Albanian j. agric. sci. 2018;17 (1): 70-77 *Agricultural University of Tirana*

RESEARCH ARTICLE **(Open Access)**

Research Priorities in Land Use and Land-Cover Change for Albania and Integrated Modelling Assessment

ROLAND ÇELA[1], VALBONA SINANI[1], ADEM META[2], FATBARDH SALLAKU[3]

[1]PhD student, Department of Agroenvironment and Ecology, Agricultural University of Tirana, Albania
[2]Faculty at Cuyahoga Community College, Cleveland, Ohio, USA
[3]Department of Agroenvironment and Ecology, Agricultural University of Tirana, Albania

Abstract

Land cover, the physical state of the earth's surface and immediate subsurface, and land use, the human employment on that land, were long studied with a distinct focus on either geographic variables employing spatially explicit models or on the analysis of econometric models employing ‘conventional, i.e. non-spatial, models. In the past few years, researchers increasingly attempt to link geographic variables and socioeconomic indicators. Recent spatially explicit studies of the determinants of land-cover and land-use changes integrate geo- and biophysical data with socioeconomic variables derived from quantitative surveys or censuses. This paper has highlighted recent and innovative methods and results that integrate observations and modelling analyses of regional to global aspect of biophysical and biogeochemical interactions of land-cover change with the climate system. To date, cooperation between these communities has been limited. Based on common interests, this paper discusses research priorities in representing land use and land-cover change in Albania for improved collaboration across modelling, observing and measurement communities. Major research topics in land use and land-cover change are those that help us better understand [1] the interaction of land use and land cover with the climate system, [2]. the provision of goods and ecosystem services by terrestrial land-cover types, and [3] land use and management decisions.

1. Introduction

Most countries of the region have since gone through substantial land reform processes as a central element in the transition from a centrally-planned economy towards a market economy. During the 1990s, most countries conducted land reforms to privatize state and collective farms and, in parallel, to build land administration systems. The countries applied a variety of land reform approaches with the main methods being the restitution of ownership to former owners and the distribution of agricultural land in either physical parcels or land shares to the rural population. In some countries, land reforms after 1989 have completely changed the farm structures that existed during the socialist era while in other countries the farm structures remain basically the same. As a result of the recent land reforms the ownership of agricultural land has become fragmented to a medium or high extent in all the countries. With regard to land use fragmentation, the situation is much more nuanced. In Albania where distributed agricultural land in physical parcels as the main land reform approach, the result has been excessive land use fragmentation: there is a large overlap between the ownership of agricultural land and land use as most land is farmed by the owners in.

An important factor in further understanding global change and the role of both human drivers and human interaction of natural systems is demonstrated via land use and land-cover change. Based on this recognition, and also in view of the role of land in providing goods and environmental services, attention to land use and land-cover change is sharply increasing. In this issue, several studies report integrative analyses that incorporate global climate, remote sensing and observations [1,2] while others discuss statistical, weather and/or observations to evaluate regional impacts of land use/land-cover change with climate or biophysical, hydrological processes. The strength of these analyses lies in the integrative nature and approach for understanding both the drivers and impacts of land cover and land use with human systems with an emphasis on physical processes. None of these analyses, however were conducted to address the issues raised from

*Corresponding author: Roland Çela; E-mail: roland.cela@giz.de
(Accepted for publication March 26, 2018)
***ISSN**: 2218-2020, © Agricultural University of Tirana*

questions that are driven by integrative biogeophysical, socio- economic and human decision-making perspectives.

The Earth System Modeling (ESM) and the Integrated Assessment Modeling (IAM) communities play an important role in understanding and quantifying Earth system analysis and, specifically, understanding the role of land use and land-cover change. These two groups come from very different perspectives, which result in distinctly different modelling strategies between the groups. The focus in the way ESMs and IAMs represent the systems they study is strongly related to the nature of these systems. In ESMs, more often historical data can be used to equilibrate the model to contemporary time. Given the inherent uncertainty in human systems, in IAMs all kinds of assumptions on future development of factors related to land use such as socioeconomic, energy and demographic processes are made. These assumptions are partly based on historical evidence. Often the focus of analysis is not the baseline, but alternative policy scenarios that explore the implications of limited alterations to this set of assumptions (e.g. a climate target).

