Leimavo Revisited: Agrarian Land-use Change in the Highlands of Madagascar

Christian A. Kull

This is an author archived pre-print version of the following article published in Professional Geographer:

Kull 1998 Leimavo revisited: Agrarian land-use change in the highlands of Madagascar. ***Professional Geographer*** 50 (2): 163-176.

The final, definitive version is available online via the Taylor and Francis and AAG websites (http://www.aag.org/cs/publications/the_professional_geographer). Direct link: http://dx.doi.org/10.1111/0033-0124.00112

Abstract: Describing and explaining land-use change is of critical concern in Madagascar, where land transformations such as deforestation and resulting environmental degradation currently capture widespread attention. While the eastern rain forest recedes in the face of swidden cultivators, the highlands demonstrate more constructive transformations. In this paper I present a case study of land-use change in Leimavo, a small village near Ambositra studied in the 1960s by Jean-Pierre Raison. Here, the twentieth century has seen a gradual reduction in irrigated rice cultivation and cattle husbandry, and a boom in market-oriented orange, vegetable, and grain production. In the long term, a historical landscape of grassy hills has been transformed into a productive cultural landscape with woodlots, anti-erosion benching, rice terraces, fruit groves, and diverse crops. Critical factors determining the trajectory of land-use change include regional population pressure, state policies, market incentives, climate variations, and access to land and water resources. These critical factors, or explanations, are linked in the discussion by the use of a simple heuristic device -- the range of choice -- as a theoretical framework. **Key Words: Madagascar, land use change, agrarian change, highlands, political ecology.**

Introduction

Humans have been present in the Malagasy highlands for approximately 1,000 years, all the time shaping the landscape with spades, seeds, cattle, and fire (Fig. 1). Minutely detailed terraces of rice paddies climb the hillsides next to fruit orchards and plots of manioc and beans, while abandoned fortifications stand near hamlets of two-story red earthen homes. Documenting and understanding processes of landscape transformation is a task of timely importance in Madagascar, where land transformations such as deforestation and resulting environmental degradation currently capture widespread attention. This paper seeks to contribute to the much-needed understanding of land-use change. However, instead of adding to the literature

documenting the disappearance of eastern Madagascar's rain forest, I highlight a different region where landscape change has been more incremental and constructive.

Figure 1: *Spades Shape the Leimavo Landscape. Laborers prepare a dormant rice field for planting at the eastern edge of Leimavo, with the view south-east across the Sahasaonjo Valley (August 1994)*

This case study of Leimavo documents several telling trends over the past six decades. The land area devoted to irrigated rice cultivation has progressively shrunk, yet increasingly diverse crops -- including oranges and market vegetables -- have an important place in the village economy. In addition, cattle are no longer kept in large numbers as outlying pastures are converted to cropland or planted with trees. These trends are the result of a constellation of factors, including demographic growth, societal differentiation, individual strategies to accumulate wealth, agricultural and land tenure policies, market signals, a slow decline in precipitation, and the spread of new ideas. The trends in Leimavo mirror land-use changes throughout the highlands, where the intensification of land use in an area already saturated with people increasingly reflects market forces (see e.g. Rakoto Ramiarantsoa 1995a; Ramamonjisoa 1995). Critical empirical lessons from this case study -- relevant to the environmental debate in Madagascar as well as elsewhere -- include the non-destructive impact of population growth and the importance of market forces and economic policies.

This historical study of agrarian change begins by describing the research method, the regional historical context, and the study site. Then I describe and seek to explain six major themes in twentieth-century land-use change in the revisited village of Leimavo. Finally, before concluding, a short discussion attempts to link explanations of land use change into a coherent framework. In the spirit of Blaikie and Brookfield's (1987) pluralistic political ecology, I suggest modifying the "range of choice" concept (White 1961; Wescoat 1987) as a simple heuristic device to link the contributions of relevant theories.

Methods

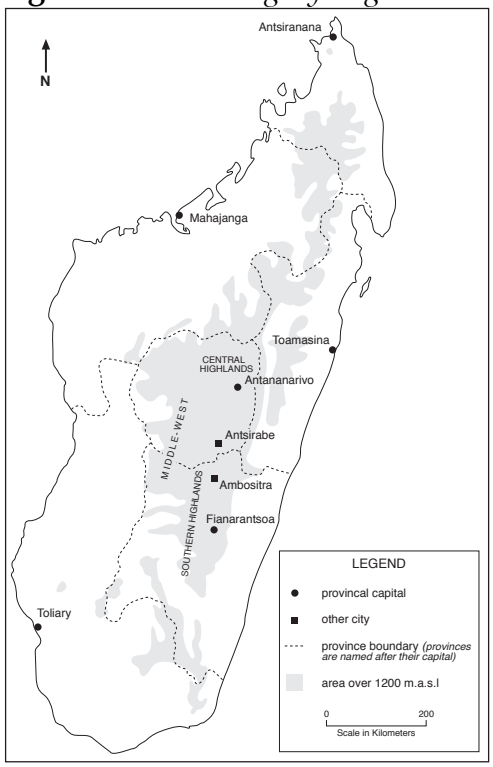
This study relies on historical comparisons of land use in a single locality. In the 1960s and early 1970s, French geographers and rural sociologists undertook detailed investigations of Malagasy

villages that included descriptions of the agricultural system, land tenure, and socioeconomics (see Donque 1979 and ORSTOM et al. 1995). These village studies are very useful for historical comparison, as revisiting a field site -- whether one's own or someone else's -- can yield important insights into longer-term processes of change (see e.g. Tiffen et al. 1994; Geertz 1995). In 1994 and 1996 I visited the hamlet of Leimavo, previously studied in the late 1960s by geographer Jean-Pierre Raison (1970; see also 1969, 1984, AGM 1969, and Clery and Rogue 1969). Raison's work was based on field surveys, aerial photo mapping, and on a detailed land tenure cadaster established by the French in 1934. I compared current land use with Raison's excellent maps and interviewed local residents. Air photos from 1950 and 1991 were also analyzed. Finally, a review of the literature provided the regional and historical context.

