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THE DYNAMICS OF HUMAN-ENVIRONMENT INTERACTIONS IN THE TROPICAL MONTANE AGROSYSTEMS OF RWANDA: IMPLICATIONS FOR ECONOMIC DEVELOPMENT AND ENVIRONMENTAL STABILITY

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ABSTRACT Using a historical-ecological approach, this paper explores those human and environmental processes that have shaped the montane agrosystems of Rwanda. The focus is on how the subsistence systems (pastoralism and cultivation) have interacted with a diversity of demographic, socio-economic, and political variables through time to create a high-density "island" within the inter-lacustrine region of Central Africa. Of particular concern are landscape and settlement changes induced by agricultural and economic development policy, natural resource management, and demographic growth. A key question considered is whether Rwanda is moving toward agricultural "involution" or "intensification" in its response to accelerated population growth. Conclusions regarding future population-resource relationships are considered.

RÉSUMÉ *La dynamique des interactions entre la population et l'environnement dans les agrosystèmes montagnards tropicaux du Rwanda: Implications pour le développement économique et la stabilité de l'environnement.* Cette étude utilise une approche historico-écologique pour explorer les processus humains et naturels qui ont modelé les agrosystèmes montagnards du Rwanda. Elle se concentre sur la manière dont les systèmes d'autoconsommation (pastoralisme et culture) ont interagi au cours du temps avec diverses variables démographiques, socio-économiques et politiques, pour créer une "île" densément peuplée au sein de la région inter-lacustre de l'Afrique centrale. L'étude porte un intérêt particulier aux changements de paysage et de peuplement causés par la politique de développement agricole et économique, la gestion des ressources naturelles et la croissance démographique. Un question primordiale se pose: le Rwanda se dirige-t-il vers une "involution" ou "intensification" agricole en réponse à une croissance démographique accélérée? Des conclusions concernant les relations futures entre la population et les ressources sont avancées.

ZUSAMMENFASSUNG *Die Dynamik der Wechselwirkung Mensch-Umwelt im tropischen, bergigen Agrarsystem von Rwanda: Folgerungen für wirtschaftliche Entwicklung und Umweltstabilität.* Unter Berücksichtigung von historischen und ökologischen Aspekten untersucht diese Veröffentlichung die menschlichen und umweltbezogenen Prozesse, die die bergigen Agrarsysteme in Rwanda geformt haben. Der Schwerpunkt der Studie konzentriert sich auf die Frage nach dem Schema, das die Selbstversorgungssysteme (Weidewirtschaft und Ackerbau) langfristig mit den vielfältigen demographischen, sozio-ökonomischen und politischen Variablen verflechtet, um eine so dicht besiedelte "Insel" innerhalb des Seengebietes von Zentralafrika zu schaffen. Auf Landschafts- und Siedelungsveränderungen, die durch landwirtschaftliche und ökonomische Entwicklungspolitik, Naturressourcen-Management und demographisches Wachstum verursacht wurden, wird besonders eingegangen. Eine wichtige Frage stellt sich: Wird Rwanda als Antwort auf beschleunigtes Bevölkerungswachstum sich in Richtung eines landwirtschaftlichen "Rückgangs" oder einer "Intensivierung" bewegen? Schlußfolgerungen bezüglich künftiger Beziehungen zwischen Bevölkerung und Ressourcen werden gemacht.

INTRODUCTION

One of the lesser known mountain regions of the world is that of Central Africa. As depicted in Figure 1, the core of this region centers on the "Mifunbiro" or Virunga Mountains (Speke, 1865; Stanley, 1878) located where the borders of three countries (Rwanda, Uganda, and Zaire) meet on the Great Western Rift Valley near Lake Kivu.

Using a historical-ecological approach, this study explores those human and environmental processes in the mountain regions of Rwanda, particularly in Ruhengeri, Byumba, and Gisenyi Prefectures (Figure 2). It aims to identify and test explanatory hypotheses that may shed light on contemporary population-resource relationships in Africa, and particularly the high-density tropical montane regions.

THE LANDSCAPE

Rwanda's highest mountain areas are in the west along the Nile-Zaire crest (the eastern rim of the Great Rift) and in the north, along the Virunga mountain chain (Figure 3). Vertical zonation is pronounced throughout the region, for example, from the cold summit of Mt. Karisimbi (4,507 m) in the nival zone to the warmer savanna bushland zone on Lake Kivu at 1,460 m. Table 1 shows that at least six natural vegetation zones are traversed within a linear

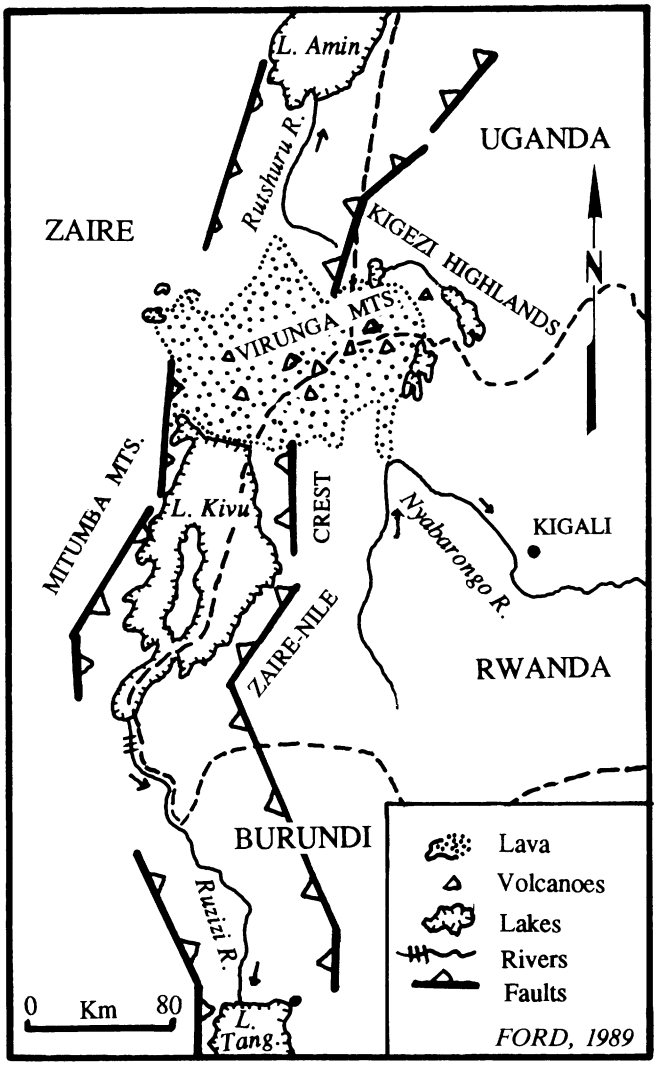

FIGURE 1. Map of the Western Rift Valley area of Rwanda showing the location of the Virunga Mountains.

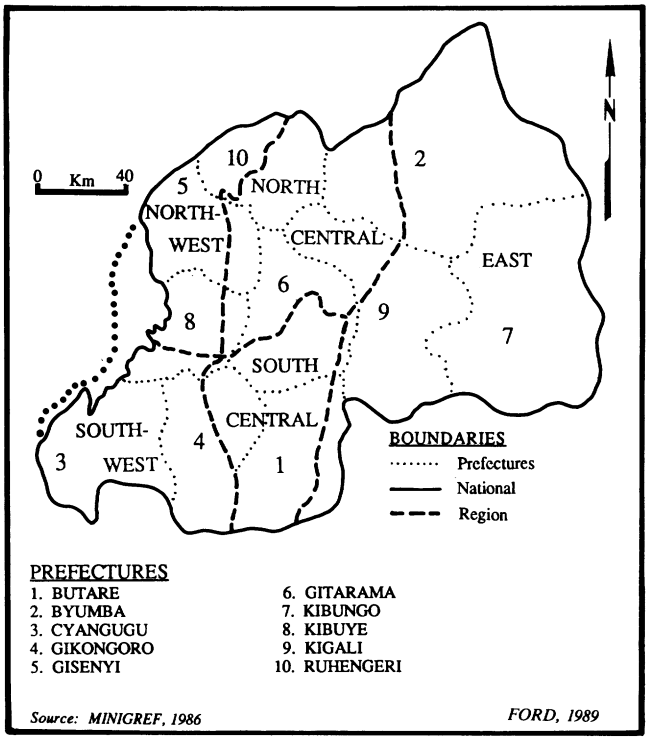

FIGURE 2. The geographical regions of Rwanda.

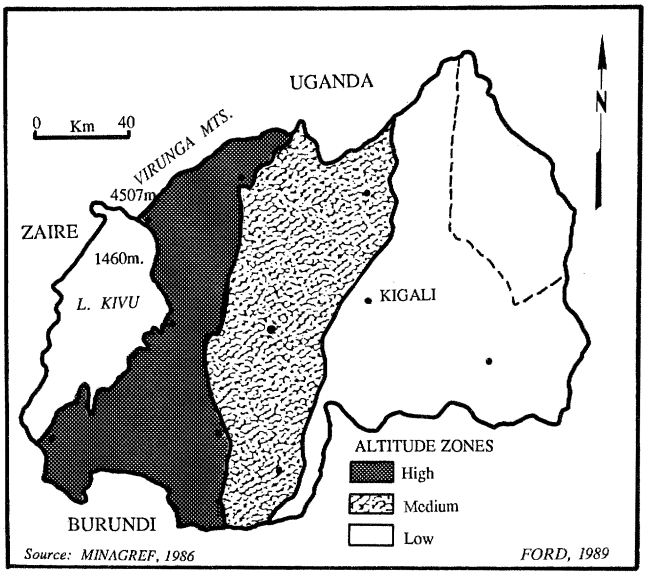

FIGURE 3. Generalized altitudinal zonation in Rwanda.

distance of about 30 km in northwest Rwanda (Hedberg, 1951; Troll, 1968; Lewalle, 1972; Lind and Morrison, 1974; Sirven *et al.*, 1974; Schnell, 1977; UNESCO, 1983; Institut Zairois pour la Conservation de la Nature, no date). Figure 4 shows that crops also correlate closely to altitude. Environmentally, Rwanda shares characteristics with other tropical montane areas in East Africa, such as Mount Kenya (Pritchard, 1979; Nyamweru, 1980; Speck, 1982; Mahaney, 1986).

