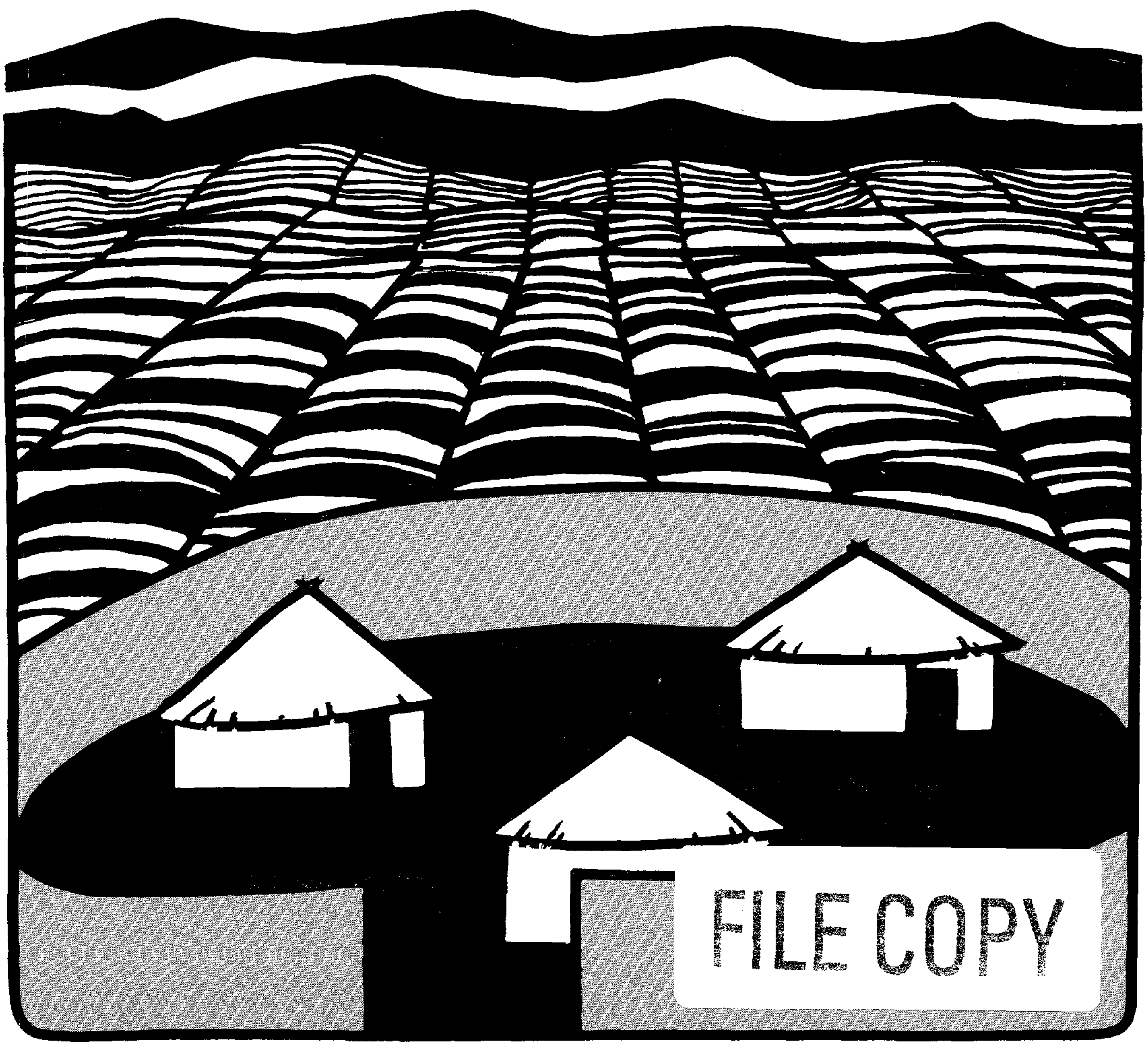
WTP- 27

WORLD BANK TECHNICAL PAPER NUMBER 27

Farming Systems in Africa

The Great Lakes Highlands of Zaire, Rwanda, and Burundi

William I. Jones and Roberto Egli



WORLD BANK TECHNICAL PAPERS

No. 1. Increasing Agricultural Productivity

No. 2. A Model for the Development of a Self-help Water Supply Program

No. 3. Ventilated Improved Pit Latrines: Recent Developments in Zimbabwe

No. 4. The African Typanosomiases: Methods and Concepts of Control and Eradication in Relation to Development

(No. 5.) Structural Changes in World Industry: A Quantitative Analysis of Recent Developments

No. 6. Laboratory Evaluation of Hand-operated Water Pumps for Use in Developing Countries

No. 7. Notes on the Design and Operation of Waste Stabilization Ponds in Warm Climates of Developing Countries

No. 8. Institution Building for Traffic Management

(No. 9.) Meeting the Needs of the Poor for Water Supply and Waste Disposal

No. 10. Appraising Poultry Enterprises for Profitability: A Manual for Investors

No. 11. Opportunities for Biological Control of Agricultural Pests in Developing Countries

No. 12. Water Supply and Sanitation Project Preparation Handbook: Guidelines

No. 13. Water Supply and Sanitation Project Preparation Handbook: Case Studies

No. 14. Water Supply and Sanitation Project Preparation Handbook: Case Study

(No. 15.) Sheep and Goats in Developing Countries: Their Present and Potential Role

(No. 16.) Managing Elephant Depredation in Agricultural and Forestry Projects

(No. 17.) Energy Efficiency and Fuel Substitution in the Cement Industry with Emphasis on Developing Countries

