and Mountain Regions*. The Mountain Research Initiative. IGBP Report 49, GTOS Report 28, IHDP Report 13. IGBP.
- Boucek, B. and E. Moran. 2004. Inferring the Behavior of Households from Remotely Sensed Changes in Land Cover: Current Methods and Future Directions. In *Spatially Integrated Social Science*, M. F. Goodchild and D. G. Janelle, eds., pp. 23-47. New York: Oxford University Press.
- Conklin, H. 1957. *Hanunoo Agriculture: A Report of an Integral System of Shifting Cultivation in the Philippines*. Rome: United Nations Food and Agricultural Organization.
- Congalton, R. G. 1991. A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data. *Remote Sensing of Environment* 37:35-46.
- Fox, J., Rindfuss RR, Walsh S, Mishra V, eds. 2003. *People and the Environment: Approaches for Linking Household and Community Surveys to Remote Sensing and GIS*. Boston, MA: Kluwer Academic Publishers.
- Guyer, J.I. and E. F. Lambin. 1993. Land Use in an Urban Hinterland: Ethnography and Remote Sensing in the Study of African Intensification. *American Anthropologist*, 95(4): 839-859.
- Kasperson, J. X., R. E. Kasperson, and B. L. Turner II. 1997. Regions at Risk: Exploring Environmental Criticality. *Environment*, 39(10): 4-15, 26-29.
- Lambin, E.F., M.D.A. Rounsevell and H.J. Geist. 2000. Are Agricultural Land-use Models Able to Predict Changes in Land-use Intensity? *Agriculture, Ecosystems and Environment*, 82: 321-331.
- Lambin, E. F. et al. 2003. Dynamics of Land-use and Land-cover Change in Tropical Regions. *Annual Review of Environmental Resources* 28:205-241.
- Liverman, D. M., et al., eds. 1998. *People and Pixels: Linking Remote Sensing and Social Science*. Washington, DC: National Research Council & National Academy Press.
- Ma, Z. and R. L. Redmond. 1995. Tau Coefficients for Accuracy Assessment of Classification of Remote Sensing Data. *Photogrammetric Engineering & Remote Sensing* 61(4): 435-439.
- Netting, R.M. 1981. *Balancing on an Alp: Ecological Change and Continuity in a Swiss Mountain Community*. Cambridge: Cambridge University Press.
- Netting, R. M. 1993. *Smallholders, Householders: Farm Families and the Ecology of Intensive, Sustainable Agriculture*. Stanford, CA: Stanford University Press.
- Openshaw, S. 1983. *The Modifiable Areal Unit Problem*. Concepts and Techniques in Modern Geography No. 38. Norwich, UK: GeoBooks.
- Rhoades, R. E. 1997. *Pathways Towards a Sustainable Mountain Agriculture for the 21st Century: The Hindu Kush-Himalayan Experience*. Kathmandu: ICIMOD.
- Rindfuss, R. S., J. Walsh, V. Mishra, J. Fox, and G. P. Dolcemascolo. 2003. Linking Household and Remotely Sensed Data: Methodological and Practical Problems. In *People and the Environment: Approaches for Linking Household and Community Surveys to Remote Sensing and GIS*, edited by J. Fox, R. Rindfuss, S. Walsh, and V. Mishra, pp. 1-30. Norwell, MA: Kluwer Academic Publishers.
- Turner, Billie L. and Meyer, William B. 1994. Global land-use and land-cover change: An overview. In *Change in Land-use and Land-cover: A Global Perspective*, edited by W. B. Meyer and B. L. Turner. New York: Cambridge University Press.
- Yang, X. and C. P. Lo. 2002. Using a Time Series of Satellite Imagery to Detect Land Use and Land Cover Changes in the Atlanta, Georgia Metropolitan Area. *International Journal of Remote Sensing*, 23(9): 1775-1798.
- Walsh, S.J., T.P. Evans, W.F. Welsh, B. Entwisle, and R. R. Rindfuss. 1999. Scale-dependent Relationships between Population and Environment in Northern Thailand. *Photogrammetric Engineering & Remote Sensing*, 65(1):97-105.
- Walsh, S. J., T. W. Crawford, W. F. Welsh, K. A. Crews-Meyer. 2001. A Multiscale Analysis of LULCC and NDVI Variation in Nang Rong district, Northeast Thailand. *Agriculture, Ecosystems and Environment*, 85: 47-64.

ACKNOWLEDGEMENTS

I want to thank Kashjung Ghale, Pancha Gurung and other farmers in Lamjung for participating in this research. Ganga Chhetri provided untiring help in the field. Birendra Bajracharya of ICIMOD provided GIS data layers of Lamjung. I also want to thank Robert Rhoades, Theodore Gragson, CP Lo, and Virginia Nazarea for their guidance and suggestions. Funding received from the following sources are gratefully acknowledged:

 NASA Earth System Science Fellowship
Grant # NNG04GQ16H

 The National Science Foundation
Cultural Anthropology
Dissertation Improvement Grant #BCS-0350127

CONTACT


Sustainable Human Ecosystems Laboratory
Department of Anthropology, 250 Baldwin Hall
The University of Georgia
Athens, GA 30602-1619
(706) 542-3141
milans@uga.edu