On the abrupt western face of the Nile-Zaire crest, panoramic vistas of drowned ria coasts on Lake Kivu, cascading falls, and steep slopes characterize a stunningly beautiful landscape. Unfortunately, however, there is also above average susceptibility to severe erosion, catastrophic rainfall, and flooding (Rossi, 1984; Byers, 1988a, b, c; Byers and Nyamulinda, 1988). Localized droughts, due to rain-shadow effects, may also occur. Most of the Nile-Zaire crest and Central Plateau regions (Figure 7) are formed from the Precambrian granitic/gneiss basement complex common to much of Africa, which is less fertile and easily eroded.

On the eastern side of the Nile-Zaire crest, the rolling hills and marshy valleys of the Central Plateau region extend toward the south and east with a gradual reduction in slope gradient and local relief that eventually blends into an area of broad, drowned river valleys, lakes, and papyrus swamps. A sizeable area of savanna woodlands

Table 1
Altitudinal vegetation zones in the Virunga Mountains

Altitudinal belt (m)	Vegetation zones	Principal plants	Location
Over 4,500	Nival zone[1]	Moss, lichen	Karisimbi
3,700-4,500	Upper afroalpine	*Senecio, Lobelia, Alchemilla*	Sabyinyo, Bushokoro, Muhabura, Karisimbi
3,500-3,700	Lower afroalpine (Ericaceous belt)	Giant heather, moss, lichen	Sabyinyo
2,600-3,500	Hagenia woodland	*Hagenia,* epiphytes, etc., *Hypericicum*	Bushokoro, Karisimbi, Sabyinyo, Muhabura
2,200-2,600	Bamboo forest	*Arundinaria, alpina*	Gahinga, Visoke, Karisimbi
1,700-2,200	Afromontane forest (agriculture)	*Podocarpus, Usambarensis, Lauraceas*	Gishwati, Nyungwe
1,400-1,700	Bush savanna (agriculture)	Sclerophilic plants/bush	Volcanic plains (Nyragongo, etc.)

[1]The Nival zone is very minimal; there is no permanent snow or ice.
After Sirven *et al.* (1974); Mahaney (1986); Schnell (1977); Institut Zairois pour la Conservation de la Nature.

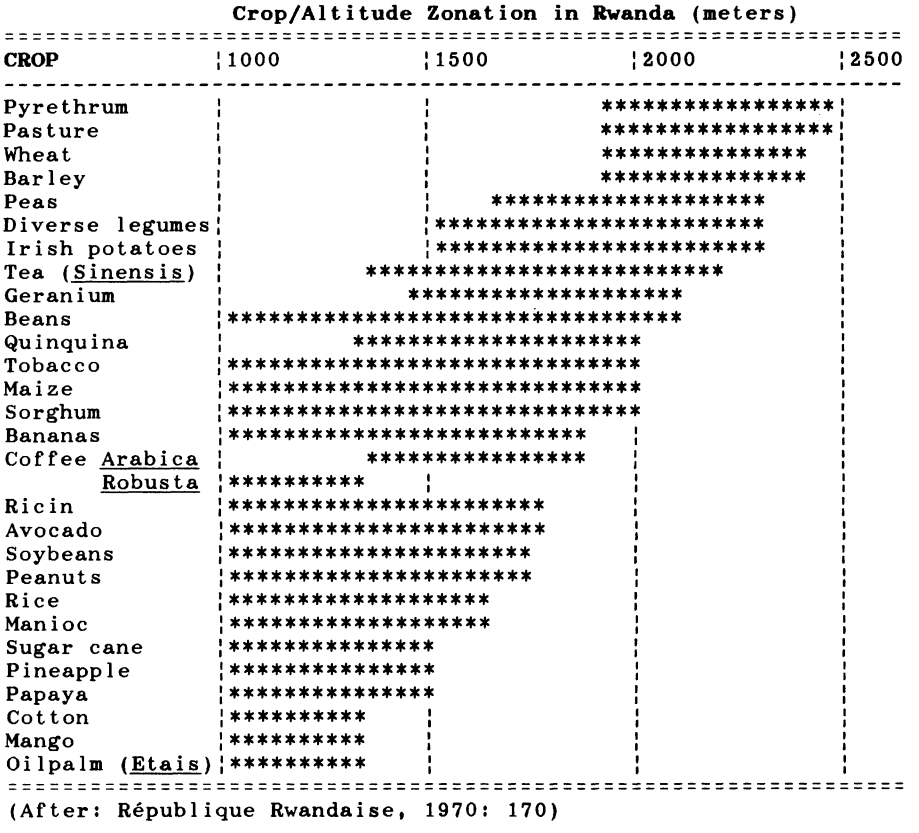

Figure 4. Crop-altitude zonation in Rwanda.

and grasslands is found in the easternmost region, most of it within the Akagera National Park which occupies almost 10 percent of the country's surface area (Figure 5).

Hydrology

The region has several features related to past tectonic and other geomorphic events. Isostatic uplift in the Lake Victoria depression and faulting and rifting in the western Great Rift Valley reversed the course of the Nyabarongo and other rivers (Beadle, 1981: 231-266; Roark and Dickson, 1986), and many marshes and lakes were formed. In addition, recent volcanic lava flows from the Virunga Mountains diverted the upper reaches of the Rutshuru River-Lake Idi Amin (Lake Edward) into the Victoria Nile (Nyamweru, 1980: 47-88).

The creation of Lake Kivu was one result of this vulcanism. It is surely one of Africa's most beautiful lakes, and one of the few not infested with bilharzia. In addition, it has a high dissolved methane content (a significant potential energy reserve), a severely impoverished natural fauna, and a beautiful ria coastline (Beadle, 1981: 267-275). After being blocked in the late Pleistocene, Lake Kivu eventually

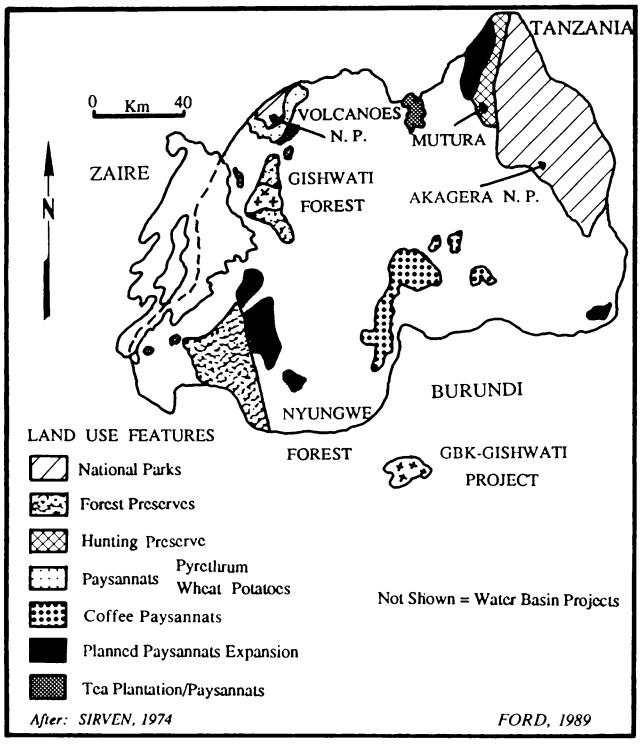

FIGURE 5. Major forms of land use.

overflowed into Lake Tanganyika and thus was reoriented toward the Zaire (Congo) Basin via a newly carved, torrential river, the Ruzizi (Figure 1).

Other similar lava-blocked lakes exist in the mountain region, such as lakes Ruhondo and Bulera in Ruhengeri Prefecture (Figure 6) and lakes Mutanda and Bunyoni in the Kigezi region of Uganda. The precipitous drop between lakes Ruhondo and Bulera has been an important hydroelectric resource for all of northwest Rwanda since the late 1950s (Roark and Dickson, 1986). Many other spectacular falls dot the landscape; some, like the Rusumo Falls on the Tanzania border, have great energy potential that is as yet not exploited.

Agro-ecological Zones

Rainfall and temperature distributions, and consequently soil resources, vary considerably over short distances throughout the plateau and mountain areas; even on the Central Plateau differences of over 300 m in relief occur. Soil fertility and agricultural productivity vary dramatically with parent rock material, altitude, slope gradient, vegetation cover, cultivation practices, and precipitation (Lewis and Berry, 1988).

Rwanda can be divided into twelve agro-ecological zones (Table 2; Figure 7); this classification is based on cultural as well as ecological variables and was proposed by Delepierre and Prefol (1978) and Delepierre (1974). Comparison of ecological zones (Figure 7) with altitude (Figure 3) shows that most of the country falls into either the high altitude or middle altitude plateau regions, except for the savannas of the east, which are largely enclosed within the Agakera National Park.

FIGURE 6. Lake Bulera, a lava-blocked lake in the Virunga Mountains.

HISTORICAL AND SOCIO-CULTURAL FACTORS

Early Exploration

The mountain regions of Central Africa have long been the focus of geographical and exploratory interest, especially in the quest for the source regions of the White Nile and Congo (Zaire) rivers in the late nineteenth century (Hickman, 1986). The peregrinations of Burton and Speke,

TABLE 2
Agro-ecological zones of Rwanda and selected characteristics

Zone	Altitude range (m)	Average precipitation (mm)	Soils	Agricultural value
Imbo	970–1,400	1,200	Alluvial	Excellent
Impara	1,400–1,900	1,400	Heavy red basalts	Good
Lake Kivu shore	1,460–1,900	1,200	Superficial loamy-clay	Excellent
Volcanic lands	1,600–2,500	1,500	Volcanic soils	Excellent
Zaire–Nile crest	1,900–2,500	1,600	Acid humic soils	Average
Buberuka Highlands	1,900–2,300	1,200	High-altitude lateritics	Good
Central Plateau	1,500–1,900	1,200	Diverse humic soils	Good
Granitic dorsal	1,400–1,700	1,100	Light gravelly soils	Average
Mayaga	1,350–1,500	1,050	Clay soils, schists	Very good
Bugesera	1,300–1,500	900	Strongly altered clays	Poor
Eastern Plateau	1,400–1,800	950	Laterites	Average/north; good/south
Eastern Savanna	1,250–1,600	850	Old, variable/texture	Very poor

After ONAPO (1982: 178–179).

