

Landsat ETM+, acquisition date: 4th March 2000 (path 124 row 51, false color composite with band combination 5,4,3)

## Agricultural Expansion versus Intensification: Empirical evidence from land use modeling in the Central Highlands of Vietnam

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Land use change, the physical change in land cover caused by human action on this land, is a common phenomenon associated with population growth, market development, technical and institutional innovation, and policy action. Land use change leads to a change in - and is influenced by - socio-economic indicators such as rural income, agricultural productivity, wealth and education. A better understanding of the complex interactions of these changes over time should enable decision makers to formulate regionally adapted policy inter-

ventions, which stimulate benefits and counteract negative consequences by simultaneously considering the trade-offs among economic, environmental and social objectives in the process of sustainable rural development.

The article emanates from a larger research program that attempts to assess the impact of policy, technology, socio-economic and geo-physical conditions on land use change and its related outcomes on economic growth, welfare, and protection of natural forests. For a more detailed description of methodology, results and implications see MÜLLER and ZELLER (2002). The research

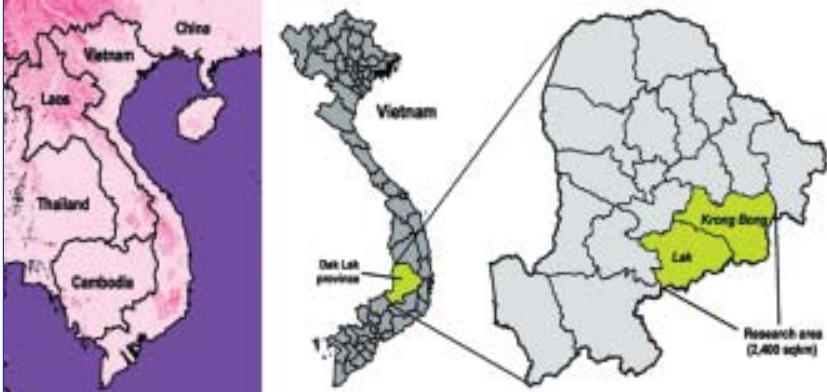
program takes place in Lak and Krong Bong districts of Dak Lak province. Dak Lak exhibits an interesting case in the study of land use dynamics with its abundant forest resources, ethnic diversity, high immigration rates, and dynamic socio-economic development, particularly in the last decade. The objectives of this research are to assess the exogenous driving forces of land use change in a spatially explicit way.

We combine land cover data with (a) geophysical data like soil quality, slope and elevation, (b) policy-induced variables like investments in infrastructure and promotion of new technologies with data and (c) socio-economic village characteristics derived from a village survey in the study area. Data is prepared using techniques of remote sensing and geographical information systems and analyzed with statistical software packages to test several hypotheses on land use change and to identify driving forces and characteristic processes of land use change.

### Satellite image interpretation

The results from satellite image

### Location of the Research Area



**Table 1: Land cover in km<sup>2</sup>, percent of total land and number of patches**

Cover class	2000			1992			1975*	
	km <sup>2</sup>	%	Patches	km <sup>2</sup>	%	Patches	km <sup>2</sup>	%
Mixed agriculture	339,8	14,2%	141	352,0	14,6%	339	146,7	6,1%
Paddy	111,0	4,6%	62	117,0	4,9%	57	67,2	2,8%
Closed forest	866,6	36,4%	14	828,2	34,5%	17	836,2	34,9%
Open forest	962,6	40,5%	56	827,9	34,6%	74	1052,3	44,0%
Grass	101,5	4,3%	159	273,5	11,4%	259	295,7	12,2%
<b>Total</b>	<b>2381,6**</b>	<b>100%</b>	<b>432</b>	<b>2398,6</b>	<b>100%</b>	<b>746</b>	<b>2398,2</b>	<b>100%</b>

Source: Interpretation of Landsat satellite images by Nguyen Thanh Huong (Tay Nguyen University, Buon Ma Thuot) and author for Lak and Krong Bong districts, Dak Lak Province, Central Highlands, Vietnam.

\* Number of patches only counted for the images from 1992 and 2000, which have the same spatial resolution of 30 \* 30 meters.