The Malagasy Highlands

The Malagasy highlands (Fig. 2) cover some 120,000 km^2, or about one-fifth of the island. Elevated between 1,000 and 2,700 m above sea level, the physiography varies dramatically, including rolling hills, large plains, volcanic cones, granite massifs, and deeply-incised valleys. Soils are largely lateritic, with some volcanic soils and alluvial soils in the valley bottoms and plains. The climate is moderated by the altitude, with cool, dry winters averaging 12° to 15° C and warm, wet summers averaging 19° to 23° C. Annual precipitation ranges from 1,200 to 1,400 mm, falling largely December through March. The highlands, home to the Merina and Betsileo ethnic groups, are one of the most populous regions of Madagascar, with over six million people and population densities exceeding 200 people per km^2 in certain areas. The agricultural system centers on intensive smallholder production of wet rice (the preferred staple) and a variety of dry-land crops such as corn, cassava, sweet potatoes, beans, fruit trees, and market vegetables. Zebu cattle graze on open lands, fallow fields, or are fed handcut grasses, and provide traction, manure, prestige, and capital.

Figure 2: *The Malagasy Highlands*



People from around the Indian Ocean rim first settled Madagascar some 1,500 to 2,000 years ago, but the highlands probably remained untouched until 1,300 years ago when the first pastoralists passed through this region. As that time, highland vegetation was characterized by a mosaic of riparian forest, woodlands, heath, and grasslands. The earliest evidence of permanent settlement in the highlands is in the thirteenth century, concurrent with increased burning for pastures, agriculture, and hunting which dramatically expanded the grasslands (Burney 1987, 1997; Dewar and Wright 1993).

By the fourteenth century, highlanders lived in politically-organized fortified hilltop settlements (Dewar and Wright 1993). As the population grew, competing small kingdoms developed, and by the early 1800s these were united into the Merina kingdom which conquered much of the island. The incipient kingdoms mobilized their subjects to transform the plains and swamps into irrigated rice fields with canals and dikes, an intensification necessitated by population growth and the exhaustion of forests. The political stability of the 1800s led to the abandonment of the hilltop fortified settlements for more dispersed hamlets and lone houses closer to the valley-bottom rice fields (Raison 1972; Le Bourdiec 1974; Berg 1981).

By the nineteenth century, populated areas had developed much of the agricultural system found today. Intricate rice fields covered the large plains, river valleys, and some slopes; cassava, sweet potatoes, corn, and peanuts grew on the hillslopes, and cattle were raised on the hill and mountain pastures. Grasslands covered vast expanses, with isolated forests in ravines or tapia (*Uapaca bojeri*) woodlands in rockier zones.

France conquered Madagascar in 1896 and stayed until 1960. Colonial laws and the resource extraction economy had several impacts on highland land use, including land tenure arrangements, agriculture, and forestry. When voluntary land registration programs failed in the 1930s, the colonial government prepared land title deeds and cadasters for the most populous highland areas, including Leimavo (Raison 1969). This process temporarily destabilized the tenure regime; many peasants chose to ignore it and continued traditional systems of tenure. The new titling scheme solidified existing social classes and created new stratifications, as absent sons were often not allocated land, yet it also allowed for increasing commercialization of land use by absentee investors (Vogel 1973; Phillips 1986). The colonial government also granted concessions to settlers, but aside from rice plantations at Lac Alaotra and some ranches and small farms in the Moyen-Ouest, few were located in the highlands. Colonial efforts in the highlands centered not on a plantation economy, but on improving and 'rationalizing' peasant agriculture. First, taxes were levied; later, great amounts of research and extension efforts sought to improve crops and livestock. In addition, while the French extracted great amounts of timber from the eastern forests, in the highlands they concentrated on afforestation in order to supply the cities and train lines with fuel and construction wood. Over 230,000 ha were planted by the 1960s (Gade and Perkins-Belgram 1986)

For the most part, the newly independent Malagasy government of the 1960s continued earlier policies, including for example a tree-planting requirement. The greatest influence on land use in this era was the *Opération Productivité Rizicole*, which sought to increase rice production through modernized cultivation practices. The socialist period following the revolutions of 1972 and 1975 had deeper implications for the rural economy and land use. The new socialist government eschewed external funding, nationalized 70% of the economy, and centralized agricultural marketing. Fertilizer inputs plummeted and poor rice prices reduced incentives to produce. As a result, the country imported more rice than it exported for most of the 1970s and 1980s (Barthélemy 1988; Dorosh et al. 1990).

The 1980s were a period of financial crisis, with external debts and International Monetary Fund (IMF) stabilization and structural adjustment programs; the effects on highland land use were mixed. On the one hand, an increase in rural insecurity to cattle and crop rustlers led farmers to abandon some newly settled lands or sell their cattle. Seasonal migration declined and many farmers returned to older agricultural techniques. On the other hand, several market-oriented rural areas prospered during this period of economic disorganization and state weakness, for the cities depended on these areas for food. More recently, the IMF-guided deregulation of the rice market in 1982 and trade liberalization in 1987 have begun to contribute to increased rice production (Barthélemy 1988; Dorosh et al. 1990; Mukonoweshuro 1994; Raison 1994).

Study Site

Leimavo is located in the Sahasaonjo Valley, just west of the town of Andina, 15 km west of Ambositra in Fianarantsoa province (Fig. 2). The current *fokontany* (municipality) of Leimavo, which also includes land outside Raison's (1970) study area, split from the former larger *fokontany* of Anjama in 1995. The Ambositra region, also known as Betsileo-Nord, is characterized by high relief and impressive terraces of rice paddies. Leimavo covers just under a square kilometer of land stretching from the Sahasaonjo River up a south-facing hillslope from 1,250 to 1,430 m a.s.l. These benched slopes are planted with cassava, corn, sweet potatoes, and ground nuts and dotted with fruit and eucalyptus trees. On some slopes, particularly in hollows, terraces of rice spill water from one level to the next, while the valley-bottom is developed into large rice fields. During my visits in the winter of 1994 and in spring of 1996, numerous paddies were planted with market vegetables and wheat. Vegetable crops are supplemented by a variety of livestock, including cattle, pigs, and fowl. While in the 1800s village homes were concentrated on the hilltop, now its adobe houses stand scattered or clustered in small family hamlets. In the upper slopes of the town there is a primary school and health dispensary. A network of paths connect the houses to two dirt roads that meet and lead to the town of Andina. The bridge over the Sahasaonjo River broke under the weight of a truck in 1993; all transport occurred on foot through 1996.