Stanley, and Baker in search of the sources of the Nile (Burton, 1862; Moorehead, 1983) led to worldwide interest in this part of "darkest Africa".

Speculation concerning the *Lunae Montes* (Ruwenzori mountains) can be dated back to Aeschylus in the fifth century B.C. and to Aristotle, both of whom referred to a "mountain of silver lying to the south-west of the Nile" (Noyce and McMorin, 1969: 140). And it was that most famous of armchair explorer-geographers, Claudius Ptolemy of Alexandria, who put the *Lunae Montes* on a map and thus fomented the "Great Nile Controversy" (Moorehead, 1983: 11–13).

PRE-COLONIAL HISTORY

Due to both historical and ecological factors, the ravages of the slave trade did not devastate these core mountain areas (the "inter-lacustrine" region) as much as the peripheral East African coastal belt and the lowland regions to the south and west in today's Tanzania and Zaire (Sirven *et al.*, 1974; Rumiya, 1985). Part of this was due to the development of militarily powerful, feudalistic, and socially stratified kingdoms, such as the Buganda, Bunyoro, and Ankole kingdoms in east-central Uganda, which were more successful in repelling the encroachments of the Arab slave trade (Beattie, 1960; Hertefelt *et al.*, 1962; Vansina, 1962; Berger, 1981; Were and Wilson, 1984).

The Ruanda and the Urundi kingdoms, located on the Rwandese Central Plateau, were closely related historically and politically to Ankole and Bunyoro. In fact, inter-lacustrine Central Africa may have achieved the highest rural population density on the African continent outside of the Nile Delta as early as the late eighteenth or early nineteenth century. Archaeological and modern ethnological and oral-historical studies attest to the social complexity and agricultural productivity of these feudal societies (Leurquin, 1960; Codere, 1973; Heremans *et al.*, 1982; *La civilisation ancienne . . . Grands Lacs,* 1981; van Noten, 1983; Jones and Egli, 1984; Rumiya, 1985).

COLONIAL HISTORY

In the scramble for colonies in the inter-lacustrine region at the beginning of this century, the area first came under

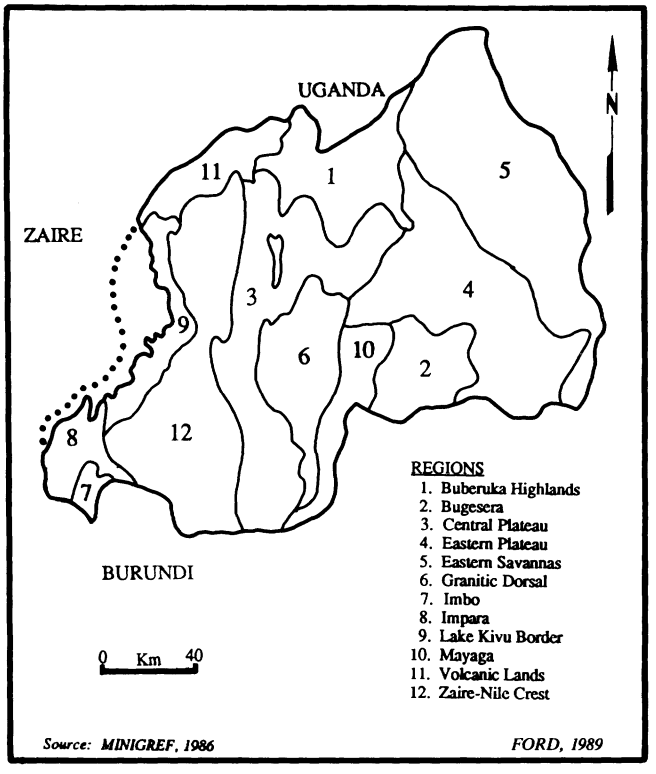

FIGURE 7. The agro-ecological zones of Rwanda.

German control. After the First World War the Belgians, initially under a Mandate from the League of Nations and then later as a Trustee under the United Nations Charter, tried to administer the territory as one entity called "Ruanda-Urundi" (Louis, 1963; Nahimana, 1987). For most of the German and early Belgian periods, indirect rule through the Mwami or Tutsi King's elaborate feudal political structure was the pattern. Little change in the traditional way of life ensued. Shortly after 1914 it was said that the colony contained a total of 190 Europeans in both Ruanda and Urundi; of these only five were civilian officials (in Ruanda), 40 were soldiers, 130 were missionaries, and a few were traders (*Area Handbook,* 1969: 12).

Ethnic Composition

Rwanda's present ethnic mix of 89% Hutu, 10% Tutsi, and 1% Twa is a reflection of a complex socio-cultural and migration history (Rumiya, 1985; Hitimana, 1985). The Twa, a pigmoid people who were the earliest arrivals, are today the least significant in numbers and the most marginal politically and economically. They live primarily along the forest-settled area fringe in the northwest: along the Nile–Zaire crest, Volcanic lands, Buberuka Highlands, and the Central Plateau (Figure 7).

For the most part, the Twa continue to follow a long established subsistence pattern of forest hunting and gathering (where still possible), small animal herding, limited subsistence farming, and arts and crafts such as the making of pottery. During the Tutsi feudal period the Twa were often located at a royal court where they served as a subservient caste (Sirven *et al.,* 1974: 56). Twa women can still be seen on market days carrying on their heads heavy loads of earthenware jugs to trade.

The Tutsi are a Nilotic pastoralist people who, according to oral history, entered Rwanda from the north around the fourteenth and fifteenth centuries. The Tutsi gradually became the feudal overlords of the majority Hutu, a Bantu sedentary farmer group, who came in from the west somewhat earlier than the Tutsi (Were and Wilson, 1984). There has been a long history of friction between the two major groups, the most recent being the rather bloody revolution of 1959, when the Hutu gained political control over their erstwhile feudal overlords. Continuing post-independence ethnic friction and other problems culminated in the coup of 1973, led by then General Major Habyarimana. The one-party system he installed, the MRND (Mouvement Revolutionaire National pour le Developpement), has greatly reduced inter-ethnic friction, although inter-regional rivalry is now a larger problem.

Close social and economic interaction has existed for so long that most religious, marriage, and other customs are common to the three groups, and the same language, Kinyarwanda, is spoken. The latter is a major unifying force to the often fractious ethnic and regional relationships (Mugabushaka, 1979; Mairieu, 1983).

SUBSISTENCE FARMING AND SETTLEMENT PATTERNS

Agricultural Land-use and Cropping Systems

The Rwandese subsistence system generally reflects the influence of both the farmer and pastoralist traditions. The rural household, consisting of all those living within the traditional enclosure or *urugo,* exploit a soil–slope sequence extending from the relatively rolling to flat hilltops of the Central Plateau down convex slopes to the marshy lowlands (Figure 8; Sirven *et al.,* 1974: 69–78; Heremans *et al.,* 1982; Jones and Egli, 1984). In the earliest periods the marshlands were unoccupied due to high disease incidence. After the introduction of modern disease-vector control programs during the colonial and independence periods these *Bas-fonds* became important areas for raised-field agriculture (Figure 9).

The *urugo* is typically surrounded by kitchen gardens and banana plantations (Figure 10). Other small plots are located further away at distinct levels on the hill-slope profile: wet season crops on the steepest slopes; sorghum,

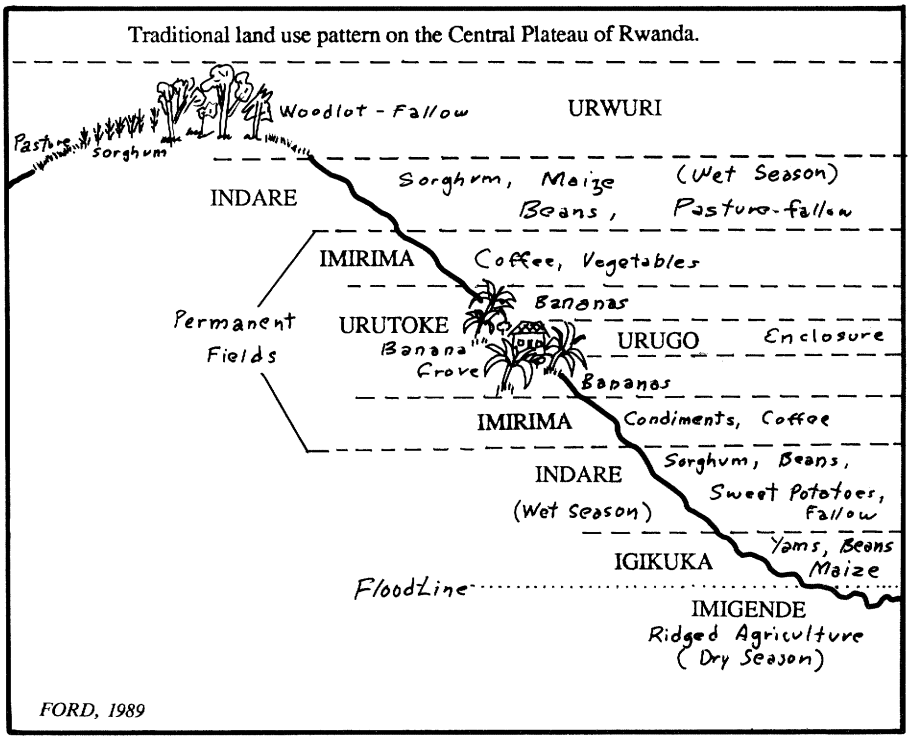

Figure 8. Cross-sectional diagram of the traditional land-use system on the Central Plateau.