The different focus of the ESM and IAM communities has led to significant differences in emphasis in describing land use and land cover. Although there is a substantial overlap in the systems modelled, there are also components that are unique to each group. Additionally, as both communities acknowledge the need for increased complexity and begin to incorporate additional biogeochemical or socially relevant components in their models, there is an increasing overlap in simulated domain with both the groups including aspects of other modelling strategies of the climate and the observational and ecosystem modelling communities.

It should be noted that the results of both the climate and IAM simulations have been made broadly available for analysis by other communities as well. The primary groups to utilize modelled results are those that study climate interactions with ecosystems, water resources, biodiversity, agriculture, human settlements and ultimately for understanding the potential for human adaptation to climatic changes, as well as for finer resolution analysis of potential socio-economic and energy transformations associated with long-run climate objectives. There are important interactions between human economic decision making about energy, land use and GHGs, and potential feedbacks in the physical climate system. In this context, these communities should be exploring new research strategies to identify the most important of these interactions, and develop ways to explore them, their consequences and ultimately the consequences of the overall evolution of the Earth system in a more comprehensive and sophisticated way than previously imagined. To some degree, the realization that a major link between human and physical systems is through the carbon cycle is compelling both communities to examine each other's strategies for missing components in their modelled systems.

Land use and land-cover change

A variety of approaches to address land use and land- cover change have been considered by both the modelling communities. These aspects of ESMs are increasingly being used for understanding the ecosystem and the impacts on hydrology which are modified by ecosystem responses. Traditionally, information to create an explicit geography of land cover and land surface properties is derived from snapshots of satellite data and often do not acknowledge temporal transitions. However, as land-cover change is also driven by human land use and decision-making processes, ESMs are increasingly adding scenarios of land-use change to their analysis.

The IAM community also recognizes the importance of land use as a critical factor in socio-economic decision making, e.g. for food and timber production, valuation of the state of ecosystems and their services, and increasingly, as a response to demand for biofuels in the electricity and transportation sectors. Although many IAMs have focused strongly on energy-economy systems and only included land-use emissions as exogenous factors, this is now changing with the development and implementation of increasingly coupled socio-economic and climate modelling strategies. The research issues that have the most potential for productive collaboration between the two modelling communities are identified in this paper. In this context, there are three major areas of research priorities where both the ESM and IAM communities may play a role with regard to land-cover and land-use change: deforestation, agriculture and bioenergy. Research on land-use and land-cover change has taken a prominent role in the international scientific community due to increasing concerns related to global climate change, decline of biodiversity levels, and widespread high poverty incidences, especially in rural areas. Research activities of various disciplines have focused on developing countries in tropical regions in view of the vast areas of tropical forests threatened by clear-cutting and conversion into other uses. Little research has been conducted in the transition countries of eastern and southeastern Europe and in the countries of the former Soviet Union

2. Material and Methods

Land cover and land use are not synonymous: however, these words are often (incorrectly) used interchangeably by the IAM and ESM communities. For purposes of clarity, in this paper, we consider land cover as a description of the actual vegetation present at the terrestrial surface. Even with this definition, differences in interpretation can arise due to the use of different classification systems to characterize land cover. Land use, in contrast, describes the anthropogenic or human use of the land surface, e.g. specific use of maize and commercial timber, and can include land management activities such as irrigation and fertilization that can alter GHG fluxes and climate but not the land cover – cropland and forest, respectively. Land-use change can thus be an important driver for land- cover change, but they are not the same. The differences between land use and land cover are also important in the context of data and observation. All models are driven by data, whether the data are derived from boundary conditions or through parameter estimation, empirical relationships or direct observations. In the end, model estimates, and therefore model error, reflect the information or analyses that are used to establish initial conditions, parameter estimation or internal algorithms. The land-use and land-cover changes associated with mitigation options may impact climate in different ways, and mitigation options currently under consideration at regional and national levels will have major consequences for land use, in particular policies with respect to avoided deforestation/reforestation and bio-energy production. Global land-use modelling in most IAMs is generally less developed than other components (e.g. energy system). IAM development is ongoing to more fully internalize land-use decisions associated with both land-use change and changes in the management of land under its existing use.