Leimavo's 40 or so households vary in wealth and access to land. Rice field ownership varies from zero to 1.8 hectares, averaging between 0.25 and 0.75 ha, while the average household owns 0.68 ha of hillside land (Raison 1970). Forty-two percent of lands in the Andina area are cultivated by renters or sharecroppers (Clery and Rogue 1969). In addition, at least one-tenth of Leimavo's land is owned by outsiders (Raison 1970). Poorer families work as wage labor, and rent or sharecrop land. Permanent out-migration has kept population steady, from 204 in 1967 to 213 in 1994. Seasonal migration as agricultural labor to regions such as Itasy or Lac Alaotra is periodically common; Raison (1984) found that over 60% of Leimavo's men had done so at least once.

The following profile of a wealthier family encapsulates many characteristics of rural land use and life in Leimavo, as well as several of the trends of the past decades. Mr. and Mrs. R. live in a typical two-story adobe house and have 13 children. Mr. R. inherited the land from his parents, who died when he, the only son, was only two months old. He owns three parcels recorded during the 1934 land registration program: a hillside plot including his house and a variety of rainfed fields, a valley-bottom parcel over 500 m away, and a river-side parcel at one km distance. The household grows about 1.5 ha of rice. This staple is supplemented by corn, cassava, sweet potatoes, beans, and potatoes. The family used to grow vegetables such as cabbage and peas in the drained off-season riverside rice paddies, but crop diseases and government extension encouragement led them to switch to wheat in 1991. By 1994 they

produced around 400 kg of marketable wheat, relying on inputs such as urea and NPK fertilizer; in 1996 the harvest was higher but Mr. R. could no longer afford commercial fertilizer.

The family also owns 30 orange trees, ten of which are in commercial production and yield 20 bushels a year. Other trees on the family's land -- peach, guava, loquats, tamarinds, coffee, and eucalyptus -- are used for family consumption. Mr. R. considers the coffee trees as an experiment, for he sees the rise in coffee prices. The family generally buys wood fuel from others, as they have too few trees to harvest. In front of the house a cattle pen, sunk into the ground and surrounded by stone and earth walls, holds three zebu steer and four cows. The cattle graze on fallow or harvested lands, and are also hand-fed rice straw, grass, and cassava. The manure and household compost collected in the cattle pen is used to fertilize the rice paddies. One of the cows produces 2.5 to 4 liters of milk daily for half the year, which the family sells in Andina; the other zebu are sold to butchers when they get old. Besides cattle, the household also owns dozens of chicken and five adult ducks.

Twentieth Century Land-Use Change in Leimavo

An analysis of land-use change in Leimavo suggests several major and minor transformations in the village's agricultural landscape during this century.

Regional Expansion of Agriculture

The first trend, the settlement of nearby uplands, occurs outside Leimavo, yet is very relevant to Leimavo's water and pasture resources. While Leimavo was already fully cultivated at the time of the 1934 land tenure cadaster, many of the uplands in the Sahasaonjo Valley were open pastures. Since that time, the uplands have gradually been worked by the spades of families in search of land. Beginning in the 1920s, uphill settlers got authorization from the colonial authorities to create new rice paddies with water collected on the nearby 1,700 m plateaus (Raison 1970). Comparison of air photos from 1950 and 1991 documents this trend in the 10.6 km^2 hill region uphill from Leimavo (Table 1; Fig. 3). In 1950, 3.2 km^2 of pasture graced the upper 30% of watershed lands. By 1991 only 0.4 km^2 of open pasture remained in the watershed, largely due to a 2.4 km^2, or 42% increase in croplands but also due to a smaller increase in woodlots.

Figure 3: *Regional Land-Use Change, Leimavo Watershed, 1950-1991*

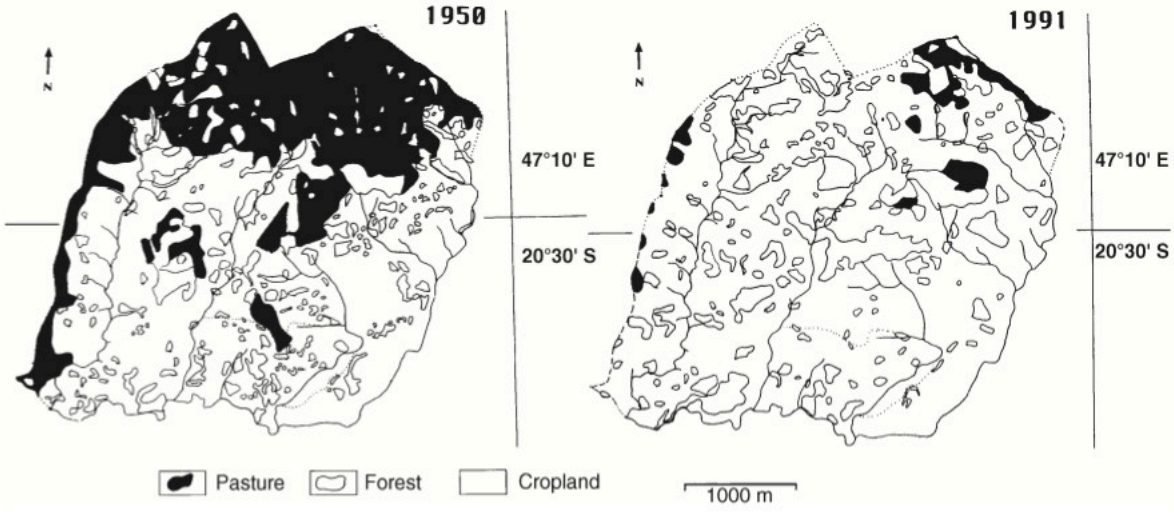


Table 1 *Changes in Land Use in the 10.6 km² Region Uphill from and Including Leimavo, Based on Figure 3.*

	1950		1991		
	km²	% of total	km²	% of total	change
Forest	1.6	15	2.0	19	+ 24%
Cultivated	5.8	54	8.2	77	+ 42%
Pasture	3.2	30	0.4	4	- 87%

The expansion of cultivation upstream was pushed by the historical growth of the population. Table 2 presents a synopsis of population change in the region. While frequent changes in administrative boundaries and names, as well as some low-quality data, make the accuracy of some figures questionable, the general trends are evident. A period of stagnation from the 1930s to the 1950s, where disease mortality and out-migration actually lowered the population of Ambositra district (AOM 1933-44; Raison 1984), was followed by a period of steep growth. Population grew at a rate of 3.4% in the district in the 1960s. More recently, while national population growth continues apace, the Ambositra region appears to have slowed its growth through continued out-migration. As a result of the population explosion since the 1950s, with densities now surpassing 200 per km², some farmers moved to the cities or migrated in search of agricultural land or labor; others chose to cultivate the cooler, poorer soils of the upland pastures (Raison 1970; Le Bourdiec 1974).