Figure 9. Raised fields in a bottomland in the Buberuka Highlands of Ruhengeri Prefecture.

Figure 10. A typical *urugo* on the Central Plateau showing a dispersed homestead, banana groves, and field plots of sorghum, beans, coffee, and other crops.

maize, and grazing lands on the upland flats; dry season fields in the valley bottoms planted with such "famine crops" as sweet potatoes, yams, and in some cases fast maturing varieties of maize or sorghum (Charlery *et al.*, 1986). The land-use distribution by principal crop categories is as follows: 28.5% cereals, 23.1% legumes, 19.1% bananas, 16.6% tubers, 5.8% coffee, and 6.9% other. About 52% of all fields are multi-cropped. Multi-cropping combinations vary depending on the region, altitude, season, and slope. (Figure 4 lists the most common crops found in Rwanda along with their associated altitudinal zones.)

The farm household today has an average of 13.4 fields located in 5.2 blocks; the average field size is 7.53 *ares* (one *are* is 10 m^2) and total cultivated land available to the household is an average of 1.21 ha. There is, nevertheless, some inequality in land holdings: for example, 16.4% of households have holdings in excess of 2 ha and this group occupies 42.9% of all cultivated land, while 56% of all households have less than 1 ha and occupy only 25.3% of all cultivated land.

According to the recent nation-wide agricultural survey (MINAGREF/SESA, 1986), from which most of the following data are taken, 7.2% of household fields are located on the summit of hills, 24.2% on the upper slopes of the hill-slope profile, 36.4% in the center, 22.6% on the lower slopes, and 9.6% in the valleys. Over 65% of all fields are located within five-minutes' walking distance of the *urugo*. The slope-angle data are of particular interest: 23.3% of fields are on slopes of 0–5 degrees, 28.3% on slopes of 6–10, 30.7% on slopes of 11–20, and 17.7% on slopes greater than 20 degrees.

Land Tenure

Traditionally, ownership of land was "communal" but

is increasingly "inherited" (Maquet, 1967; Reintsma, 1982; Ruhashyankiki, 1985). A major effort by the government to "modernize" the legal basis of the land tenure system is now in process. Today, 50.9% of all fields cultivated by households are "owned directly" and 47.7% are worked under a variety of systems including rent, loan, gift, and share-cropping, which is a relatively new and rapidly increasing concept. The need for families to search for additional lands through "non-traditional" means, such as purchase and rent, has been cited by several experts as a "symptom" of grave land pressure (LeMarchand, 1982).

Frequency of Cultivation

The frequency of cultivation is also significant. At the time of the agricultural survey in 1984, 81% of all fields had been under cultivation for over ten years and 56% for over twenty years. Fallowing, when it is practised today, is for very short periods, usually for no more than a few growing seasons. Even 75% of so-called "non-cultivated" fields, which comprise 23% of all field types and include pasture and woodlots, had been "at rest" for less than ten years.

Household Characteristics

Rural households in Rwanda today are usually monogamous nuclear family units composed of an average of 4.99 members; 78.3% of the households are headed by males. Of the rural population, 47.9% is under 15 years of age; 79.8% of all heads of households are between the ages 15–64 with the 25–34-year age group predominating (28.4%). The household unit also serves as the principal labor unit, and has on average 2.5 workers (between ages 15–64) who support an average of 2.5 dependents. The rural dependency ratio is 103.8. Today 59% of the heads of households have had no formal education and only 2.5% have had more than seven years of education. The sex ratio in the rural areas for ages 15–64 is only 89, reflecting the large number of males who have migrated either temporarily or permanently in search of work.

Labor Patterns

Division of labor along gender lines is evident: women do most of the work on "subsistence crops" (cereals, tubers, legumes), while men work with "cash crops" (bananas, coffee). In the high-altitude zones, wheat, pyrethrum, and potatoes have, at different times, become important (male-oriented) cash crops. There is some sharing of work for the hard land-clearing activities and for crops that require special heavy work at harvest time, such as manioc and sorghum. Weeding and other crop maintenance is almost totally "women's work", as are most "post-harvest" activities. Men are responsible for most monetary transactions outside of the home, such as buying of supplies and selling banana beer.

Wage labor outside the home is a rapidly increasing phenomenon: the household's members work collectively an average of 210 days per year outside the home (almost 40% agriculturally related). Some 70.8% of households hire day-labor for specific activities at least 32 days out of the year, most often for land preparation for planting the key subsistence crops, such as beans; 75% of payment is in cash (MINAGRI/SESA, 1987).

Pastoralism

Pastoralism was fully integrated into the traditional subsistence system, although with considerable social complexities due to the ethnic/class distinctions. Seasonal migration to the higher altitude regions, post-harvest crop-residue foraging, exchange of milk and meat products with the Hutu "vassals", and other intricate socio-economic relationships were governed by a rigid social regulatory system imposed by the Tutsi hierarchy.

Today, 59% of all households raise chickens, 56% keep goats, 23.7% cattle, 20.6% sheep, 12.6% pigs, and 8.7% raise rabbits. The majority of cattle-owning households produce less than 100 litres of milk per year but 27.4% of the households who have milk cows produce over 300 litres per year and contribute over 63% of the total annual milk production of the country. Many of the elaborate social patterns characterizing the pre-independence pastoral system have broken down and considerable changes are taking place in animal husbandry.

Food Crops, Nutrition, and Altitudinal Zonation

The dietary regime provided by the subsistence systems in the interlacustrine region can be roughly divided into two main types (Vis, 1984: 18). First, that of the medium-altitude regions (1,400–2,000 m) characterized by four main food crops: beans, sweet potatoes, manioc, and bananas—cooked and for banana-beer (Figure 4). The first two foods provide over 50% of the calories in the diet.

The second dietary regime corresponds to the high altitude areas (over 2,000 m) where the main foods are legumes (beans and peas), cereals (maize, sorghum, and more rarely wheat), and white potatoes. This zone is too high for manioc, bananas, and most varieties of sweet potatoes, but the diet is much more varied. Both regions have very low proportions of fat in the diet: 4.5% for lower altitudes and 9% for the higher.

Seasonal fluctuation in food availability does occur, but, generally due to the two-to-three cropping seasons possible, some food crop is usually ready for harvest year round. Typically, peasants do not store large amounts of food. When occasional droughts or other natural disasters do occur, the impact on diet is immediate and severe. Such was the case in those areas hardest hit by the 1984 drought affecting the Lake Kivu Border, the Zaire–Nile crest, and Central Plateau agro-ecological zones (Figure 7).

DEMOGRAPHIC, POLITICAL, AND ECONOMIC CHARACTERISTICS

Economic Indicators

Rwanda is among the poorest countries in Africa (UNICEF, 1985, 1986). The GNP per capita was US$233 in 1983, which reflected a decrease from the 1980 figure of US$237. Economic growth between 1980–1983 was 3.7%, exactly matching the population growth rate. This

compares to an economic growth rate of 5.6% for the period 1976–1980. Other indicators are also discouraging: the level of external debt is rising; the major mining company has gone bankrupt; pyrethrum and quinquina, coffee, and tea prices crash cyclicly. In addition, external sources of development aid have decreased in actual dollar value, much of this being due to major currency fluctuations. During the period 1980–1983 the balance of payments became negative, attaining a peak of 86% of the value of all exports (10% of GNP).

Population Distribution

For the 95% of the population living outside the minor urban areas of Rwanda, life revolves around "the hill" (*la colline*). Thus Rwanda well deserves the appellation of *pays de milles collines* (country of a thousand hills). This spatial characteristic has contributed much to the relative isolation of rural areas from the social and economic changes emanating from the urban power centers of Africa.

Rwanda is one of the least urbanized areas in Africa. And although its population density is one of the highest in Africa, the population is extremely dispersed (Gourou, 1952; Trewartha and Zelinski, 1954; Brass *et al.*, 1968; Prioul, 1981; Nwafor, 1981). Several reasons for this "*sous-urbanisation*" or "under-urbanization" have been proposed (Sirven *et al.*, 1974; Sirven, 1984):

i) the comparatively healthful environment found in Rwanda and Burundi, particularly between 1,500 and 1,900 m where the highest densities are found;

ii) a diverse habitat allowing for adoption of many cultivars adapted to diverse agro-ecological niches. Martin (1987) thinks that this has been a significant factor in Rwanda's ability to cope with population growth since early colonial days;

iii) the relatively stable rainfall regime which allows two growing seasons (and three, if "wetlands" in the valleys are utilized);

iv) social and political stability imposed by the pastoral Tutsi who, though authoritarian, did not become an oppressive absentee "landed" class;

v) isolation from the worst ravages of slave raiding;

vi) a peasantry that is hardworking and prolific, with no option but to "make do" on the limited land available.

Migration to adjacent "empty" areas has been periodically proposed and occasionally employed as a solution to Rwanda's overpopulation (Chretien, 1978; Cambrezy, 1984). But this is no longer an option under today's political, economic, and demographic situation. The three adjoining regions of Kigezi in Uganda, Burundi, and Kivu in Zaire were either already heavily populated in colonial times or are politically inaccessible today.

The Demographic Problem

Essentially, Rwanda's demographic problem remains one of accelerating growth on a limited land base. It has the second highest population growth rate in the world after Kenya (3.7%) and one of the highest rural population densities in Sub-Saharan Africa (Johnson, M., 1986). As early as 1950, the then colonial government cited "demographic pressure" as its most "preoccupying problem" (Munyenbaraga, 1985: 10). Gourou (1952: 191) also predicted that unless the problem of "demographic inflation" could be solved all solutions to Rwanda's development were likely to come to naught.