3. Results and Discussions

Specifically, new modelling is improving the representation of land-use competition, forestry investment behavior, changes in forest management, modelling heterogeneous land endowments, internalization of mitigation costs in production and budget decisions, economic rents of land, land-use transitions between specific land types/uses and the supply and access of unmanaged lands [3,4]. IAMs often have several model components that communicate at various levels and frequencies (e.g. energy, climate, land use and land cover).

Table 1. Delineation of near and long-term for general reference to broad representation of climate modelling communities [12]

Near-term (<5 years	Longer-term (>5 years)
Terrestrial carbon cycle model (typically without nitrogen or nutrient limitations)	Nitrogen cycling and limitations
Vegetation dynamics and regrowth following disturbance	Anthropogenic fire (including ignition and suppression
Anthropogenic land-use change and corresponding net carbon fluxes	River biogeochemistry (particularly dissolved organic carbon fluxes from land-to-ocean)
Mechanistic wildfire	Interactive biogenic fluxes of methane, volatile organic compounds (VOCs) for coupling to atmospheric chemistry
Marine biogeochemistry, including simple ocean ecosystem (e.g. nutrient – phytoplankton – zooplankton – detritus (NPZD) models	Advanced vegetation and successional processes; possibly explicit dispersal mechanisms Multiple agriculture (crop × management) PFTs and associated local/regional land-use practices Transient urban fractional cover Tropospheric interactions with O_3 and vegetation Organic and peatland soils Wetlands

While model components within an IAM are implemented with variable coupling strength, it is clear that agriculture, land, land-use change emissions, the economy, energy, CO_2 concentrations and climate change are strongly connected.

Main activities in land-cover and harmonization strategies and remote sensing

Both the ESM and IAM communities have only recently implemented land-use and land-cover change dynamics. At present, several data sets for historical, present and future land use/land cover have been published, but there have been few formal multi-model data comparisons to assess the implications for climate system feedbacks. The development of a single land-cover data system is under development with both communities involved in assessing differences in land-cover characterization and implementation [4, 5,8]. With regard to land use/land cover, most spatially explicit data sets are based on remote sensing and national statistics. Uncertainties, however, are still significant and can result in considerable differences in modelling outcome. Despite these uncertainties, the role of remote sensing for data and model parameterization, calibration and evaluation should be further explored, e.g. concerning key model parameters such as albedo, leaf area index [5,7,8] yields, potential uses and land-use change transition matrices and the behavioural drivers.

It has long been recognized that observations and, in particular, remotely-sensed products are often cross calibrated with various global data sets as well as spatial heterogeneity of land-cover classes [10, 11]. These and other analyses have initiated the development of strategies for a land- cover classification system (LCCS), providing a common terminology where various data sets can be compared and evaluated to improve their synergy, usability and flexibility.

Table 2: Spatially explicit land use and deforestation models

Dependent variable	Econometric approach	Level of analysis	Operationalized variables	Definition	Effect
Land use	Multinomial logit	11,712 pixels (1 km^2)	National land	Binary	Low probability of commercial cultivation on national land
			Forest reserves	Binary	High probability of semi subsistence; agricultural use unlikely
Land cleared for agriculture	Tobit	6,776 census tracts (= 486 mio ha)	Conservation areas, protected areas, national parks, indigenous areas	Binary	Protected areas with positive, but smaller conversion rates in low-rainfall areas; little impact at higher rainfall levels
Deforestation	Bivariate probit	Pixel (1 km^2?), province	Protected area	Binary	Protected areas less likely to be cleared; protected areas in areas of low agricultural value
Deforestation	Probit	Pixel (1 km^2), municipio	Land under ejido tenure	Proportion	All reduce deforestation significantly
			Share of indigenous population	Proportion	
			Protected area	Binary	
Land use	Multinomial logit	317 Plots	Land title (of any kind)	Binary (title)	Positive influence on paddy and tea relative to swidden
Annual deforestation; area forested in 1991; regrowth	I guess OLS	Sample of 398 land holdings	N.A.	N.A.	More deforestation further away from cities on similar farms: timing of settlement and length of activities have influence
Deforestation	Logit	900 m^2 pixels, no of	Colonization zones	Binary	Negative in first two periods, but positive from 92-99