No. 18. Urban Sanitation Planning Manual Based on the Jakarta Case Study

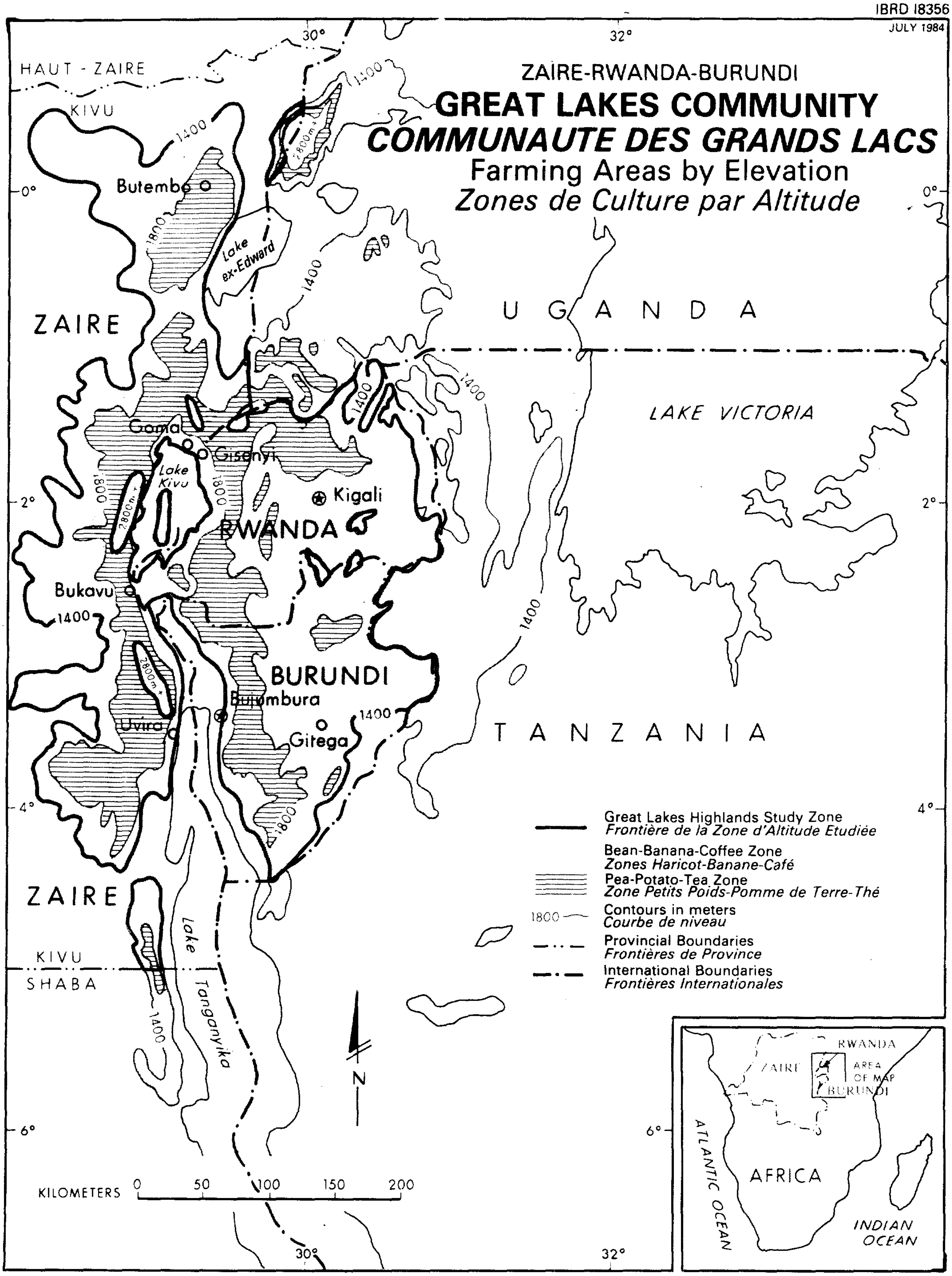
No. 19. Laboratory Testing of Handpumps for Developing Countries: Final Technical Report

No. 20. Water Quality in Hydroelectric Projects: Considerations for Planning in Tropical Forest Regions

( ) Indicates number assigned after publication.

(List continues on the inside back cover)

Farming Systems in Africa


IBRD 18356
JULY 1984
ZAIRE-RWANDA-BURUNDI
GREAT LAKES COMMUNITY
COMMUNAUTE DES GRANDS LACS
Farming Areas by Elevation
Zones de Culture par Altitude
HAUT - ZAIRE
KIVU
ZAIRE
UGANDA
LAKE VICTORIA
RWANDA
BURUNDI
TANZANIA
ZAIRE
KIVU
SHABA
Butembo
Lake ex-Edward
Goma
Gisenyi
Lake Kivu
Kigali
Bukavu
Bujumbura
Uvira
Gitega
Lake Tanganyika
Great Lakes Highlands Study Zone
Frontière de la Zone d'Altitude Etudiée
Bean-Banana-Coffee Zone
Zones Haricot-Banane-Café
Pea-Potato-Tea Zone
Zone Petits Poids-Pomme de Terre-Thé
1800 Contours in meters
Courbe de niveau
Provincial Boundaries
Frontières de Province
International Boundaries
Frontières Internationales
KILOMETERS 0 50 100 150 200
N
RWANDA
ZAIRE
AREA OF MAP
BURUNDI
ATLANTIC OCEAN
AFRICA
INDIAN OCEAN

WORLD BANK TECHNICAL PAPER NUMBER 27

Farming Systems in Africa

The Great Lakes Highlands of Zaire, Rwanda, and Burundi

William I. Jones and Roberto Egli

The World Bank
Washington, D.C., U.S.A.

First printing September 1984

William I. Jones is an agricultural economist in the South Asia Projects Department of the World Bank. Roberto Egli is an agronomist and a consultant to the World Bank. When this paper was written, both authors were in the East Africa Projects Department of the Bank.

Library of Congress Cataloging in Publication Data

Jones, William I.
Farming systems in Africa.

(World Bank technical paper, ISSN 0253-7494 ; no. 27)
1. Agricultural systems--Africa, Central. 2. Agriculture--Africa, Central. 3. Agricultural innovations--Afric, Central. 4. Soil conservation--Africa, Central.
I. Egli, Roberto, 1919- . II. Title. III. Series.
S472.C46J66 1984 630'.967 84-17405
ISBN 0-8213-0398-8

ABSTRACT

This agroclimatic zone -- equatorial, yet temperate and well-watered -- has a population of 12 million people and covers an area of 93,000 km^2 in three countries: Burundi, Rwanda, and Zaire. At 130/km^2, population density is high for Africa. The population is almost entirely rural; agriculture and livestock raising are virtually the only economic activities. As a consequence, farms are small. Farming is, for Africa, quite intensive. This population density and this intensivity of land use are recent developments resulting from rapid population growth. They are coupled with extreme economic isolation.