The population of Rwanda in 1948 (Figure 11) was about two million in a country of 26,338 km^2, a density of 72/km^2. At the time of the 1978 census (Figure 12), the total population was around 6 million, a density of 230/km^2 (Prioul, 1981). Sirven (1984) estimates that by 1993 density will be over 300/km^2; some localized areas already have much higher densities than this (Ford, 1988). Unless present growth rates are dramatically cut, the population in the year 2000 will easily reach 10 million (the present doubling rate is 19.5 years).

Comparison of Pierre Gourou's 1952 analysis of population density in Rwanda with today's data is quite revealing (Sirven, 1974: 58; 1984: 305–362). The continuing reduction in available new land for farming is evident in the fact that regional disparities in population density are being reduced while the overall numbers continue to increase dramatically, due to the increased cultivation of empty or under-utilized land.

The anticipated increase in rural–urban migration is also occurring at an accelerated rate; Kigali, the capital city, now has an annual growth rate of 11%, one of the highest for a city of its size in Africa (Nwafor, 1981). Munyenbaraga (1985: 10) estimates that before the year 2000 the urban areas must absorb over two million persons if the average farm holding is not to be reduced below 1.1 ha, the estimated "minimum subsistence" farm size.

Delepierre and Prefol (1973), Delepierre (1974), and others determined the figure of 1.1 ha to be the "minimum economically profitable" size of a farm in Rwanda, one that could provide basic subsistence and a certain cash income such as coffee. By 1987 the national average farm holding size was 1.21 ha, and in some prefectures, Ruhengeri for example, a large proportion of farms have fewer than 1.0 ha (RRAM, 1987: 18).

Recent government reports conclude that "the reduction in average farm-holding size is continuing; and output per man-hour of labour is decreasing" (ONAPO, 1982: 160). These reports also note that outside the major parks and forest preserves, almost all available land, except for some marsh areas with potential to be drained, is being utilized. They further predict that, "the future of agricultural production in Rwanda will clearly be one of stagnation or outright reduction unless a large number of producers adopt new methods of intensive production" (ONAPO, 1982: 160). The paramount questions remaining are: how did it get this way in Rwanda, is it really that bad, and what do these trends portend for the future?

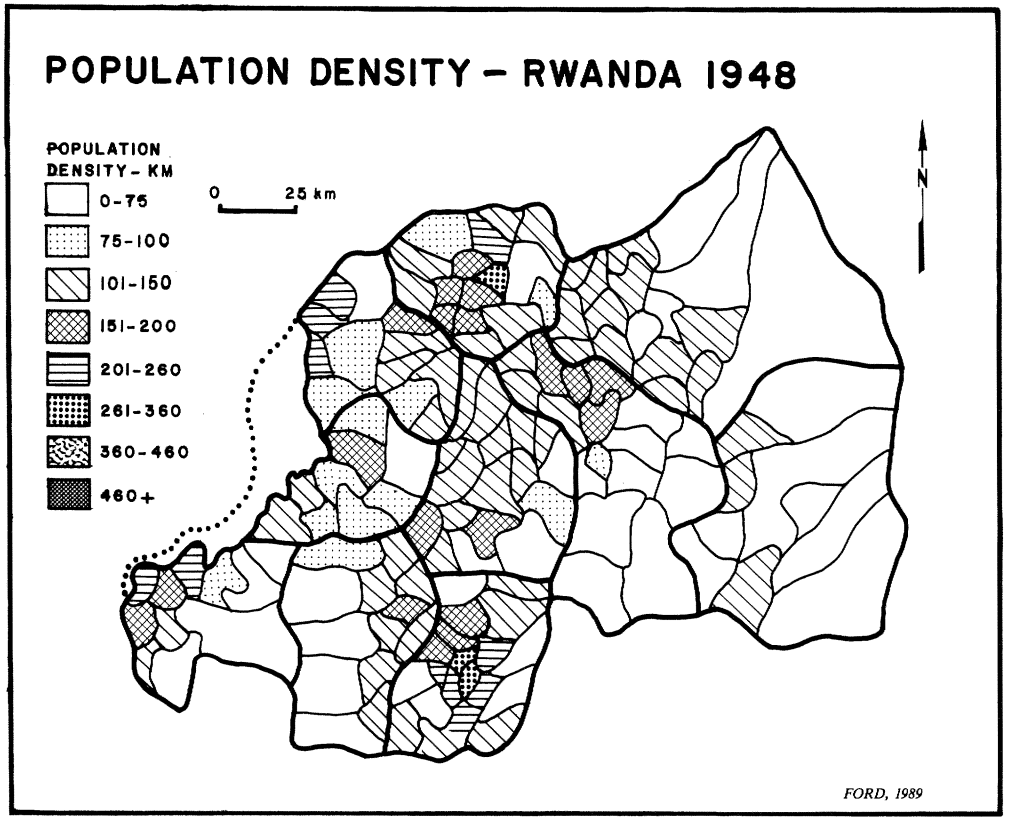

Figure 11. Population density of Rwanda—1948.

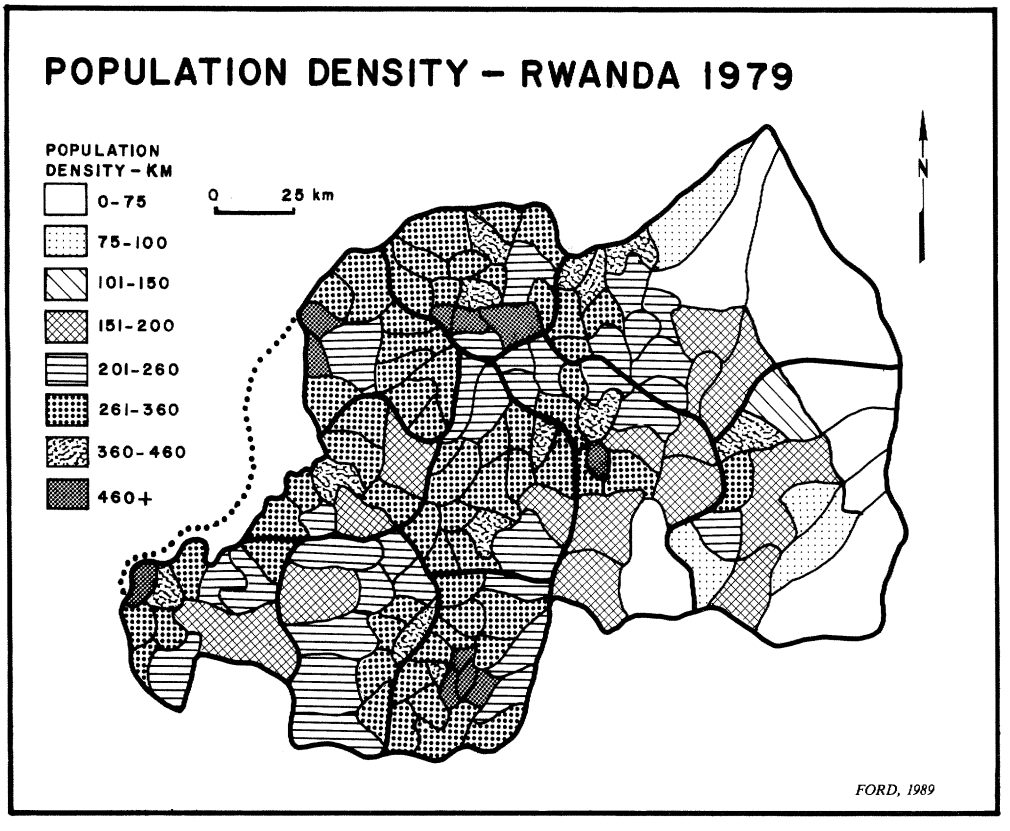

Figure 12. Population density of Rwanda—1979.

INTERNAL AND EXTERNAL CHANGES AFFECTING CURRENT POPULATION-RESOURCE RELATIONSHIPS

Historical, Political, and Economic Changes

The colonial and the post-independence periods put into motion basic forces for change that have had lasting effects. Through modifications of the tax structure, introduction of cash crops, and an often coercive over-emphasis on soil conservation, reforestation, and animal control programs, the traditional subsistence system began to evolve toward a new form (Heremans *et al.*, 1982; Jones and Egli, 1984). And improvement in basic medical services, growth of mission-operated educational systems, installation of famine relief plans, and building of a minimal economic and communications infrastructure to allow for commercial exploitation led to an accelerating population growth and increased political demand for social and economic reform (Gourou, 1952).

Economic reform was sought particularly by an awakened minority of newly educated Hutu who saw possibilities for breaking out of their feudal relationship with the dominant Tutsi. And, as noted by Gourou (1952: 170–78), the Belgian Administration in the early 1950s actively sought ways of indirectly breaking down the Tutsi feudal social structure, based on *Ubuhake,* the use of cattle as the material, visual symbol of all social contracts (LeMarchand, 1982). Colonial edicts were enforced aimed at a drastic cut in livestock herds by up to 50%.

To Gourou (1952) this policy in reality had the potential of undermining the very socio-economic and political system that probably enabled the Hutu to maintain such high population densities in the pre-Colonial period. Though sympathetic with those who decried the inequities of the old feudal structure, he cautioned that brash, Draconian attacks on the core-elements of the social system could have both long- and short-term effects not foreseen by the colonial administration.

Although Independence in 1962 saw the dreams of the Hutu majority realized, political and economic problems plagued the first administration. In 1973 a military coup, led by then Lt. Colonel Juvenal Habyarimana, brought the country into a period of relative economic and political stability under an enlightened one-party state leadership. In spite of the continuing undercurrent of ethnic friction and resentment, President Habyarimana's current civil administration has provided an environment of political and economic stability, openness to change, and a relatively liberal, pragmatic outlook that has encouraged entrepreneurial growth, and a considerable involvement by bilateral, multilateral, and NGO (non-governmental organization) donors in the "modernizing" of the society (Harroy, 1981; Godding, 1986). Sixty percent of the national development budget in 1983 came from external sources as either grants-in-aid or long-term loans. This large input of foreign aid has increasingly become the single most important source of economic growth.