Table 2 *Population in the Study Region, 1900 to 1990s*

	1900s	1930s	1940s	1950s	1960s	1970s
Madagascar	2,644,675[1]	3,760,000[2]	4,080,000[2]	4,776,000[2]	6,562,041[3]	7,603,790[4]
Ambositra district[a]	125,145[1]	160,819[6]	158,505[6]	~180,000[7]	~250,000[7]	295,539[8]
Andina canton[b]		6,950[7]	6,930[7]	8,758[7]	11,043[7]	12,061[7]

Notes.

[a]*Data reflect the Province of Ambositra (1904), District of Ambositra (1933, 1944), Districts of Ambositra and Fandriana (1956, 1966), and the Fivondronas of Ambositra and Fandriana (1975, 1993), all of which cover the same geographic area.*

[b]*Data reflect the Canton of Andina (1939 to 1975), and the Firaisana of Andina (1993). Today's firaisana however no longer correspond with the original cantons; Ambositra district has gone from 14 cantons to 21 firaisana.*

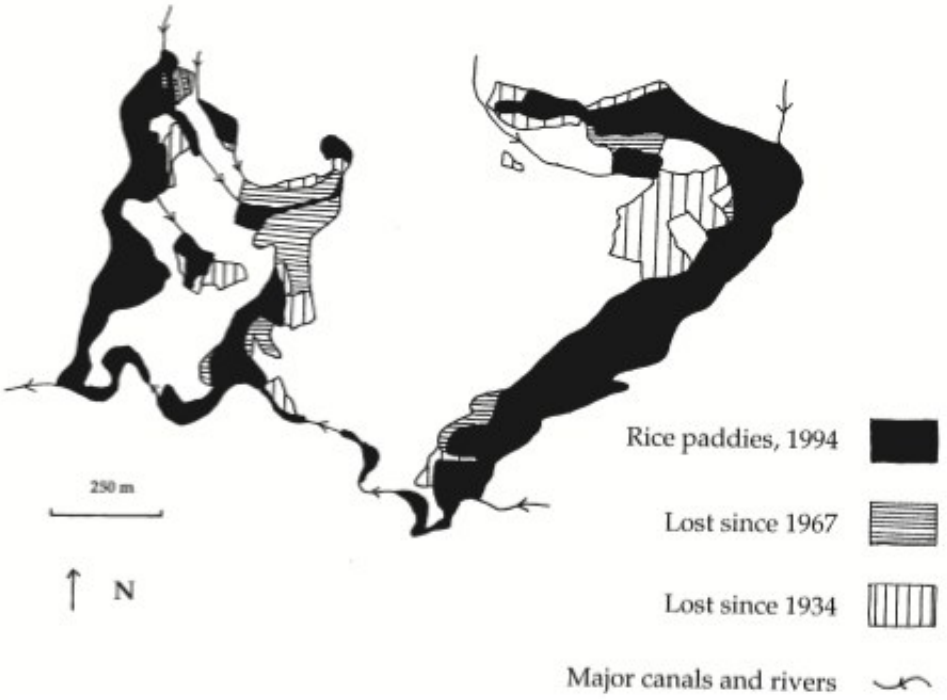
Sources.

[1]*Gouvernement Général 1906,* [2]*Bastian 1967,* [3]*AGM 1969,* [4]I*UCN/UNEP/WWF 1987,* [5]*Repoblikan'i Madagasikara,* [6]*AOM 1933-1944,* [7]*Raison 1984,* [8]*Ministère de l'Agriculture 1978*

Loss of Rice Paddies

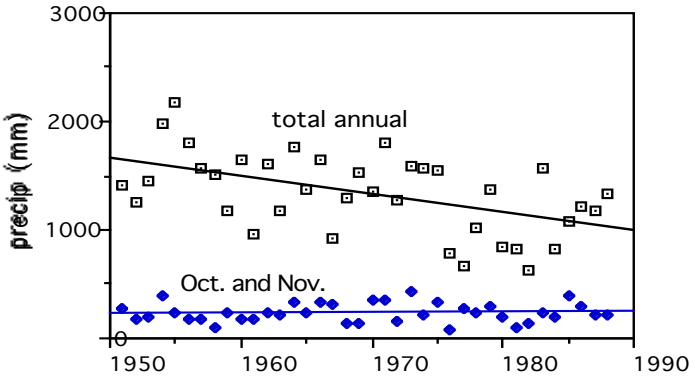
The surface area irrigated for wet-rice cultivation has declined in the past six decades. Several terraces of rice paddies stand in disuse; others are planted with orange trees or other crops. Raison's (1970) research showed a 22.4% decline from the 1930s to the 1960s; my fieldwork shows an additional loss of 20% from the 1960s to the 1990s (Fig. 4). Raison distinguishes between three types of rice fields: the valley-bottom large, undrainable fields; the steeply terraced tributary valleys; and the terraced, deep soiled, moderately-sloped hillside paddies. The majority of change in rice cultivation has occurred in the latter category.

Figure 4: *The Loss of Rice Paddies in Leimavo. Note that this map simplifies the actual situation, where a few modern paddies did not exist in 1934 and/or 1967. Sources: Raison (1984) and AGM (1969).*



Several potential explanations are suggested for this trend. A local man blamed the rice paddy decline on diminishing rainfall, a hypothesis supported by precipitation records at Ambositra, over the mountain 15 km to the east, slightly more humid and subject to winter fogs (Raison 1970). There, rainfall has decreased noticeably during the past 40 years (significant at 0.001; see Fig. 5), as it has in four of six stations nearby (Ramamonjisoa 1995). Less precipitation reduces available irrigation water, especially for hillside paddies that are completely dependent on canals. Interestingly, however, precipitation during October and November -- crucial months for the transplanting of main season rice -- has remained constant (Fig. 5), suggesting that rainfall is not the only factor.