Dependent variable	Econometric approach	Level of analysis	Operationalized variables	Definition	Effect
		observations	Reserve areas	Binary	Negative in all three periods
Land use	Multinomial logit	20,000 pixels of 2,500m^2	Protected areas	Metric (years protected)	Increases likelihood of forests of different quality
Land use	Multinomial logit	15,991 pixels with 0.25 km^2	Protection of national park; protection of two indigenous reserves	Binary	Existence of park and one reserve reduce human interventions; simulations by setting variables to zero

Table 3: 'Conventional' statistical models on land management, resource use, and productivity

Dependent variable	Econometric approach	Level of analysis	Operationalized Variables	Definition	Effect
Land conservation investments	Random effects generalized least squares	1260 hh	Share of holdings rented in	Binary	Not more investments on rented land
			Landholdings owned	Hectare	More investments in land conservation on owned plots
Land improvements	Logit	200 – 300 farm households (different provinces)	Title	Binary	Titles have significant positive effect in most provinces; number of years a plot is owned has positive effect on land improvements
Farm productivity	I guess OLS…				Farm revenue 12 – 20 % larger among titled farmers; yields and labor input positively influenced
Private land ownership	Logit	Subset of 1320 pixels (16m^2)	Private ownership of land	Binary (dep. var.)	Landform and proximity to roads can predict private land ownership
Adoption of land management practices	Maximum likelihood censored regression; censored least absolute deviations estimator	198 villages	Land redistribution; tenure insecurity index	Binary; ordinal	Not significant effect on land management practices and resource outcomes
Resource outcomes			Land redistribution; tenure insecurity index	Binary; ordinal	
Rice productivity	I guess OLS…	40 provinces	Year dummies to capture the impact of collectivization (1980) and decollectivization (1985) policies	Binary	1980 dummy significantly negative for the north, 1985 dummy positive for whole country
Crop yields	Fixed effects and error components model	Hh survey in several regions of three countries (sub-samples between 97 and 629 hh)	Parcels ranked from most to least secure	Ordinal	Not significant
Land improvements	Logit				Positive effect of land rights only in Rwanda

Dependent variable	Econometric approach	Level of analysis	Operationalized Variables	Definition	Effect
Normalized total administrative (parish) area	2SLS	64 and 42 parishes	Customary and mailo tenure	Proportion	Customary tenure positively related to agricultural land conversion; no difference in LUC in mailo and public tenure
Change in tree cover				Binary	individual rights to land and trees strongest in mailo land
% area under coffee	Tobit	40 and 57 households (two sites)	Difference in impact of land rights between customary and other tenure institutions (customary plus three land tenure institutions)	Binary	Coffee tree planting enhances tenure security under customary tenure
whether field was fallowed	Probit				Fallowing less common on customary land then on land with stronger rights
trees and fruit trees planted/ha	Tobit				Trees planting less common under less secure individual rights
Value of production/ha; profits/ha	OLS				Short term benefits not affected (tenure dummies not significant); profits linked to coffee (unaffected by tenure)
Rice production per capita and upland cropping intensity	OLS, 2SLS	56 communes	Farmland covered by Directive 100 and Resolution 10	Proportion	Lowland policy variables mostly insignificant; implementation of resolution 10 has 'tendency' to arrest reforestation

Table 4. Global terrestrial essential climate variables and examples of existing and observing systems

Terrestrial ECV	Observing system
River discharge	*In situ*
Water use	*In situ* networks, regional remote sensing activities
Groundwater	*In situ*
Lake and reservoir levels and volumes	*In situ* networks, regional remote sensing activities
Land cover	GLOBCOVER, MODIS land cover
Biomass	Regional activities
Soil moisture	SMOS satellite mission

Land use and deforestation, agriculture and bioenergy

Three global land-use phenomena (deforestation, agriculture and bioenergy) are very topical for international policy making and are being studied by the ESM and IAM communities. We argue that these three phenomena are main areas where further collaboration between these communities, together with observing communities, could advance current scientific understanding. The phenomena are clearly driven by socio-economic drivers and different policies, but understanding them also requires a comprehensive examination of physical, biogeochemical and ecosystem processes. These directly relate to the issues we have raised in the previous sections (e.g. through hydrology, disturbance, biogeochemistry and socio-economic).