The opening of commercial road links through Uganda, Tanzania, and Kenya to Mombassa and Dar-es-Salaam, as well as the forging of the Economic Community of the Great Lakes Countries (Zaire, Rwanda, and Burundi), has also aided the breakdown of economic and political isolation of the country. In recent years, as better roads have been built connecting the capital with tourist attractions, external demands for the preservation of natural plant and animal resources have been added to the resource-management equation. The latter is coming into conflict with the increasing political pressure which cries out for creation of additional cropland for peasant farmers (Fossey, 1983; Rosenblum and Williamson, 1987).

Demographic, Land-use, Settlement, and Agricultural Changes

Migration and Land Use

As population increased during the colonial and early independence periods, migration from the overpopulated Central Plateau to "unused" lands on the Nile–Zaire crest and to the higher altitude Volcanic Lands along the slopes of the Virunga Chain accelerated. Much of this migration was local, from lower to higher elevations, rather than regional – to the savanna lands of the east, although this has also been at times significant (Chretien, 1978; Cambrezy, 1984).

Much of the migration was absorbed into a new type of land-use pattern known as the "paysannat". These were cash crop-producing household units organized into government supervised cooperatives. The land itself was subdivided into equal-area plots aligned along linear access roads hugging the contours of the former Afro-montane bamboo belt (2,200–2,600 m), or just below it.

Unfortunately, great expanses of the Parc National des Volcans were eliminated in the 1960s (about 50% of its area) by a Belgian-funded pyrethrum project which predicted a great bonanza, but the world price of pyrethrum later crashed (Figure 13). Regrettably, that irreplaceable habitat has been permanently alienated. Some of the new lands taken from the preserves were developed into large state tea plantations, on which the resettled immigrants or displaced locals became day laborers. In addition, many high-altitude marshlands in Ruhengeri, Gisenyi, and Byumba (Figure 2) were drained for tea plantations (Chapuis, 1986).

In a ten-to-fifteen-year period (1960–70s) these "new" agricultural settlements spread rapidly up the slopes of the Virungas, into the Gishwati Forest Preserve (Figure 14), and onto the Buberuka Highlands causing, in some cases, severe pressure on wildlife resources such as the mountain gorilla and rare tropical mountain flora. Other *paysannats* are located in the eastern savanna lands or in the "coffee belt", the middle-altitude zones in the south-central parts of the country (Figure 5).

New Crops and Cropping Systems

The major cash crops grown in these "new lands" are coffee, tea, sugar-cane (in the lower river valleys), and newer food-crops including potatoes and wheat (Horowitz and Little, 1987). Much of the research and extension

Figure 13. Snow-capped summit of Mt. Karisimbi (4,507 m), highest point in Rwanda, seen from Mudende, Gisenyi Prefecture—on a former Belgian pyrethrum plantation.

activities of the post-Independence agricultural ministry has been oriented toward these lands, as they provide needed foreign exchange (Zaag, 1980; Durr, 1983). Between 1978 and 1982 over 56% of foreign earnings came from coffee, 16.4% from cassiterite and wolfram (both minerals), and tea provided 8.2%, quinquina 1.3%, and pyrethrum 0.7% (Munyenbaraga, 1985: 12).

Traditional agricultural systems are under great pressure from the many "external" forces. For example, one of the most important traditional crops, bananas, used primarily for local beer production, is being "squeezed" through government policy and economic demand, in preference of newer urban-oriented food crops and those hard-currency generators such as coffee and tea. Preferential monopolistic pricing and advertising policies also favor the modern brewing industry. The traditional exchange of banana beer between the lower altitudinal zones (below 1,900 m) where bananas grow best, and higher zones where they do not, is being significantly altered (Gotanegre, 1983). A major agricultural policy of the government is to gradually reduce the role of banana beer culture, although varieties of bananas for cooking purposes are still encouraged.

Present government agricultural research, much of it bilaterally funded, has focused on "commodity-crops" that can substitute for the increasing dependency on imports, e.g., sugar-cane, wheat (for bread and pasta), maize and sunflowers (for oil), white potatoes, rice, and soybeans (for food). The three latter crops are rapidly increasing in importance as food sources, in comparison to the traditional beans, bananas, sweet potatoes, mountain peas, and sorghum (Horowitz and Little, 1987).

Recently a major USAID-funded project, the ISAR/FSRP (Farming-Systems Research Project) located on the densely populated northwestern Buberuka Highlands, has de-emphasized extension and on-farm trials oriented toward traditional food crops, and has increased emphasis on the newer commodity crops. This project, as well as other government plant-breeding programs, has generally been quite successful. Included have been efforts to introduce triticale, a "man-made" crop being encouraged as an alternative to wheat on the poorer soils of the Central Plateau and Eastern Savanna. The most dramatic improvements in crop yields have been made by PNAP, the National Potato Research Project.

Animal Husbandry/Dairying

Another major agricultural change specifically affecting the high-altitude zones (generally over 2,000 m) is the introduction of modern dairying. Previously, these areas had been the habitat of wandering Twa hunters and gatherers or Tutsi herders seeking naturally available forage vegetation such as *Pennisitum clandestinum,* the wild Kikuyu grass. Strong pressure from the Hutu-dominated central government sought to "transform" the wandering, low milk-producing, long-horned Ankole cattle into modern dairy herds (Figure 15). Many traditional Tutsi pastoralists are being supplanted by larger permanent dairy enterprises that are urban-oriented and dependent on outside financing, inputs, and management.

A particularly controversial project has been the GBK Project, funded by the World Bank, which carried out a major clear-cutting operation in one of the two largest remaining forests, the Gishwati Preserve (Figure 14). The environmental damages incurred were even reported by the international press (Rosenblum and Williamson, 1987). Besides radically altering the landscape, this project has introduced exotic cattle and forage crops. It is attempting, for instance, to cross-breed the traditional Ankole cattle with several exotic breeds such as the Jersey, Holstein, and Swiss Brown—the latter were first introduced into the Mitumba Mountains of Zaire a few years ago.

In the near future, animal husbandry, practised today by the small farmer, will be integrated with other cropping systems using "zero-grazing" techniques. It is estimated that by the year 2000 the total number of cattle will be reduced by about 40% from 1970 levels, and the traditional vertical transhumance pattern of free-grazing of native Ankole on natural pastures, similar to the *Alpwirtschaft* system described by Rhoades and Thompson (1975), will be well on the road to extinction (MINIPLAN, 1983).

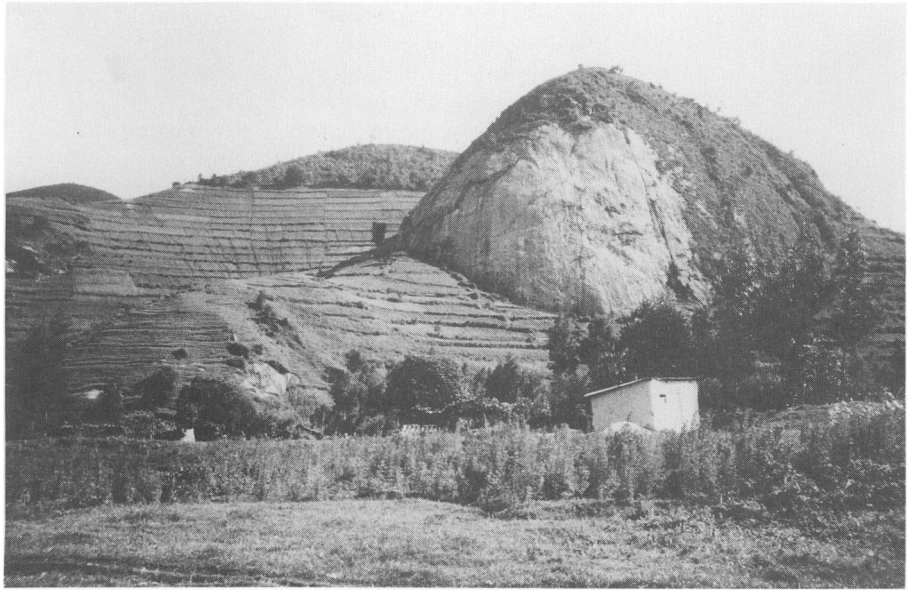

FIGURE 14. Granitic outcrop on the Zaire–Nile crest on the edge of the Gishwati Forest Preserve; note sharp demarcation between advancing peasant agriculture and the forest; severe erosion and soil creep are clearly visible on the cultivated slopes.

FIGURE 15. Crossbred cattle (Jersey and Ankole) in the Buberuka Highlands near Rwerere (FSRP Project).

Settlement Patterns

Where in colonial and early Independence days a dispersed settlement pattern was dominant in Rwanda, now new macadamized road development and large-scale farming enterprises for urban-oriented food and cash crops have commercialized agriculture in the mountain areas, providing a comparative advantage to those living closest to the new roads. This has increased rural–urban migration and stimulated growth of small market centers into rural agglomerations. These settlement changes have paralleled major shifts in population from the middle-altitude Central Plateau regions of Gisenyi and Ruhengeri prefectures to the higher-altitude Volcanic Lands, Buberuka, and Zaire–Nile crest zones (Figure 7).

On a local scale, there has been a rapid shift of population toward the major new transportation arteries. Thus, the former dispersed settlement pattern has been transformed by ribbon housing development similar to that in the developed world. These agglomerating and redistributive population trends have been greatly encouraged by the government because of the relatively easier task of providing social services to a more concentrated population (Hyden, 1983). The Ministry of Health, for example, has in many areas banned home-based immunization and "Road-to-Health" record systems, so that people will become accustomed to patronizing centralized government health clinics, or better yet will relocate near them. Sirven (1984) feels that any efforts to stimulate agglomeration of settlements in Rwanda and Burundi will help to siphon off excess rural population to the cities.