Figure 5: *Precipitation at Ambositra, 15 km East of Leimavo, 1950 to 1988*



Source: Service de Météorologie, Antananarivo

Raison (1970) argued that the loss of rice fields is the result of the interception of water by newly-settled upstream cultivators; this argument was repeated by Mr. R. As described above, large expanses of Leimavo's watershed have been converted from pasture to cultivated lands, including irrigated rice fields. Some water then evaporates from the paddies or infiltrates into the soil, altering the hydrologic regime and leading to a reduction in flows to Leimavo. Other farmers (Raison 1970) blamed the loss of rice fields on the spread of water-hungry eucalyptus trees, which can cause a localized lowering of the water table (Le Bourdiec 1974; Rakoto Ramiarantsoa 1995a). As I show below, however, in the last three decades the number of eucalyptus has actually declined in Leimavo, while the loss of rice paddies has continued. A final explanation looks to the economic policies of the Malagasy government. The nationalization of rice marketing and price controls in the 1970s reduced farmer incentives to grow rice beyond subsistence needs (Vérin 1994). Farmers sought more profitable uses for their land; as a result, 60% of Malagasy are net purchasers of rice (Barrett 1997). In Leimavo, several former hillside rice fields are now profitable orange and mandarin groves.

The trend of disappearing rice fields has persisted for over six decades. Raison (1970) argues that the settlement, rice-field development, and water piracy of uphill areas is the primary cause of this trend, forcing Leimavans to seek alternative income possibilities. This explanation, however, must be supplemented with the fact of reduced precipitation, as well as with the effects of economic stimuli, such as the rice-price controls of the 1970s or lucrative market opportunities such as oranges.

Bovine Decline

The decline in rice area is accompanied by a decrease in the village cattle population. In 1967, villagers owned about 100 head of cattle, and anecdotal evidence suggests that previous herds were much larger (Raison 1970). Interviews in 1994 confirmed that the cattle population had continued to decline, with only some two dozen cattle currently present. Bovine decline is also a regional trend (see Table 3). While in the 1960s, the average household owned 4.1 heads of cattle, today only a few households, such as the R. family, own cattle at all.

There are three ways to explain the bovine decline: loss of pasture, rural instability, and changing socioeconomic traditions. First, the long-term process of intensification from a mixed pastoral economy to intensive agriculture has slowly reduced the cattle population as pasture

becomes more scarce. Raison (1970) notes that the traditional pastures of Leimavo lie to the south, across the Sahasaonjo River, but that these areas are now cultivated. The second, more immediate reason for the decrease in cattle is insecurity. During the 1980s fiscal crisis the nation experienced a dramatic increase in cattle thefts by bandits. About 20 cattle were stolen in the Sahasaonjo valley, and in 1983 Leimavo itself was attacked. The threat of cattle rustling makes it more attractive for farmers to sell their cattle than risk losing them in the future, investing the money in land, agriculture, or to purchase manure like Mr. R. (Fujisaka 1990; Raison 1994; Ramamonjisoa 1995). While cattle rustling is not new to the highlands, access to modern weapons and the weakness of the state have recently allowed the bandits greater power. Finally, bovine decline may also be a result of the preference for paying cash for wage labor instead of keeping animals for exchange-based labor and ceremonial occasions (Fujisaka 1990).

Table 3 *National and Regional Cattle Population 1904-1991.*

political unit /year	Madagascar	Fianaranstoa province	Fianarantsoa prefecture	Ambositra fivondrona
1904	2,867,612			
1939	5,266,000			
1945	5,941,000			
1951	5,912,000			
1965	6,421,079			
1974	6,042,600	1,025,268	739,089	
1977	6,171,306	967,040	630,520	
1985	7,461,114	809,603		47,818
1991		681,574		18,919

Sources: Ramaroson and Razafindrakoto (1972-3); Service de Statistique Générale (1953); Ministère de l'Agriculture (1974-1991); and Gouvernement Général (1906).

Fruit Tree Expansion

The Leimavo-Andina region has become a renowned center for fruit tree crops, primarily oranges and mandarins. Oranges were cultivated in the highlands already in the 1870s (Vérin 1969). By 1905 there were 41 hectares of fruit trees in the Ambositra region -- largely owned by Europeans (Gouvernement Général 1906). In the 1930s, Andina was already well-known for the quality of its orange production (Raison, pers. comm.). At that time oranges were still unimportant to the village economy of Leimavo, yet by 1967 the village had 500 productive trees (Raison 1970). By 1994 there were far more than 5,000 productive trees. Some orange trees, such as those of the R. household, are grown informally and intercropped with corn, cassava, or other crops. The rights to the orange harvest are sold to collectors before the fruits ripen, and these collectors are then responsible for marking the fruit, maintenance, pesticides, harvest, and transport. Other orange trees are cultivated in well-kept groves, ringed with impenetrable sisal hedges. One enterprising Merina investor living in Andina owns several such groves in Leimavo. He also operates as an orange collector, as do some Leimavans and other merchants from Ambositra and Antsirabe.

The development of Leimavo's fruit specialty is clearly driven by market forces (see Suryanata 1994 for similar arguments in Java). The reputation of Andina canton for oranges and the existence of a well-functioning commercialization network promoted the expansion of this

crop, as did the unsure profitability of rice in the face of state price controls (Raison, pers. comm.). Oranges became simply more profitable than rice. The cultivation of oranges also has interesting tenurial aspects. First, the colonial land cadaster has facilitated land transfers, absentee land holdings, and expensive yet long-term investments in profitable tree crops. Second, Suryanata (1994) points out that the complex tenurial relationships of fruit-tree cultivation, where trees and their harvest are often leased or sharecropped separate from the land they grow in, can have an important impact on the actual land-use strategy. This is clearly the case in Leimavo, where the groves of outside investors are monocropped and locally-owned groves -- to which harvesting rights are sold to collectors -- are intercropped with subsistence crops.

Market Cultivation

A fifth important development in Leimavo's agricultural landscape is the advent of commercial vegetable and grain crops. The growth in grain production is due to the demands and extension efforts of the food industry in Antsirabe. The baguette has become the fast food of the urban Malagasy, and wheat production is encouraged by government extension (H. Wright, pers. comm.). As a result, winter grain crops now add color to the landscape in the Vakinankaratra region (Ramamonjisoa 1995), but also on Mr. R.'s fields in Leimavo.