This study, based largely on field interviews but also on a review of the zone's exceptionally poor data sources, makes a first attempt to describe farming systems in the region, which is broken into 11 models for this purpose. Evolution of farming practices and adaptation to changing conditions are analysed. Then the study reviews and assesses a large number of farm-level system changes, most of them proposed by governments and development projects, but some which the mission observed farmers undertaking on their own initiative. The study's assessments lead to recommendations on soil conservation and enrichment measures likely to be interesting to all parties under different circumstances, including the appropriate role of forestry and for using fertilizers on food crops. There are also suggestions on possible diversification in export crops, and on attractive changes in existing cropping patterns and in the present livestock system.

ABRÉGÉ

Dans cette zone au climat équatorial mais tempéré et où les chutes de pluies sont assez abondantes vit une population de 12 millions d'habitants répartis sur une superficie de 93.000 km^2 recouvrant trois pays : le Burundi, le Rwanda et le Zaïre. La densité de la population, 130 habitants au km^2, est élevée pour le continent africain. Il s'agit d'une population presque entièrement rurale et vivant presque exclusivement de l'agriculture et de l'élevage. Les exploitations sont de petite taille et il s'y pratique une agriculture qui, pour l'Afrique, est très intensive. Cette densité démographique et cette utilisation intensive des terres sont le résultat d'une croissance démographique rapide, ces dernières années, jointe à un isolement économique extrême.

La présente étude, la première en son genre, fondée principalement sur des enquêtes sur le terrain en raison de la très nette insuffisance des données disponibles, s'emploie à décrire des systèmes de culture répartis en 11 modèles, pour lesquels il n'existe aucune étude préalable. Elle analyse tout d'abord l'évolution des méthodes culturales et leur adaptation aux changements survenus dans la situation de ces pays. Elle examine et évalue ensuite un grand nombre de modifications apportées aux systèmes d'exploitation, pour la plupart proposées par les gouvernements des pays intéressés et les promoteurs de projets de développement, ainsi qu'un certain nombre d'initiatives prises par les agriculteurs eux-mêmes et observées par la mission. Cette évaluation débouche sur des recommandations en matière de préservation et d'enrichissement des sols - notamment le rôle qu'il convient d'attribuer au secteur forestier et l'utilisation d'engrais pour la production de cultures vivrières - susceptibles d'intéresser toutes les parties. Elle propose également des solutions possibles en matière de diversification des cultures d'exportation et de modifications rentables de la répartition actuelle des cultures et des pratiques d'élevage en vigueur.

EXTRACTO

Esta zona agroclimática --ecuatorial y, sin embargo, templada y con buena precipitación pluvial-- tiene 12 millones de habitantes y una superficie de 93.000 km^2 que abarca tres países: Burundi, Rwanda y Zaire. Su densidad de población, de 130 habitantes/km^2, es alta para Africa. Esta población es casi por completo rural, siendo la agricultura y la ganadería prácticamente las únicas actividades económicas. En consecuencia, las explotaciones agrícolas son pequeñas. Tratándose de Africa, el cultivo de la tierra es bastante intensivo. Esta densidad de población y esta intensidad de uso de la tierra son hechos recientes, resultantes del rápido crecimiento de la población, y van unidos a un aislamiento económico extremo.

En el presente estudio --basado sobre todo en entrevistas en el terreno, pero también en un examen de las fuentes de datos de la zona, excepcionalmente deficientes-- se hace un primer intento de describir los sistemas de cultivo de la región, para lo cual ésta se desglosa en diez modelos. Se analizan la evolución de los métodos de explotación agrícola y su adaptación a las condiciones cambiantes. Después se examinan y evalúan numerosos cambios en los sistemas de cultivo a nivel de las explotaciones, en su mayoría propuestos por los gobiernos y como resultado de proyectos de desarrollo agropecuario, pero también algunos introducidos por propia iniciativa de los agricultores, según pudo observar la misión. Las evaluaciones del estudio llevan a recomendaciones en cuanto a medidas de conservación y enriquecimiento de los suelos --incluida la función apropiada de la silvicultura y del uso de fertilizantes en los cultivos alimentarios-- que seguramente serán de interés para todas las partes en diferentes circunstancias. Se hacen también sugerencias sobre la posible diversificación de los cultivos de exportación y acerca de modificaciones atrayentes en las modalidades de cultivo y los sistemas de cría ganadera actuales.

ACKNOWLEDGMENTS

This study would have been impossible without the active and enthusiastic cooperation of the Commission Economique des Pays des Grands Lacs. Mr. Athanase Ngendahimana, economist from CEPGL headquarters in Gisenyi, accompanied us during all of the field work, as did CEPGL driver, Ramazan, who often assisted as translator as well. While they helped mightily, they bear no responsibility for the conclusions of the study. CEPGL also contributed a vehicle and fuel for the Zaire and Burundi portions of the field work.

In the course of our field work, we bothered a larger number of farmers, merchants, truckers, agricultural researchers, and some Government officials as well. All were extremely cooperative and, thanks, we believe, to the patronage of CEPGL, we were completely free to cross borders, travel wherever we wished when we wished, and ask what we wished. it would be unfair to single out a few individuals from this large group, many of whose names we do not even know, for special mention.

Within the Bank, it was the vision of Katherine Marshall, then our Divison Chief, that allowed Bank resources to be devoted to this project. Many secretaries were involved in document processing, but three, Mily Chung Tan, Kim Anh Pham Nguyen, and Simone Bazinet especially so. Also, many Bank technicians with experience in the area gave us their ideas and corrected our mistakes. Especially helpful in this regard, though not responsible for remaining errors, are Messrs. Jean Heidebroek, Etienne Baranshamaje, and Mikael Grut.