Land use and deforestation

Deforestation and its associated processes are important with regard to the carbon cycle and feedbacks to the cli- mate system. Empirical evidence of the rates of change of deforestation has been available for the past 25 years, and future progress is anticipated with new observing systems, and measuring and modelling tools. Deforestation comprises the aspects of both human decision making, as it is clearly a consequence of both economic and non-economic decision making, and biogeochemical processes. Deforestation is a major element in climate policy discussions. The skill of IAMs to reproduce land-clearing phenomena that resemble the timing and magnitude as recorded by observing systems has not been tested. Consequently, an important research priority is to improve the representation of recent past (e.g. 25+ years) to contemporary deforestation in models, including the relationship between deforestation and climate policy choices. Based on the current experiences, it is recommend coupled analyses with both modelling and observing communities to (a) better quantify socio-economic and political processes that drive rates of deforestation and (b) evaluate the integrated impacts of deforestation accounting for both biogeophysical and biogeochemical feedbacks.

Land use and agriculture

Analyses with IAMs have explored range finding exercises on agricultural productivity through analyses of crop productivity for food *versus* fuel and whether or not carbon is valued [7,8,13,17. Assumptions on agricultural productivity critically determine land use in the coming century. Both socio-economic and cultural decision-making processes govern agricultural production from individual landowner to landscape and regional scales. However, there are significant uncertainties in fundamental economic and land productivity parameters that can meaningfully affect results. Appropriate scales for decision making to specific changes in crop management strategies as a consequence of changes in climate, changes in demand for food and changes in the relative cost of land inputs to production in the context of a dynamic policy environment provide a backdrop of the complexity of agricultural economic and policy landscapes.

Land use and bioenergy production

Within the last several years, bioenergy production has generated substantial political and economic interest. Most IAM groups have initiated simulation studies of bioenergy production and there have been some comparisons of results [10,11,13]. Although ESMs can specify a vegetation proxy (e.g. grass and crop) to simulate biofuels, it is not clear how to incorporate bioenergy production into an ESM experimental design. Several approaches can be considered: whether to simply and artificially increase agricultural productivity, or whether processes and energy fluxes associated with increased fertilization, irrigation and crop rotations require a new bio-geophysical modelling strategy, including the implementation of age or cohort structure.

4.Conclusions

Within the topics of deforestation, agricultural production and bioenergy, interaction with the impacts, adaptation and vulnerability communities is clearly important. A model-evaluation exercise that incorporates a ‘soft coupling’ (e.g. offline) between IAMs and ESMs of land would provide a ‘proof of concept’ for short-term analyses that could be linked with impacts and/or adaptation studies.

Land cover shows a very dynamic behavior in the research area between 1988 and 2015 in Albania. The predominant changes in land cover, i.e., forest regeneration, deforestation, and cropland abandonment, lead to a substantial reorganization of the landscape. Land change is highly heterogeneous across the four districts and across villages. A large share of the heterogeneity, particularly in shrub and grassland cover, cannot be explained by the variables hypothesized to influence land use.

The change in trends appears to be connected with changes in the broader dynamics of rural transformation in postsocialist Albania. Between 1988 and 1996, forests expand onto land previously used by agricultural cooperatives during socialism but abandoned after reform. In the second period, forest regeneration is off-set by an increase in logging, most of which is illegal.

The move out of agriculture is reinforced by a shift from crop cultivation to livestock husbandry. The numbers of goats have increased, while cropland is being abandoned. Remittances are no longer invested in cultivation, losing their statistically significant influence on cropland. Cropland becomes less likely where steep terrains reduce the profitability of production. These changes suggest that the decreasing profitability of agriculture, in general, and crop cultivation, in particular, is increasingly reflected in farmers' land-use decisions and also in land-cover patterns.