Vegetable crops other than leafy greens were practically non-existent in the highlands in the 1820s, but by the 1860s the European presence led to the introduction of a large variety of crops (Donque 1964). By 1905, Ambositra province already had ten hectares of market vegetable crops (Gouvernement Général 1906). In the 1960s, one-eighth of the farmers in Anjama hamlet west of Leimavo grew tomatoes, cabbage, or leafy greens (Clery and Rogue 1969), yet in Leimavo market vegetables were still non-existent (Raison, pers. comm.). Now, however, significant areas of Leimavo are planted with vegetable crops, particularly in drainable off-season rice paddies or in the *vodi tanety* fields at the base of hillslopes (Blanc-Pamard 1986). These plots support entire crops of tomatoes, potatoes, wheat, and leafy greens -- as well as green onions, peas, cabbage, parsley, pumpkins, and cucumbers -- mostly destined for markets at Andina and Ambositra. The expansion of vegetable cultivation is clearly a result of market forces, a trend noted throughout the highlands (Donque 1964; Portais 1974; Rakoto Ramiarantsoa 1995a). Market vegetables are to a large extent a female crop, for men are often absent during the off-season earning money as migrant laborers (Le Bourdiec 1974).

Forests and Trees

At the turn of the century there were little or no trees in most highland areas; early Europeans invariably commented on the vast grasslands of this region. Aside from some fruit trees associated with its hamlets, Leimavo and its region were once much more open. Air photo analysis of Leimavo's surroundings documents a 24 percent increase in tree cover in the past four decades (Table 1, Fig. 3), largely due to eucalyptus afforestation. The case in Leimavo itself, however, is much less clear, and demonstrates a dynamic tree cover. The area under tree cover, 15 hectares in 1950 and 17 hectares in 1991, has hardly changed. However, the type of tree cover has changed. Orange groves expanded while eucalyptus stands declined. Field investigations in 1994 show that of the 13 major stands of eucalyptus mapped by Raison in 1967, six have disappeared, while only two new stands were established.

The evolution in tree cover reflects a variety of factors. Afforestation policies promulgated by both the colonial and early independent governments encouraged and even required tree planting (Gade and Perkins-Belgram 1986). A dramatic expansion of eucalyptus planations in the highlands east of the capital has occurred as a result of the urban market for

fuelwood and lumber, as well as the desire of residents to use trees to claim and mark land tenure (Bertrand 1995; Rakoto Ramiarantsoa 1995a, b). Similarly, Leimavo's woodlots are profitable to their owners, as sources of marketable building materials and fuel. The net loss of woodlots in Leimavo proper may be the result of the end of tree-planting policies in 1972 and from population pressure (Gade and Perkins-Belgram 1986), yet it more likely reflects purely economic decisions for alternative land uses.

Coffee and Tobacco Cultivation

Finally, coffee and tobacco have come and gone in Leimavo. The French introduced coffee to the region as early as the turn of the century. From 1953 to the mid-1960s a coffee nursery in Andina provided up to 85,000 *Arabica* plants per year; in 1967 coffee covered over two ha in Leimavo (Raison 1970, 1984). However, several frosts, a worldwide drop in coffee prices, and increased competition from coffee growers on the eastern escarpment (Raison, pers. comm.) led to the gradual abandonment of coffee. By 1994 only a few trees remained. Tobacco cultivation -- which also covered almost two ha in 1967 (Raison 1970) -- has suffered a similar fate as marketing controls and competition from better-suited regions reduced the profitability of the crop.

Explaining Land-Use Evolution

The landscape of the highlands changes from decade to decade, from century to century. The agricultural transformations of Leimavo are but one of many trajectories of change in Madagascar; others include the vast grasslands of the Moyen-Ouest slowly colonized by migrants, or the great forest of the east rapidly retreating in the face of cultivators. How can we explain and understand these changes? In this section I present a conceptual model -- the range of choice -- as a useful way of understanding the process of land use change.

The sections above described and attempted to explain land-use change in Leimavo. Explanations mentioned included population pressure, reduced rainfall, economic incentives, government policies, extension efforts, tenure security, and increased banditry. Also relevant are gender and class dynamics, such as the landless providing labor for the orange barons, or women using market vegetables to gain an economic foothold. What is missing is a means to link these explanations into an overall understanding of the process that leads to land transformation. In order to make sense of the forces affecting land-use evolution, one needs an approach that handles a variety of intertwined, yet distinct explanations. Much research on rural land use has focused on single-theory explanations such as ecological regulation, neo-classical economics, political economy, or local structures of access. It is clear that each of these diverse approaches have their persuasive moments. Yet, often more than one theoretical orientation can contribute to the analysis of rural society and land use. Explanatory theories are more usefully regarded as complementary than as exclusive (Shipton 1989; Hefner 1990; Turner et al. 1993). This is the spirit of much recent writing under the rubric of political ecology, which began as a call for cross-fertilization between Marxian political economy and ecological approaches (Blaikie and Brookfield 1987; see also Peet and Watts 1996).

Inquiry that accepts plural explanations requires some mode of organizing and conceptualizing a variety of ideas. Gilbert White's "range of choice" concept (White 1961; see also Wescoat 1987) provides a useful way to organize the contributions of various theories of land use change. It is chosen here because it emphasizes political ecology's concern with the land manager, for farmers, wage laborers, and landlords are the primary actors in the land transformations of so much concern in Madagascar. The range of choice concept is based on the assumption that a person's use of land resources reflects the range of opportunities, or choices, he

or she possesses. The practical range of choice available to the land user is conditioned by ecological, political-economic, cultural, market, perceptual, and social factors (Wescoat 1987). For example, diminishing rainfall may exclude certain agricultural strategies, while IMF-inspired liberalization of rice marketing gives paddy owners wider choices. Similarly, the advent of an urban vegetable market can increase the choices available to a household, just as social differentiation may limit the choices of poorer households.

The range of choice concept, when used in this way, results in a conceptual decision-making model not unlike Blaikie's (1985) scheme of land use decisions and soil erosion. The assets, income opportunities, and access qualifications of households are evaulated in order to decide their land use strategies. Thus, when considering land transformation in a specific region the analyst must imagine the range of opportunities and obstacles facing local land managers, both rich and poor. Imagine Mr. and Mrs. R., profiled earlier. They need to satisfy their basic needs for food, shelter, and clothing and to earn money for taxes, school fees, medicine, tools, celebrations, and so on. The options available to meet these needs are to utilize the land they own or to migrate seasonally or permanently in search of employment. Their uses of the land are constrained by the soil and water resources, the extent of their access to resources, and the availability of family or hired labor, while market prices dictate opportunities. Cultural preferences and priorities will also shape their choices, as will the evolution of social structures in their post-colonial society.