These above-mentioned spatial changes in population distribution seem to suggest that "accessibility" to economic

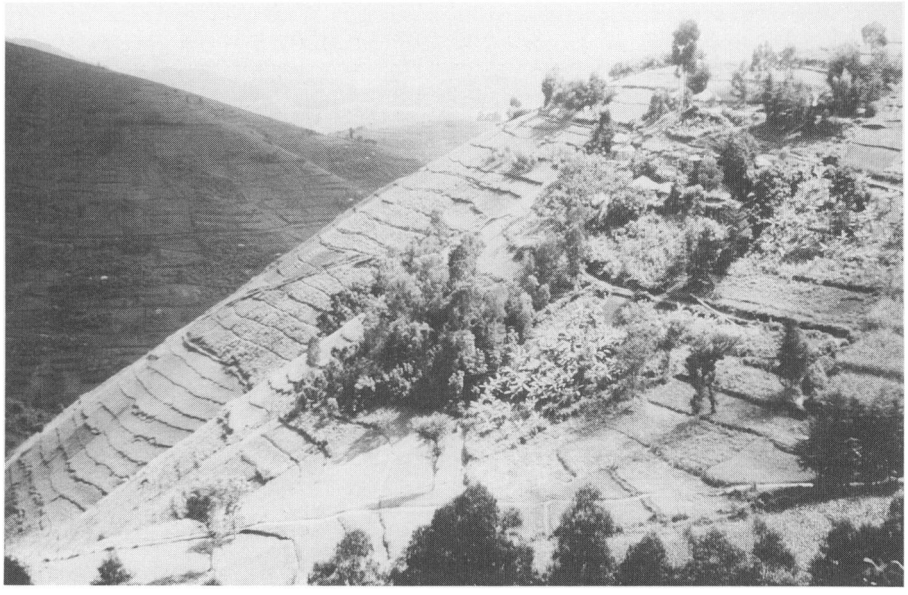

Figure 16. Erosion-control pseudo-terraces on steep slopes in the Buberuka Highlands (Ruhengeri Prefecture).

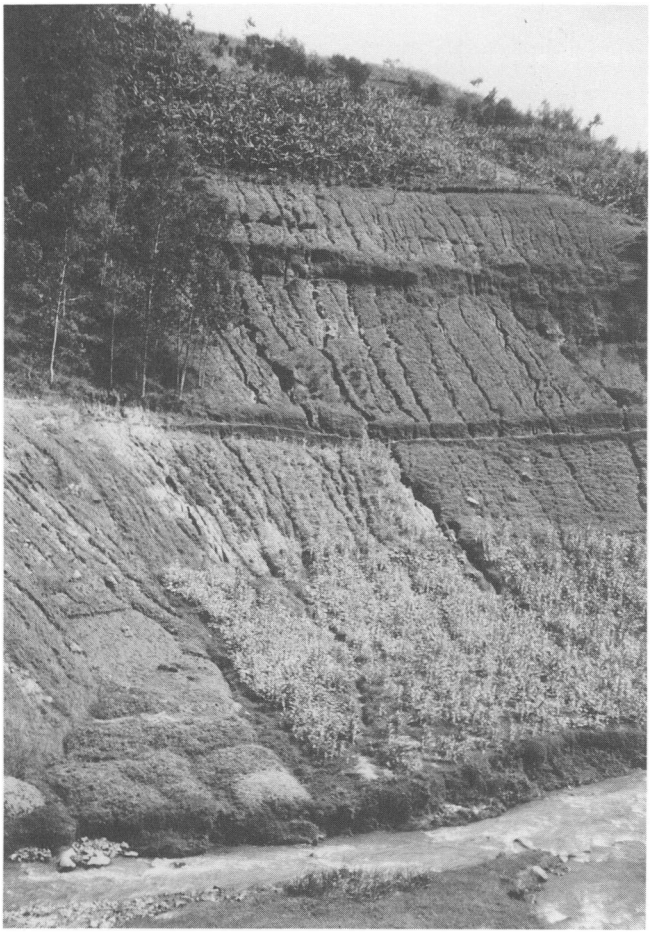

Figure 17. Severe erosion on marginal steep slopes in the Central Plateau region of Ruhengeri Prefecture.

and political resources is becoming a major driving force on the landscape. This trend has been noted by others studying Third World regions (Chambers, 1983; Allan, 1986; Greenland, 1986; Uhlig, 1986). Indeed, the factor of accessibility in many cases may have greater influence on contemporary land-use patterns than altitudinal zonation, a traditional explanatory mechanism used by cultural ecologists in both geography and anthropology (Troll, 1968; Troll and Lauer, 1978; Soffer, 1986; Uhlig, 1986; Guillet, 1986; Ives and Ives, 1987).

Housing Changes

The recently increasing rate of urban growth is having significant changes on the housing characteristics of the country. For example, housing styles on the Central Plateau areas show a great increase in the use of clay soils for brick and tiles as building materials, giving rise to a significant rural industry. Because of reduced availability of forest products and recent government policy, it is now illegal to build the traditional round, thatch, or bamboo-frame hut in most areas.

The volcanic lava regions face an especially severe building materials crisis due to the lack of easily accessible, low-cost clay soils. The author was instrumental in implementing a GATE-funded project (German Appropriate Technology Exchange) to test the making of building blocks from lava and pumice as an alternative to forest products. A recently inaugurated government monopoly for the manufacture of tin roofing and cement has also become a major cost factor in housing construction.

Changes in Natural Resource Management

Conservation of Flora and Fauna

Scientific and aesthetic interest in this African mountain region with its unique natural flora and fauna was stirred early in the colonial period; in fact, the Volcanoes National Park was the first to be established in the entire

TABLE 3
Soil losses in Rwanda due to diverse factors (tons/hectare/year)

Crop	Soil loss	Slope gradient	Soil loss
Peanuts	6.0	0-5 degrees	
Beans	9.8	6-10 degrees	4.2
Peas	11.8	11-20 degrees	11.9
Soybeans	9.2	Over 21 degrees	25.7
Maize	26.5	Non-crop cover	Soil loss
Sorghum	13.9	Forest cover	12.4
Sweet potatoes	12.4	Pasture	8.7
Irish potatoes	16.8	Trees + pasture	9.9
Manioc	18.2	Other non-cultivated	8.5
Bananas	2.9		
Coffee	0.6		

Regional differences in soil loss.

Prefecture[1]	Soil loss	Agro-ecological zone[2]	Soil loss
1. Butare	8.3	1. Buberuka Highlands	12.3
2. Byumba	8.9	2. Bugesera	2.6
3. Cyangugu	15.7	3. Central Plateau	8.8
4. Gikongoro	17.2	4. Eastern Plateau	3.3
5. Gisenyi	16.5	5. Eastern Savannas	4.5
6. Gitarama	5.2	6. Granitic Dorsal	6.2
7. Kibungo	3.0	7. Imbo	11.4
8. Kibuye	15.9	8. Impara	11.3
9. Kigali	4.9	9. Lake Kivu border	12.0
10. Ruhengeri	13.3	10. Mayaga	5.1
		11. Volcanic lands	13.6
		12. Zaire-Nile crest	21.7

[1]See Figure 2 for locations.
[2]See Figure 7 for locations.
After MINAGREF/SESA (1986b).

continent. Unfortunately, less than half the original preserve remains today, as a result of the Belgian pyrethrum project misfortunes of the 1960-70s (Byers, A., 1989, pers. comm.).

Full appreciation of the inestimable value of these rare natural resources came slowly. It is their rather recent recognition as a tourist asset that has accelerated significant local and international efforts to preserve and manage them better. Tourism, during the last five years, has overtaken all other sectors as the prime producer of foreign exchange in Rwanda. This has in large part resulted from high-profile research and conservation efforts by many on behalf of the mountain gorilla, and other rare flora and fauna in the Virunga National Park. Among the noteworthy students and protectors of the gorilla and its habitat are Bill Weber, Alan Goodall, Craig Sholley and, of course, the now famous Dian Fossey (1983). As might be expected, natural resource management issues have recently become an increasingly contentious topic of debate within the Rwandese political environment.

SOIL EROSION

Erosion Risk

The combination of phenomenal human population growth, high precipitation on steep slopes, and other complex ecological variables make the mountain regions of Rwanda highly susceptible to accelerated erosion (Figures 16 and 17). One of the earliest quantitative studies of soil erosion was carried out by Lewis and others (under USAID and government auspices) using Gerlach trap-study techniques (MINAGREF/SESA, 1986b; Lewis and Berry, 1988). That pilot study reported the average slope gradient of cultivated fields in Rwanda to be 13.3%. Its estimate of average soil loss (using the Universal Soil Loss Equation) was 10.1 t/ha/year. Table 3 summarizes some of its major findings. This early estimate generated a rather optimistic picture of erosion in Rwanda, and may have induced a dangerous complacency.

More in-depth, follow-up studies by Alton Byers (1988a, b, c) and Nyamulinda (1988), who utilized Wischmeier-type runoff plots and other hydrological measurements (Byers, E., 1988), found that "soil losses were dramatically higher than the Lewis study" (Byers, A., pers. comm.). Whereas the earlier study attributed to the Nile-Zaire crest (Figure 14) an average soil loss of 21.7 t/ha/year, the most recent measurement puts the figure over 200 t/ha/year, and over 100 t/ha/year were found for the Central Plateau region. It is yet unclear whether the much higher figures found by Byers reflect inadequacies in the earlier measurements by the Lewis study, a significant worsening of the erosion problem during recent years, or both.

Recent documentation by Byers and Nyamulinda (1988) of catastrophic landslides and severe flooding near Nyarutovu, Ruhengeri during the 1987–88 cropping season is quite alarming. It illustrates the great potential in these mountain agrosystems for major soil erosion and mass wasting, when climatic, soil, and human factors interact in their most devastating combinations.

Erosion Control

Prevention of soil erosion by the traditional subsistence system was largely one of: a) avoidance of marginal slopes and soils, b) dispersal of agricultural plots over the soil catena, c) careful scheduling of soil preparation and planting activities (to avoid having the soil exposed at those times when catastrophic downpours are most probable), and d) maintenance of a near continuous vegetative cover on field plots for most of the year (Nyamulinda, 1988). It appears that these "avoidance techniques" worked adequately until 1920–1930 after which population pressure began to increase and, subsequently, erosion accelerated.