William I. Jones

TABLE OF CONTENTS

Introduction 1

I. Evolution of Agriculture in the Highlands 4

Early Highlands Agriculture 4
From the baNtu Migration to the European Conquest 6
The Present Century 9
Public Health and Expansion 9
Transport 11
Crop Introductions 12
Beer Banana 12
Maize 12
Wheat 13
Tubers 13
Legumes 13
Export Crops 13

II. Ecosystems That Differentiate 15

The Factors 15
Altitude 15
1800 m 15
2800 m 15
1400 m 17
1550 m 17
Soil 17
Volcanic 17
Basic Pre-Cambrian Shield 18
Aluvial 20
Population 23
Government 24
The Zones 26
High Plateau (A) 26
Kagera Piedmont (B) 28
Kivu Lakeshore (C) 28
Kayna (D) 28
Maniema Slope (E) 29

Central Congo-Nile Divide (1) 30
Volcanic Highlands (2) 30
Bututsi (3) 31
Batembo Highlands (4) 31
Mitumba Range (5) 32

III. Farm Models 33

Zone A 33
Zone B 36
Zone C 37
Zone D 40
Zone E 42
Zone 1 43
Zone 2 44
Zone 3 46
Zone 4 47
Zone 5 49
Summary 49

IV. Proposed System Changes 54

Soil Conservation 57
Mulching 58
Perennials for Soil Cover 63
Forests 63
Boundary Trees 64
Tea 66
Banana 67
Annuals and Grasses for Soil Cover 69
Contour Ditching 72
Contour Strips 73
Nitrogen Fixation 75
Green Manure 76
Chemical Fertilizers 76
Manure and Compost 78
Changes in Cultural Practices of Existing Crops 79
Mulch Coffee 79
Prune Coffee 79
Improve Coffee Cover 80
Spray Coffee 80
Sweet Potato Cover 80
Improved Maize Varieties 81
Improved Potato and Cassava Varieties 82
Potato Fungicides 82
Improve Marsh Cultivation 83
Multiple-crop Marshes 83

Changes in Cropping Patterns	84
Thin Bananas and Interplant Beans	84
Shift from Beer Bananas to Cooking Bananas	85
Intercrop Beans with Grains	85
Intercrop Coffee with Bananas, Beans	86
Expand Sweet Potato, Soya, Wheat	87
New Crops	88
Expand Marsh Cultivation	91
Changes in Livestock System	91
Replace Cattle with Goats	91
Stall-feed Animals	91
Improve Animal Health	92
Improve Animal Breeds	92
Meat or Milk	93
Fix/Individualize Grazing-Land Tenure	93
V. Elements of a Strategy	95
Practices to Encourage Now	95
A Research Agenda	98
The Role of IDA	100
Annex - Conservation and Improvement of Soil Fertility	101
Recycling of Plant Nutrients	101
Soil Cover	105
Fallow	105
Composting and Integration of Crop and Animal Production	106
Use of Fertilizers	106
Table - Zones by Area, Population and Country	27
Maps	
Farming Areas by Elevation	frontispiece
1. Farming Zones	16
2. Land Use Patterns in Kayanza-Gatara (Zone A)	21
3. Land Use Pattern in Bururi (Zone 3)	22
4. Land Use Pattern on Gatovu Hill (Zone A)	34

Introduction

0.01 The East African Highlands, like the central Andean Highlands, represent an exceptional agro-climatic zone--equatorial, yet temperate and well-watered. They are attractive environments for human settlement because they are free of certain diseases endemic in neighboring areas and because they are conducive to agriculture and animal production. Consequently, human settlement is very dense (75-400/km^2) compared to surrounding lowlands. So attractive are the Highlands that within the past few decades and in some areas at least, agricultural use of land has reached the point where there is little fallow land or grazing land left.

0.02 Such agricultural intensity is not at all unusual. Continuous cropping is the rule in temperate farming zones; in lowland, monsoon Asia, cropping is both continuous and, where water can be controlled, double. But this is not the traditional system of the East African Highlands. We are now witnessing a struggle to evolve a cultural system consistent with higher and increasing population densities and to adapt the traditional system to it.

0.03 The countries of the CEPGL (Economic Commission of Great Lakes States) offer a unique opportunity to try to understand these changes and, hopefully, to plan agricultural policies and project interventions that will promote useful transitions to new farming systems, thus improving the well-being of the highland farmers and pastoralists of this area.

0.04 In Rwanda, Burundi, and Kivu Province of Zaire, geological faulting has produced two mountain chains--the Mitumba Mountains in Zaire and the Congo-Nile Divide in Rwanda and Burundi--with a great Rift Valley in between that is partly filled with lakes. This area contains about 12 million people in an area of 93,000 km2 or 130/km^2--easily eight times the population densities of the surronding lowlands. To the identifying characteristics of all tropical highlands, the Great Lakes Highlands add extreme economic isolation; over 90% of the population are farmers and pastoralists so that there is no substantial internal market for agricultural surpluses. Moreover, the nearest significant urban center is over 1000 km. away. The sea is over 1000 km. away too, and the transport routes to it are not cheap.

0.05 Bank Group involvement in the primary sector of the Great Lakes Highlands has been modest--total committments have been $123 million or about $10/head. Initially, efforts focused on increasing the efficiency of producing the area's major export crop: arabica coffee, or on settling surplus population from the Highlands in adjacent areas of slightly lower-altitude. Yet over 90 % of the area's population lives on small Highland farms, and virtually all of what they produce is food for their own use.

0.06 This predominant "subsistence" food-production sector of the economy pretty much took care of itself up to the present. Cultivated area expanded with expanding population. Now it can continue to do so only because of secular emigrations from the more densely-settled parts of the area; emigrants expand cultivated area in similar ecological areas of Zaire or Tanzania. Resistance to Highlanders' settling is rising in the host regions. But even with emigration, expansion of cultivated area in the Highlands, particularly by cultivating steep and/or infertile slopes formerly reserved for grazing and by shortening fallow to less than that necessary to sustain soil fertility, is mining soil fertility. This phenomenon has worried experts and public authorities, colonial or national, for decades. However, there is now scattered evidence from declining yields per unit of land and from examination of soils, at least in some of the most densely-settled areas, that these worries are well founded.