Watts (1978, 240) criticizes what he calls the Kates-White-Burton paradigm, the origin of the range of choice concept, for a lack of social theory to address the mediation of individual action by social context and political economy. My use of the range of choice is meant only to be seen as a heuristic device to link the contributions of relevant theories, *including* theories of social change. Such theoretical analyses should be the focus of any work, and the range of choice employed only as a tool to come to terms with the whole picture of human-caused land transformations. It is through the range of choice, for example, that we can combine factors of climatic variation, market stimuli, and culturally situated meanings of certain crops into one model. As such, the range of choice must of course be seen as a historically changing range, molded through the processes predicted and explained in political-economic, ecological, social, and other theories.

Conclusion

The example of Leimavo, when viewed through the range of choice model, provides several lessons. The land managers of Leimavo have transformed their use of the land based on the opportunities and obstacles facing them. Population growth, for example, constrained pasture lands and helped cause reduced water flows to Leimavo, causing a reduction in cattle and in rice fields. The Leimavan farmers were forced to seek other opportunities to meet their needs, and found those in the profitable orange crop and in the intensified use of off-season rice paddies to produce other marketable crops. Government policies sometimes constrained their choices, as when rice prices were controlled, or broadened them, as with the promotion of winter grain crops. The farmer's position in society -- as dictated by wealth, class, gender, or even the results of the 1934 cadaster -- further dictated his or her choices.

In Madagascar, booming populations, growing market demands, and the associated extension and intensification of agriculture have led to Malthusian concerns of resource degradation. In the east, demographic pressure and political-economic forces cause unprecedented rates of deforestation. In the highlands, Mittermeier (1988, 12) implies that due to humans, "the country is now a barren landscape." However, Leimavo's landscape of rice paddies and orange groves tells another story, one of constructive environmental change. The

intensification of agriculture can slow soil erosion, as labor is expended on soil conserving tactics such as terracing and berms (Tiffen et al. 1994). The densely-settled region around Leimavo is a case in point, with widespread benching of hillslope lands and little evidence of erosion. Similarly, in areas of intensification, tree cover has often increased. This is the case around Leimavo, just as it is in the Antananarivo region, where tree cover has grown from 22,000 to 60,000 ha in the past three decades (Raharivelo 1995). Rakoto Ramiarantsoa (1995a, b) notes that east of the capital over 70 percent of the land has been forested while population densities reach over 250 people per square kilometer. In these human landscapes, fire-climax grasslands are replaced by an intensive agroforestry system.

Netting (1993) sees population pressure, market incentives, and the social structure of the smallholder farm household coming together to create intensive, sustainable agriculture. He points to examples in China, southeast Asia, Nigeria, and Switzerland to assert the strength and adaptability of this mode of production in areas where land is scarce and labor plentiful. The Malagasy highlands provide a strong case to further Netting's argument. Agricultural intensification, based on demographic growth, market incentives, and a social structure including secure property rights, is taking the once "barren" central highlands, formerly burned annually for pasture, and transforming them into a highly productive rural landscape.

Literature Cited - REFERENCES

A.G.M. 1969. *Atlas de Madagascar*. Tananarive: Bureau pour le Developpement de la Production Agricole and Association des Géographes de Madagascar.

AOM 1933-1944. Rapports politiques et administratives, District d'Ambositra. Archives d'Outre Mer, Aix-en-Provence, France, mad ggm 2/d/19.

Barrett, Christopher B. 1997. Food marketing liberalization and trader entry: evidence from Madagascar. *World Development* 25(5): 763-77.

Barthélemy, J. C. 1988. The case of Madagascar. In *The Supply of Manufactured Goods and Agricultural Development*, 11-81. Paris: OECD.

Bastian, Georges 1967. *Madagascar, Etude Géographique et Economique*. Paris: Nathan.

Berg, Gerald M. 1981. Riziculture and the Founding of Monarchy in Imerina. *Journal of African History* 22(3): 289-308.

Bertrand, Alain 1995. La sécurisation foncière, condition de la gestion viable de ressources naturelles renouvelables? in *Sustainable land management in African semi-arid and subhumid regions* Eds. F. Ganry and Bruce Campbell. Montpellier: CIRAD. 313-27.

Blaikie, Piers 1985. *The Political Economy of Soil Erosion*. London: Methuen.

Blaikie, Piers and Harold Brookfield 1987. *Land Degradation and Society*. New York: Methuen.

Blanc-Pamard, Chantal 1986. Dialoguer avec le paysage ou comment l'espace écologique est vu et pratiqué par les communautés rurales des hautes terres malgaches. In *Milieux et Paysages*, eds. Chantal Blanc-Pamard, Yves Boulvert, Lawrence Busch, Yvon Chatelin, Francis Hallé, Christian Prioul, Jean-François Richard, and Gérard Riou, 17-35. Paris: Masson.

Burney, David A. 1987. Late Holocene vegetational change in central Madagascar. *Quaternary Research* 20: 130-43.

------1997. Theories and facts regarding Holocene environmental change before and after human colonization. In *Natural and Human-induced Change in Madagascar,* eds. Bruce D. Patterson and Steven M. Goodman, 75-89. Washington DC: Smithsonian Press.

Clery, F. and R. Rogue 1969. *Etude de deux secteurs de la Z.E.R. d'Ambositra. Antananarivo*: C.E.F.E.B./Dévéloppement Rural/S.A.T.E.C.