\*\* 18 km<sup>2</sup> missing in 2000, because part of the research area was not covered by the scene.

interpretation suggest a decrease in open canopy forest in the first period due to conversion into rainfed and irrigated agricultural land. Forest cover increased during the 1990s by 7%, mainly due to natural regeneration of mixed grassland. Fallowed fields formerly used for shifting cultivation were largely abandoned in the last decade and regenerated into bamboo and open canopy secondary forest.

Overall, mixed agriculture remained constant in the 90s, as the reduction in shifting cultivation was compensated by an expansion of cropping intensity. Over time, agricultural production became more locationally concentrated (less patches) with potential environmental benefits for preserving integrity of ecosystems and endangered species populations.

These changes in land use show that shifting cultivation as the traditional farming system practiced by the indigenous population in the research area almost entirely disappeared in its traditional form during the last decade. Forest regeneration predominantly occurs closer to ethnic villages. The increase in forest cover over the last decade despite the observed population growth does not correspond to the widely stated positive correlation between higher population density and lower forest cover. Permanent conversion of primary forest into agricultural land was hardly observed and if so, it took place between liberation day and 1990, the key period of government resettlement programs.

### Results from data analysis and policy implications

Access to all-year roads improved

substantially in the last decade thereby facilitating market integration, access to infrastructure, agricultural inputs and public services. The investments in irrigation and infrastructure, combined with improved access to roads, markets and services, were successful in intensifying agricultural production. Higher agricultural productivity on existing land reduced the need for shifting cultivation, thus preserving forest cover while sustaining a much greater population on virtually the same agricultural land area. This was possible through increases in the productivity of food and cash crops, as well as an increase in area under cash crop production. Because of this, upland arable area as well as paddy area reduced slightly, whereas much of the grassland of the earlier period (due to shifting cultivation) was reforested into open canopy forest and to a lesser extent into closed canopy forest. Protected areas somewhat contributed to this development by decreasing the likelihood of non-forest land uses. Thus, the policy measures have contributed to a reduction in shifting cultivation and facilitated agricultural intensification.

In the first decade we can observe a pathway of land expansion into previously uncultivated areas. Low population density facilitated extensive land cultivation based on forest fallows. Few farmers applied intensive cultivation techniques and production was subsistence-oriented. The last decade brought about significant changes in the policy environment like investments in road upgrades, irrigation facilities and introduction of new technologies. This period is characterized by intensification without further land expansion and allowed

forests to regenerate. Today, forests cover nearly the same area as in 1975. Labor-intensive technical progress diverted resources away from land intensive farming systems like the various forms of shifting cultivation by augmenting the return on labor. At present, more people produce more per capita on less land than ten years ago.

Investments in the road network did not significantly reduce forest cover as it was outweighed by intensification. Road development seems to contribute significantly to improvements in productivity and welfare, in that way reducing land expansion and removing pressure from forests. At the same time, the shift to a market-driven economy at the end of the eighties, state policies on sedentarisation and forest protection encouraged production and made traditional farming techniques more difficult to pursue, thus further contributing to the transformation from traditional subsistence-based into market-driven production. Construction and improvement of irrigation enabled and facilitated agricultural development. Rice yields and production almost tripled in the study region in the last decade. Intensification from improved irrigation systems may have greatly reduced the pressure to expand cultivated area at the expense of forest.

As the analysis showed, intensification of agriculture - combined with the protection of forested areas - can reduce the pressure on forested land, and slow down or even halt the expansion of agricultural land if coupled with the right policy instruments. The analysis shows that investments in infrastructure can facilitate this much-needed intensification of agriculture without detrimental

consequences on forest resources. The two districts in our study were purposively selected and are not representative of the entire province. Secondary data and satellite images of other districts in Dak Lak Province not analyzed in this research show a less positive picture as forest cover continued to decline there

during the second decade. This is presumably due to less mountainous topography and the widespread existence of basaltic soil in these other districts. For that reason, the plantation of coffee and

pepper expanded rapidly in the 1990s at the detriment of forest cover. Therefore, our findings relate to one part of Dak Lak province and cannot be generalized to all of the Central Highlands.

**References:**

MÜLLER, D. and ZELLER, M. 2002. *Land Use Dynamics in the Central Highlands of Vietnam: A spatial model combining village survey data and satellite imagery interpretation. Agricultural Economics. In press.*

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