0.07 Therefore, the Bank Group has started to concern itself more directly with the small-farm food-production complex which constitutes the core of the Highlands' agriculture. This concern is most evident in the Buyenzi (Ngozi) and Kirimiro projects in Burundi. In the former, what was once a coffee improvement project has been broadened to try to help participating farmers with food-crop agricultural problems as well. The latter tries to help participating farmers with food-crop problems, but with emphasis on coffee. Until recently, Bank Group farming projects in Rwanda were essentially settlement schemes and avoided the densely settled areas of traditional small farms. Now the Kivu Lakeshore Project, like the Burundi projects mentioned above, aims to help small farmers with coffee and foodcrop development. There are now no Bank Group agricultural projects in Kivu. However, possible future projects are under discussion. Moreover, the second Ituri project, further north in the Mitumba Mountains than the area covered by this study, addresses the animal-husbandry problems of the rural population and contains some modest interventions to address farming problems.

0.08 These beginnings of interventions to modify the predominant mode of agricultural production in the area are handicapped by our weak understanding of the agricultural system in this area. The "we" whose understanding is thin applies not just to the Bank Group but to all concerned. The least ignorant are the roughly two million farmer families who understand the system that their own farms represent and the extremely subtle land and labor allocation decisions they make, the varieties they choose, the timing of their operations, etc. But even they are unable to see the regional agricultural economy as a system. Consequently, farmer actions that make individual and short-term sense sometimes add up to collective and long-term folly.

0.09 This report is a stock-taking based on three weeks of field work (including two weeks of actually visiting farms and talking with farmers) plus a review of general and Bank internal literature. No scientifically designed, farm management studies of farms in the area exist and, manifestly, one was not conducted for the region by the mission.

0.10 This study treats an area that is ecologically defined (but within the three CEPGL countries; otherwise the Kigezi region of Uganda and the"Buta" region of Tanzania would be included). Politics in its broadest sense does have consequences for farming systems; the effects of being in three different countries with three different economic policies are discussed just like any other factors that tend to differentiate the Great Lakes Highlands farming systems. But the study focuses on farms and livestock-raising enterprises. Government is taken into account only in its effect on production units and is not an object of interest for its own sake. In this regard, this study is quite different from a country agricultural sector memorandum, with its focus on government institutions, budgets, and plans.

0.11 In focusing on production units, this study tries to understand them in their broadest context, then, to evaluate suggestions that are current for modifying these production systems, concluding with suggestions for the strategy which governments, the Bank Group, and the donor community might follow if they wish to promote a sustainable primary sector in the Great Lakes Highlands that will provide for the wants of farmers and pastoralists better than it does now. It is divided into five chapters which deal respectively with:

- history -- how the present pattern of Highlands agriculture evolved;

- structure -- patterns of differentiation in Highland agriculture in response to altitude/temperature/rainfall, soil, population, and government;

- production-unit types -- first approximations of farm models based on the above;

- proposed practices -- the Mission's assessment of the many proposals, the extent to which their financial/economic profitability is already proven, and research that might be indicated to settle such questions; and

- strategies -- considerations of what governments and/or international financiers might do to cope with stress on the Highlands' agricultural system and improve the living of the rural masses.

I. Evolution of Agriculture in the Highlands

1.01 Highlands agriculture is evolving rapidly at present. This evolution is a response and adaptation to two variables outside the agricultural sector: increasing human population which has now reached critical numbers relative to the farming system practiced in 1900 and before; and cheaper commercial and transport links to the outside world, which have lowered the amount of work necessary to produce agricultural goods for export and to purchase a given quantum of imported goods.

1.02 Now the speed of change of these two exogenous variables since 1900 has clearly been many times faster than it was before that time. Population growth, now more than 2%/year, was certainly less than 0.5%/year before the present century (and even if it had not been, population levels relative to available arable land were such that it would not have made much difference). The public-health revolution had not begun in 1900. And techniques of trading and moving goods common in 1900 were presumably more similar to those 19 centuries earlier than to those of today. Not only were there no roads or railroads, but the Germans had not yet introduced mule paths in Ruanda-Urundi. Long-distance trade and credit transactions were quite exceptional; the slave trade provided an exception but, happily, it generally flowed around, not through, the Great Lakes Highlands.

1.03 With these relationships in mind, two observations seem pertinent:

- firstly, agricultural change in the pre-colonial Great Lakes Highlands must have been taking place very slowly, so that the agricultural systems practiced in 1900 must have been very similar to those worked out gradually over the preceeding millenium or two; and

- secondly, despite the rapid evolution since then, that the "traditional" agricultural systems of 1900 were, by all evidence, remarkably similar to those practiced today. Moreover, as we shall see, the lines of evolution from the systems of 1900 to those of 1982 and their causes are reasonably clear.

That is why it turns out to be operationally useful to see how Great Lakes Highlands agriculture evolved, even from the distant past.

Early Highlands Agriculture

1.04 Agriculture arrived in the Great Lakes Highlands when the first wave of baNtu arrived. Previous inhabitants, ancestors of today's baTwa pygmies, practiced hunting and gathering, not agriculture and animal husbandry. These baNtu migrants were part of the great baNtu expansion which, as we know from linguistic evidence, started from the Mount Cameroun area in west Africa towards the end of the first millenium B.C. The west African ancestors of most of today's inhabitants of the Great Lakes Highlands had invented an agricultural system based on sorghum, millet, cowpea, vouandzou (Bambara groundnuts), yams, and certain plants of the curcubit family; they smelted iron from lateritic deposits to make tools and weapons. These innovations conferred a dramatic superiority over hunting/gathering peoples limited to tools and weapons of wood or stone. The baNtu peoples were fruitful and multiplied, expanding into a nearly empty continent and choosing their expansion into areas appropriate to their agriculture--well-watered, wooded savannahs. Thus, they spread eastward through the savannahs north of the Congo rain forest and south of the Sahara Desert and its Sahel until they reached the east African Great Lakes region early in the first millenium of our era.