Dewar, Robert E. and Henry T. Wright 1993. The culture history of Madagascar. *Journal of World Prehistory* 7(4): 417-66.
Donque, Gérald 1964. Les cultures maraîchères dans la région de Tananarive. *Madagascar Revue de Géographie* 5: 71-104.
------ 1979. Bilan de dix-sept années de recherches du Laboratoire de Géographie de l'Université de Madagascar. *Bulletin de l'Academie Malgache* 55(1-2): 309-16.
Dorosh, Paul A., René E. Bernier and Alexander H. Sarris 1990. *Macroeconomic Adjustment and the Poor: the Case of Madagascar*. Ithaca: Cornell Food and Nutrition Policy Program.
Fujisaka, Sam 1990. Agroecosystem and farmer practices and knowledge in Madagascar's central highland: toward improved rice-based systems research. *IRRI Research Paper Series* 143.
Gade, Daniel W. and A. N. Perkins-Belgram 1986. Woodfuels, reforestation, and ecodevelopment in highland Madagascar. *GeoJournal* 12(4): 365-74.
Geertz, Clifford 1995. *After the Fact: Two Countries, Four Decades, One Anthropologist*. Cambridge: Harvard University Press.
Gouvernement Général 1906. *Statistiques Générales. Situation de la Colonie au 1er Janvier 1905*. Melun: Imprimerie Administrative.
Hefner, Robert W. 1990. *The Political Economy of Mountain Java*. Berkeley: University of California Press.
IUCN/UNEP/WWF 1987. *Madagascar, an Environmental Profile*. Gland: IUCN.
Le Bourdiec, Françoise 1974. *Hommes et Paysages du Riz à Madagascar*. Antananarivo: FTM.
Ministère de l'Agriculture 1974-1991. *Annuaire des Statistiques Agricoles*. Antananarivo: (Agricultural Ministry, under various names) Repoblikan'i Madagasikara.
Mittermeier, Russell A. 1988. Strange and wonderful Madagascar. *International Wildlife* 18(4): 4-13.
Mukonoweshuro, Eliphas G. 1994. Madagascar: the collapse of an experiment. *Journal of Third World Studies* 11(1): 336-68.
Netting, Robert M. 1993. *Smallholders, Householders*. Stanford: Stanford University Press.
ORSTOM, BDPA and CIRAD 1995. *Bibliographie des Travaux Orstom, Cirad, et BDPA sur Madagascar*. Paris: ORSTOM Documentation.
Peet, Richard and Michael Watts, eds. 1996. *Liberation Ecologies*. London: Routledge.
Phillips, Lucie C. 1986. Madagascar: the Central Highlands. in *Land Tenure Issues in River Basin Development in Sub-Saharan Africa,* ed. Peter C. Bloch, 116-212. Madison: University of Wisconsin.
Portais, Michel 1974. *Le Bassin d'Ambalavao*. Paris: ORSTOM.
Raharivelo, Verosoa M. N. 1995. Evolution de l'état des bassins versants et protection contre les crues de la ville et des plaines d'Antananarivo. *Akon'ny Ala* 16: 24-6.
Raison, Jean-Pierre 1969. Note sur l'utilization des cadastres malgaches pour la réalization de cartes de terroirs. *Cahiers ORSTOM, série Sciences humaines* VI(3): 5-23.
------1970. Paysage rural et démographie, Leimavo (nord du Betsileo, Madagascar). *Etudes Rurales* 37-38-39: 345-77.
------1972. Utilisation du sol et organisation de l'espace en Imerina ancienne. *Tany Malagasy/Terre Malgache* 13: 97-121.
------ 1984. *Les Hautes Terres de Madagascar et leurs Confins Occidentaux*. Paris: Editions Karthala.
------ ed. 1994. *Paysanneries Malgaches dans la crise*. Paris: Editions Karthala.
Rakoto Ramiarantsoa, Hervé 1995a. *Chair de la Terre, Oeil de l'Eau... Paysanneries et recompositions de campagnes en Imerina (Madagascar)*. Paris: ORSTOM.

------ 1995b. Les boisements d'eucalyptus dans l'est de l'Imerina (Madagascar). in *Terre, Terroir, Territoire: Les Tensions Fonciers* , eds. Chantal Blanc-Pamard and Luc Cambrézy, 83-103. Paris: ORSTOM.
Ramamonjisoa, Josélyne R. 1995. Le Processus de développement dans le Vakinankaratra, Hautes Terres Malgaches. Thèse de doctorat d'Etat, Université de Paris I - Panthéon/Sorbonne.
Ramaroson, Seth and Désiré Razafindrakoto 1972-3. L'élevage à Madagascar: situation actuelle et perspectives d'avenir. *Tany Malagasy/Terre Malgache* 14: 1-22.
Repoblikan'i Madagasikara 1993. *Recensement Général de la Population et de l'Habitat: Résultats Préliminaires*. Antananarivo: B.D.E.
Service de Statistique Générale 1953. *Annuaire Statistique de Madagascar, Vol. 1 1938-1951*. Tananarive: Imprimerie Officielle.
Shipton, Parker 1989. Bitter money: cultural economy and some African meanings for forbidden commodities. *American Ethnological Society Monograph Series* 1.
Suryanata, Krisnawati 1994. Fruit trees under contract: tenure and land use change in upland Java, Indonesia. *World Development* 22(10): 1567-78.
Tiffen, Mary, Michael Mortimore and Francis Gichuki 1994. *More People, Less Erosion*. Chichester: John Wiley and Sons.
Turner, Billie L. II., Goran Hyden and Robert W. Kates, eds. 1993. *Population Growth and Agricultural Change in Africa*. Gainesville: University Press of Florida.
Vérin, Pierre 1969. L'agriculture en Imerina il y a un siècle. *Tany Malagasy/Terre Malgache* 6: 95-104.
------ 1994. *Madagascar*. Paris: Karthala.
Vogel, Claude 1973. Organization familiale et territoriale en Imerina orientale. *Cahiers du Centre de Sociologie et d'Antropologie Sociale, Université de Madagascar* 2.
Watts, Michael 1978. On the poverty of theory: natural hazards research in context. In *Interpretations of Calamity: From a Viewpoint of Human Ecology* ed. Kenneth Hewitt, 231-62. Boston: Allen and Unwin.
Wescoat, James L., Jr. 1987. The 'practical range of choice' in water resources geography. *Progress in Human Geography* 11(1): 41-59.
White, Gilbert F. 1961. The choice of use in resource management. *Natural Resources Journal* 1: 23-40.

CHRISTIAN A. KULL is a doctoral student at the Department of Environmental Science, Policy, and Management, University of California at Berkeley. His research interests include the politics of conservation, the use of fire in land management, the history of rural landscapes, and political ecology, particularly in Madagascar.

*This research was supported by National Science Foundation and Environmental Protection Agency graduate fellowships and by the University of Colorado Graduate School. The author gratefully acknowledges the goodwill and comments of Jean-Pierre Raison, the help of Arsène Rabarison in the field, as well as the comments of Henry Wright, Daniel Gade, Jim Scott, Terry McCabe, Jim Wescoat, Gary Gaile and the anonymous reviewers.