During the Belgian Trusteeship colonial administrators became greatly concerned by what appeared to be an increasing erosion problem. Many peasants were coerced to install infiltration ditches and other erosion-controlling devices (Gourou, 1952; Dumont, 1960; Leurquin, 1960). Since Rwanda's independence, the government has continued to put a high priority on erosion control, particularly since it is evident that the traditional avoidance techniques are no longer sufficient.

The Lewis study (referred to above: Lewis and Berry, 1988; MINAGREF/SESA, 1986b) estimated that nationwide only 32% of all cultivated fields had any form of erosion protection in 1984. The infiltration ditch, along with a type of contoured bund (planted with grasses or shrubs) is the most common technique used. In addition, both Lewis and Byers have shown that there is a much higher risk of erosion associated with specific soil-crop combinations such as maize, potatoes, and manioc, particularly when grown on steep, marginal slopes.

Many diverse government and outside donor groups are addressing the erosion problem, including ISAR (Institut des Sciences Agronomiques au Rwanda); USAID through such projects as RRAM (Ruhengeri Resource Management Project) and the FSRP (Farming Systems Research Project); and German and Swiss agencies. The year 1985, the end of the latest National Development Plan, was the target date for completing a major post-Independence erosion control system. A mass mobilization approach was used, often with direct high-profile participation of the President, to dig ditches, plant trees, and even build some terraces (though this has been minimal and somewhat controversial).

The visual effect on the landscape of the massive anti-erosion campaigns has been striking (Figures 14 and 16). Evaluation of their cost-effectiveness is only now beginning. Recent assessments by RRAM within Ruhengeri point out that although initial efforts to install erosion control features were largely successful, development and implementation of long-term mechanisms for their continued maintenance may be more problematic (A. Byers, 1989, pers. comm.).

Forestry

Wood provides 95% of all energy needs in Rwanda. With the dramatic increase of population in recent decades, pressure on forests has been severe. Between 1958 and 1982 total forest cover in Rwanda was reduced by 43% (not counting those areas within preserves) and the annual regression was estimated to be on the order of 5,200 ha per year. Since 1982 a massive tree replanting program has reforested a maximum of 19,500 ha in one year. Yet, even if the target of replanting an average of 14,000 ha per year can be maintained until the year 2000, predictions are that there will still be a deficit due to the expanding population (MINAGREF, 1987).

Early reforestation programs, first under Belgian rule and then under the new national government, have emphasized massive planting of eucalyptus, cypress, and other exotic species in pure stands on marginal land such as rocky, steep slopes and along roadsides. The success of these mass forestry programs has been debatable, both in terms of erosion control and fuelwood production. Currently, it is in vogue for expatriates to criticize the use of eucalyptus, although RRAM reports that many local farmers still laud its fast-growing characteristics (Byers, A., pers. comm.; RRAM, 1988a, b).

Critics of the early monocrop tree-planting programs most often cite the ostensible damage to traditional pasture lands and native plants through soil desiccation and competition. The increased cost to peasant households is also cited as a negative trend as most tree farms are found on commune lands and the firewood must now be purchased. Most serious has been the criticism that more efficient and ecologically sound techniques of mixing of crops and trees on the same land (agroforestry) was not encouraged or practised by government programs (Raintree, 1983; Buchholz, 1984; Rottach, 1986; Balasubramanian and Egli, 1986; RRAM, 1988a).

Applied research near Nyabisindu on the Central Plateau by a German Project (Neumann and Pietrowicz, 1986) as well as by other groups such as the Swiss government, CARE/Gituza, and ISAR/FSRP are testing new agroforestry approaches that attempt to maximize multiple use of land for trees, crops, and livestock directly on peasant holdings. This approach has shown considerable promise, as traditionally the practice of growing trees on minuscule woodlots is common in Rwanda. The intercropping of diverse shrubs and trees around the *urugo* and in the fields to create hedges and terrace borders is also typical.

Until recently, the official national forest-resource inventory largely ignored this peasant practice, and may thus have greatly underestimated their contribution to fulfilling wood-product needs (MINAGREF, 1987). One expatriate forester claims the government underestimates actual forest resources by a factor of two or three because of this oversight (Weber, 1987, pers. comm.).

Nevertheless, this uncertainty does not negate the fact that a serious forestry problem still exists. Heavy urban demand for cheap firewood or charcoal continues to put great pressure on the government to further implement massive monocrop tree-plantings, even though the benefits have not been compelling, particularly from the rural household's perspective.

PROSPECTS FOR THE FUTURE OF POPULATION-RESOURCE RELATIONSHIPS IN RWANDAN MOUNTAIN REGIONS

Agricultural Involution or Intensification

Is Rwanda moving toward, or has it already attained, a state of "agricultural involution", a concept made famous by Geertz (1963)? Specifically, the concept refers to a "treadmill effect"—a required higher and higher input of labor per unit/area of land without increases in per capita income or production. Furthermore, the condition is often considered to be accompanied by severe environmental degradation.

If this implies, in the Rwandan case, that there are increasing pressures to more efficiently and intensively make a living on less and less land, then yes, involution is evident. But does the present constellation of forces portend an impending disaster in the near future? That scenario is possible but as yet not probable, in this author's opinion.

A recent case study of Ruhengeri Prefecture written by Ford (1988) explores this issue directly. It appears that significant agricultural intensification is occurring, and room for major improvements in agricultural productivity still exists, using remaining wetlands and currently available "biotechnic" methods. Furthermore, although environmental and socio-economic stresses are evident, there appears to be enough time and political will to bring the population under control within the next thirty years before a land-people squeeze is reached.

Some theorists suggest that population pressure can actually be the trigger that forces the needed intensification essential to diffusion of the "population bomb" (Schultz, 1964; Boserup, 1965, 1981; Chayanov, 1966). The application of this theory in Africa and elsewhere is currently being explored by many persons (Turner and Doolitle, 1978; Pingali and Biswanger, 1984; Kates, 1987; Martin, 1987; Kates *et al.*, 1988).

However, this positive scenario may be ephemeral, or worse, an illusion, and continued vigilance and action are needed. Martin (1987) suggests that most increases in agricultural productivity in Rwanda since about the 1930s have been achieved by adoption of new crops, land expansion, and, more recently, "mining" of soil nutrients and reduction in fallow cycles.

Policy Options for the Future

Rwanda's population density is as yet far below that of other high density "islands" in Africa, such as the close-settled zone around Kano and the southeast of Nigeria (Mortimore, 1988; Martin, 1988; Goldman, 1988). Many feasible options still exist. The official government document: *Strategie alimentaire au Rwanda: objectifs chiffres et programmes d'actions,* outlines some of them, including:

i) an increase in mixed farming emphasizing "zero-based grazing" schemes combined with agroforestry approaches to land use. (Of particular importance will be the combination of trees, crops, and small livestock.)

ii) concerted efforts to control population growth over the next twenty years

iii) increased intensification of agriculture, including a greater use of Green Revolution technologies adapted to the peasant environment. (This presupposes development and implementation of a fully functioning and effective agricultural research and extension service.)

iv) stimulation of the urban, commercial, and industrial sector which may serve as the catalyst and source of essential technical, informational, economic, and political inputs to the development process

v) increased regional economic and political cooperation and integration that could possibly open some of the empty lands of Zaire as a safety valve for population expansion from the more crowded areas

vi) accelerated diffusion of new crops, and specifically a greater emphasis on higher-calorie and higher-yielding crops, e.g., more maize, manioc, rice, wheat, and soybeans, and less bananas, meat (from free-grazing cattle), and low-yielding traditional beans and peas

vii) promotion of changes in socio-cultural norms regarding marriage (dowries), land inheritance, and family size

viii) increased efforts to protect, preserve, and scientifically manage the remaining exotic natural areas in wetlands and high altitude areas within the parks, preserves, and estates. (Their significance as tourist assets, if nothing more, is now widely appreciated.)

Other policy options are also explored, but those listed above are the most crucial.

CONCLUSIONS

Effectiveness and timeliness in the implementation of the above policies will determine whether positive or negative scenarios are warranted. In either case, prediction of "inevitable outcomes" is always risky, as Geertz (1963) warned years ago.

The onus of avoiding a disaster (if such is possible for Rwanda) is as much in the hands of the external scientific, political, and donor groups as the local, individual peasant community. The external groups can do much to equip these mountain peoples with the information, technologies, and political and economic power that will restore to them the autonomy over their own actions, and the consequences, that all peoples so jealously desire and seek.

So often it has been external changes in the political-economic realm that have the greatest effect on mountain systems. For example, where the resource-use factors formerly encountered by mountain farmers in Kigezi (Uganda) were similar to those in Rwanda, being from the same ethnic and cultural roots (Hecq *et al.*, 1963; Vis *et al.*, 1969; Kasfir, 1988), they are today experiencing totally different futures, precisely due to the increased differential impact of external forces. The Kigezi farmers, who a few years ago were rapidly developing an intensive market gardening agriculture based on markets in Kampala, Nairobi, and even Europe, are today recovering from a post-Amin breakdown in basic economic and social infra-

structure (Hargrave, 1972; Hickman, 1986; Wiebe and Dodge, 1987).

Rwanda must adapt to a severe land-population squeeze over the next twenty years, whereas Zaire has extensive empty lands on which to resettle excess population. Yet the current anarchic and bankrupt political and economic situation in Zaire presents peasants in the Mitumba Mountains with a possibly worse "development" future than those in Rwanda.

Even the present politically stable Rwandese environment could change quickly, thus upsetting the delicate balance that Rwanda is seeking between stability and instability, in both political economy and agricultural systems. And recall that this is an African country where development-project effectiveness is at present relatively high. It is hoped that natural resource policy making and management practices, with encouragement from outside agencies, will continue to promote greater environmental stability.

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