1.05 In the Great Lakes Highlands, the area most suitable for sorghum-legume agriculture was and is the wooded savannah between 1550 m and 1800 m in altitude. It had and has rainfall between 1000 mm and 1500 mm per year, spread over two seasons--enough to make crop failure due to drought rare, but not too much for the crops 1/. Altitudes higher than 1800 m were covered with heavy, almost impenetrable tropical highland forest; they had higher rainfall, were too cold to be easy climates for human habitation, and for sorghum to grow. Lower altitudes in the Rift Valley and to the east were similar to the drier parts of the west African savannah; rainfall was and is sparse enough (when spread over two seasons) to make sorghum culture risky. Moreover, these lower altitudes were unhealthy places to live; as in the west African savannah, malaria and onchocerciasis were endemic, and human sleeping sickness was a scourge. The lowlands west of the Highlands were inhospitable too: having the same disease problems and being too wet for the crops the baNtu migrants were expert in cultivating. (To this day, there is no sustainable system of annual cropping for the humid tropics, except for rice culture in water-retentive bottom lands.)

1.06 A glance at the map on the frontispiece shows that the biggest block of land with elevations between 1550 m and 1800 m is east of the Congo-Nile Divide in what is now Rwanda, Burundi, and Uganda. It is precisely this area that was the cradle of the Great Lakes Highlands civilization and which has always been its epicenter. We will call this area the High Plateau, even though scarcely any of it is flat enough to be a plateau. (See Zone A on Map 1, page 16).

1.07 The larger area to which baNtu agriculture was adapted -- the 1400-1800m altitude area -- is, in fact, extremely hilly, a deeply and intricately dissected peneplain with small hills of steep slopes. The least hilly part of this very hilly area is the wide portion that forms the

---

1/ At lower altitudes, such as the West African savannah, with 1000-1500mm of rainfall, the risk of crop failure due to drought could be severe - say once every four or five years. This is not the case, however, above 1550m in the Great Lakes Highland. Both elevation and higher degree of cloud cover reduce temperature and therefore evapotranspiration, so that a given amount of rainfall goes farther.

bulk of Rwanda and Burundi. The small streams that divide its hills form marshes between them. The narrow area between the Congo-Nile Divide and the Great Lakes (Mumirwa in KinyaRundi), and that between the Great Lakes and the Mitumba Mountains on the Zaire side are hillier still and have few marshes (Zone C). The area between the Mitumba Mountains and the Congo rain forest is a bit less hilly, but is influenced by the humid area to its west (Zone E).

1.08 On the High Plateau, east of the Congo/Nile Divide, the baNtu-speaking immigrants established their agricultural system based on sorghum, millet and legumes, and simple iron tools. That system required no large-scale social organization. Defense requirements were modest in an isolated part of the world where there was, then, plenty of arable land; possession of iron tools gave adequate protection against economically more primitive hunter/gatherers to agriculturalists organized at the clan or sub-lineage level. Consequently, early Great Lakes Highlands agriculture determined cultural organization: notably, (a) a "segmented" political system based on small kinship groups and highly decentralized, and (b) a disbursed settlement pattern with almost nuclear families living on their farmland and not in villages. Isolated farmhouses (rugo) evidently did not mean lack of social organization. The origins of some of the interactive customs that hold the very rural Highlands together today, notably the custom of giving, taking, and drinking beer together among neighbors, must be extremely ancient.

1.09 In the first millenium, the beer was more apt to be sorghum beer; today it is more apt to be banana beer. This change is indicative of both the continuity and of the change in the agricultural system of the Highlands in the past two thousand years. New crops have arrived; Nilotic peoples with more interest in cattle have arrived; disruptive international trade (in slaves) made it important to organize larger political units for defense; but the basic agricultural (and cultural) pattern of the societies has remained. The physical and cultural descendants of those early immigrants speak closely related and largely mutually intelligible languages: kinyaRwanda, kinyaRundi, kiShi, and kiNande. The hunter/gatherer baTwa that came earlier and the pastoralist baTusi and baHima who came later have had their influence on cultural systems, but they have not changed the basic character of the agricultural and cultural systems. They all speak the same baNtu languages as everyone else.

From the baNtu Migration to the European Conquest

1.10 Between the establishement of baNtu agriculturalists in the High Plateaux of Rwanda and Burundi and 1900, evolution in the farming systems was extremely slow. It did not need to be faster. Land was plentiful enough to allow population to concentrate in the optimal farming areas--at elevations of 1550 to 1800 m. and where slopes were not over 20% (see zone A on Map 1) --and still have enough land to allow fertility-restoring fallow and ample pasture for livestock. Additions to the stock of cultivable plants came principally from selection and up-grading of local plants similar to these domesticated earlier in West Africa.

1.11 Although the ancestors of the sweet or table banana come from the Philippines, useful plants known as bananas [2]/ or plantains are in fact a bewildering variety of species of the musaciae family, members of which are indigenous just about all over the tropics. In the Great Lakes Highlands, the bananas which were chosen as part of the farming systems were the beer bananas. Beer bananas early became the most important crop in terms of cultivated area (granting that they are perennial and occupy land all year round) and of gross weight of output (though not on a dry matter basis, since much of that output is water). Over 90% of bananas are of this type. They are harvested green, ripened over fire or in pits, mixed with grass in a wood container until the juice is expressed and fermented for about three days. In the process, an estimated 41% of the bananas' calories are lost (cf. para. 4.38 below). Nevertheless, they are a major source of food energy for Great Lakes Highlands people and the basis for the most important institution of social interaction and cohesion. (North and east of the Great Lakes Highlands, in the Buganda, cooking bananas predominate and are the major staple food).

1.12 West African savannah agriculture replaced or mixed sorghum with bullrush millet (Pennisitum typhoidium) where there was sufficient risk of drought. Once they established themselves in the Great Lakes Highlands, farmers used finger millet (Eleusine coracana), whose wild relatives are indigenous to the area, instead. The pea seems to have been introduced to the area from its native west India through Ethiopia well before the first contact with Europeans. As the higher altitudes started to be cultivated, peas and finger millet became more important because they tolerate cold better and also because they do relatively well as very extensive cultures, sown on pastures, hardly tended and then harvested. This is exactly how the higher altitudes were initially used.