Clearly, both ESMs and IAMs will require confrontation with data. In addition, guidelines for interpreting land-use and land-cover classes (e.g. pasture lands and grazing lands) are needed. For instance, land allocations for grazing lands can be quite different, or how a global model classifies whether a land allocation is to be grazed can be distinctly different between mesic or arid/semi-arid ecosystems.

It is also important to note that it is simply not enough to reproduce observations, as calibration for one region may result in distorted results in another.

The discussion illustrates that land cover and land use in Albania exhibit significant changes in the wake of postsocialist reform. Land cover displays a significant move away from cropping in a period of merely 25 years. Local livelihood and land-use strategies demonstrate similarly pronounced trends away from cropping and toward migration and off-farm activities between 1991 and 2015. Changes in the determinants of land cover indicate the growing influence of market principles on land-use practices in the wake of reform, mirrored by a shift to alternative income sources and by the increasing importance of terrain suitability for agricultural production.

It would be interesting to compare the results from Albania to those from other countries in Central Eastern Europe. Changes in land cover and land use may follow a particular trajectory in Albania, as the country may be considered a special case of postsocialist transformation.

5. References

1. Alcamo J, Döll P, Henrichs T, Kaspar F, Lehner B, 2003. Development **and testing of the WaterGAP 2 global model of water use and availability**. *Hydrological Sciences Journal,* 48 (3): 317 – 338.
2. Bouwman L, Kram T, Klein-Goldewijk K. 2006. **Integrated modeling of global environmental change.** An overview of IMAGE 2.4. Netherlands Environmental Assessment Agency: Bilthoven.
3. Claussen M, Mysak LA, Stone P, Wang Zh. 2002. **Earth system models of intermediate complexity: closing the gap in the spectrum of climate system models**. *Climate Dynamics* 18(7): 579 – 586.
4. Costa MH, Pires GF. 2009. **Effects of Amazon and Central Brazil deforestation scenarios on the duration of the dry season in the arc of deforestation**. *Int. J. Climatol.* 30: 1970 – 1979.
5. Cramer W, Bondeau A,. 2001. **Global response of terrestrial ecosystem structure and function to CO2 and climate change: results from six dynamic global vegetation models**. *Global Change Biology* 7: 357 – 373.
6. Fall S, Niyogi D, 2009. **Impacts of land use land cover on temperature trends over the continental United States: assessment using the North American Regional Reanalysis**. *Int. J. Climatol.* 30: 1980 – 1993.
7. Foley JA, DeFries R, Snyder PK. 2005. **Global consequences of land use**. *Science* 309 (5734): 570 – 574.
8. Gitz V, Ciais P. 2004. **Future expansion of agriculture and pasture acts to amplify atmospheric CO2 in response to fossil fuel and land-use change emissions**. *Climatic Change* 67: 161 – 184.
9. Herold M, 2008a. **Some challenges in global land cover mapping: an assessment of agreement and accuracy in existing 1 km datasets**. *Remote Sensing of Environment* 112: 2538 – 2556.
10. Herold M, 2008b. **Land cover observations as part of a global earth observation system of systems (GEOSS): progress, activities, and prospects**. *IEEE Systems* 2(3): 414 – 423.
11. Hertel T, Rose S, Tol R (eds.) 2009. **Economic Analysis of Land Use in Global Climate Change Policy.** Routledge Publishing: 343.
12. Hibbard KA, Meehl G, Cox P, Friedlingstein P. 2007. **A strategy for climate change stabilization experiments**. *EOS* 88(20): 217 – 221.
13. Jain A, Yang X. 2005. **Modeling the effects of two different land cover change data sets on the carbon stocks of plants and soils in concert with CO2 and climate change**. *Global Biogeochem. Cycles.*
14. Lawrence PJ, 2010. **Investigating the climate impacts of global land cover change in the community climate system model**. *Int. J. Climatol.* 30: 2066 – 2087.