1.13 After the discovery of the New World, a host of New World plants were introduced to Africa, principally by the Portuguese in the Congo, as part of what has come to be called the Colombian Exchange. A number of these plants: beans, maize, manioc, sweet potato, potato, have become important, indeed, dominant in the Great Lakes Highlands farming systems. But though the spread of New World plants was rapid in Africa, they had not yet made a significant impact on Great Lakes Highlands agriculture by 1900; there is no firm evidence that they were grown there at all. Jones indicates that manioc had spread from Kongo to the Baluba states of northern Shaba between 1500 and 1900, but that its use did not extend to the Great Lakes Highlands [3]/. A similar conclusion applies to maize,

---

2/ The biological distinction between bananas and plantains is not clear. Therefore, the Belgian practice of calling all useful members of the Musa genus bananas will be followed. Following the system of distinguishing between cooking, beer, roasting, and desert bananas (see J.D. Jameson, Ed. Agriculture in Uganda. Oxford, 1970, pp. 141-2), almost all Great Lakes Highlands bananas are beer bananas.

3/ William O. Jones. Manioc in Africa. Stanford: Food Research Institute, 1959, p.68.

which spread both east from the Kongo Kingdom and west from the East African coast by slave traders through the savannah areas of what is now Tanzania 4/. Other than the pea, the only crop introduction about whichwe can be reasonably sure between 900 and 1900 is rice, introduced from Asia by Arab slave traders and their collaborators and not from the secondary centers of rice domestication on the Niger bend. Rice was and is a crop of little importance in the Highlands.

1.14 The slave trade had a major impact on settlement patterns and, consequently, on farming systems in the Great Lakes Highlands. Before 1600, slavery existed in Africa, as in other parts of the world, but it was largely a local matter. From 1600 to 1850, it was big business -- a major item in international trade. The big increase in people capture and trade came in the Atlantic slave trade, which mainly affected West Africa. However, the Arab-Swahili East African slave trade was big business too and its volume evidently grew dramatically in the 18th and 19th centuries. The earliest European explorers and colonizers found that Arabs, coastal Africans and their local allies had organized trade and sometimes politics over large parts of eastern and central Africa -- but not in present-day Rwanda and Burundi. As in western Africa, organizing the slave trade meant disorganizing local culture: setting a premium on war and capture of neighbors, and discouraging investment and settled life, including agriculture.

1.15 The advent of slave trading to the Great Lakes Highlands' larger region roughly coincides with the organization of the interlacustrine kingdoms, of which Rwanda and Burundi were two. From the middle of our millenium onwards, Nilotic pastoralists had been migrating south into the Great Lakes Highlands region, presumably establishing largely symbiotic relationships with the more numerous established, baNtu-speaking agriculturalists. There was plenty of land; cattle could be grazed on fallowed farmland (and besides, farmers had probably already cleared parts of the tropical-forested highlands over 1800 m, turning it into grasslands). Little by little, the pastoralists adopted the agriculturalist's language and many of their customs, such as banana-beer socializing and communal work. Their mode of production continued to be different, however, and so their culture continued to be different. It was they who organized the custom of feudal relationships based on ownership and custodianship of cattle (Ubugabire) which grew into the organizing political principle on which the kingdoms were built. They also turned communal work into a feudal subordinate's duty to his patron in the institution of ubureetwa and later feudalized land rights through the institution of ubuhake 5/.

4/ See Marvin Miracle. Maize in Tropical Africa. Madison: University of Wisconsin, 1966.

5/ For more information, see Jacques Maquet. "La tenure des terres dans l'Etat rwanda traditionnel", Cahiers d'Etudes Africaines (1967) VII (4), No. 28, pp. 624 - 636, and Lydia Meschi." Evaluation des structures foncières au Rwanda: le cas d'un linage hutu", Cahiers d'Etudes Africaines (1974) XIV (1), No. 53, pp. 39 - 51.

1.16 By organizing larger political units, the residents of the Highlands of today's Rwanda and Burundi were stronger militarily. Slave traders avoided them. The slave trade flowed around them. Their culture, their political organization, and their agriculture were better able to develop; they became more numerous than their periodically decimated neighbors. And, being secure, they did not have to live in defensible villages. Farmers and herders lived where their livelihood was, close by their fields and flocks.

1.17 Neighboring areas were not so. People in the adjacent lowlands and people in the Highlands west of the Rift Valley (principally baShi and baNande) did not organize large-scale, feudal, political systems based on cattle ownership and custodianship. Their politically-segmented societies were vulnerable to roving bands of slave traders or neighbors looking for captives. They gathered themselves into villages for safety and walked to fields, making the land-use pattern and farming systems somewhat different, as they remain today. The institutions of giving and receiving beer and cattle were less essential for social cohesion than they were in the area of dispersed settlement; they have always been less important west of Rift than east of Rift. And, despite villagization, the baNande, baShi and relatives must have been less successful in establishing peace and prosperity in the times of slavery. Comparing areas of equal fertility and other ecological conditions east and west of Rift, areas to the west are much less peopled.

<u>The Present Century</u>

1.18 In 1900, as colonial rule was overtaking the Great Lakes Highlands, its population was about 3 million, compared to 12 million today. That population was more highly concentrated in the High Plateau then than it is now because there was less impulsion to farm less desirable land. Probably half to two-thirds of the Great Lakes Highland's population lived in the High Plateau at the time.

1.19 As a result of colonial rule and independence, this pattern has changed. Population growth has induced settlement and farming of ecological zones that were not farmed formerly, as well as farming of a higher percentage of the land in the High Plateau than was traditionally used. Three factors have made the pattern of changes in farming systems since 1900 possible. They are the revolutions in <u>transport</u> and in <u>public health</u>, and the <u>introduction of new crops</u> into the systems.

1.20 <u>Public health and expansion</u>. In fact, the public-health revolution also made farming-system changes necessary. There is no need to dwell here on the fact that it is the fall in death rates that has led to rapid population growth, not any increase in birth rates. As the record shows, even rudimentary modern health care has major long-term consequences far more important than the cessation of the wars and slave trading of the Nineteenth Century. More people has meant expansion of settlement, of farming, and of livestock raising. With abundant land resources, intensification has not been necessary (although, as we shall argue, in some cases, it would now certainly be desirable). Expansion has been able to take place within the agricultural frontier, and also by expanding that frontier.

1.21 On the early-settled agricutural lands of the High Plateau and ecologically similar areas like the slopes of the Rift Valley between 1400 and 1800 m elevation (which we will call the Kivu Lakeshore; see Map 16849, zone C), expansion within the frontier means: (a) shortening grazed fallows by planting a higher proportion of the land each year on land of moderate slope; (b) starting to cultivate steeper land (say, more than 20% slope) that had previously been left for grazing; and (c) clearing the papyrus swamps at the bottom of hills and using them for a dry-season crop. This internal expansion in the High Plateaux is still going on. The extent to which it has run its course is largely determined by population density. Marsh development, for instance, began not too long ago in the most densely peopled hills around Butare, Gitarama and Kigali in Rwanda and around Kayanza and Ngozi in Burundi. In these areas and in some others now (e.g. Gitega), all marshes are being exploited for one or two dry-season crops. In areas of lower population density, such as the Karuzi arondissement in Burundi, swamps are partly reclaimed; reclamation will probably not be complete for another five or ten years. There are similar variations within the High Plateau in the time at which and the extent to which the other aspects of expansion within the frontier have taken place.

1.22 Expanding the agricultural frontier took the form of settling higher and lower lands that had previously not been used. Above the 1800 m contour, fire and grazing gradually degraded the natural forest and turned it, little by little, into grassland. By the present day, there is virtually no natural forest below 2500 m east of the Rift and very little farming above 2500 m on either side of it. But the process that led to this result was gradual. As land pressures increased on the High Plateau, farmers began to colonize the higher lands. In this, they were particularly aided by the introduction of peas, a substitute for the beans of their preferred habitat, and of maize, a substitute for sorghum. Probably agricultural colonization of the higher regions began with extremely extensive sowing and gathering of finger millet and peas in semi-pastures. Sorghum and beans do not do well above 1800 m. Then, availability of maize, peas, potatoes and finally of cash crops like tea and pyrethrum enabled farmers to farm the Congo-Nile Divide (Map 1 Zones 1 and 2) with an intensity similar to that of the High Plateau. Also, presumably settlement began with the rich volcanic soils around Ruhengeri and Goma (Zone 2) and extended progressively to areas of mediocre and poor soils. Present population densities so indicate.

1.23 High Plateau farmers have been moving down the hills too, most notably into the Kagera Piedmont (see Map 1, Zone B) which is still very similar to their preferred region but a little drier and a little warmer. Very similar farming systems to those of the High Pleateau are appropriate in this zone of 1400-1550 m elevation.

1.24 On the Kivu side of the Rift, areas of similar resource endowment have lower population densities than those east of Rift, presumably as a result of their less successful organization to resist the slave trade -- their less-organized political systems. The major population centers west of the Rift were the buShi state of the Bukavu area, which fought off Arab-Swahili attacks in the 1880s and 1890s, and the baNande group in the Beni-Butembo area. Much of the rest of this side of the Highlands was empty enough to encourage establishment of European plantations once colonial control was consolidated. This was particularly the case for the west shore of Lake Kivu and the Rutshuru area, where plantation arabica coffee culture flourished, and for the Masisi, where Europeans organized pyrethrum-growing on a plantation basis. These areas are in the Kivu Lakeshore (Map 1, Zone C) and Volcanic Highlands (Map 1, Zone 2) zones. The number of Europeans involved was very small; they organized and financed, but hired labor to do most of the work. Therefore, this development too led to an expansion of the agricultural frontier and African colonization of an area previously little settled.

1.25 Transport. The Great Lakes Highlands area today is among the most expensively removed from world markets of any place in the world. Nevertheless, real unit transport costs are much lower by rail, road and even air than they were by foot, often through hostile or disorderly country, before 1900.

1.26 Even today, high transport costs severely limit the region's trade with the outside world. Agricultural exports from the Highlands: coffee, tea, cinchona and pyrethrum, all have high value per unit weight and bulk. Nonetheless, transport typically takes 15 to 30% of these commodities' cif prices at east Africa ports. Obviously, export of bulky crops of low value per unit weight, such as maize, manioc or beans, to world markets is out of the question. Transport costs per ton for them are about the same, thus prohibitively high as a percentage of cif port prices. There is nothing left to pay farmers for their labor, risk, and management.

1.27 But today's transport costs are nothing compared to those before 1900. Transport costs per ton kilometer by head portage are characteristically anywhere from fiteen to fifty times those using ruddimentary roads and wheeled vehicles. And such costs are real. Even if the porters are slaves, their use as porters precludes other work they might otherwise have done. Moreover, whatever the demerits or merits of European colonialism in terms of justice, it did enforce peace. The force of German and Belgian arms and logistics had pretty much enforced peace by 1908 (though sporadic "pacification" continued until World War I). So, goods traffic in the Highlands no longer had to pass through war zones nor to pay passage fees to the many local authorities across whose domaines it passed.

1.28 The actual change in transport means started immediately with European control -- the Germans designated mule paths as soon as they got to Rwanda-Urundi -- but the penetration of the wheel and/or animal or motorized traction has been gradual. Even today, transport to and from field and rugo is almost invariably by head portage. Nevertheless, Highlands farms are economically much closer to markets than they were less than a century ago. Therefore, nearly 5% of land has been devoted to crops for export, principally coffee. It is less than 5% of farm land and less than 5% of farm family labor too, but this opening of the Great Lakes Highlands to international division of labor is the principal way Highlands' farmers have of purchasing things they do not produce themselves[6/].

1.29 Crop introductions. New plants were the most important facet of Highlands' farming-systems' adjustment, between 1900 and the present, due to the fact of increasing population density and to the opportunity of lower transport costs. But probably the most important adjustment in cropping pattern stemmed from increasing cultivation of an already known plant.

1.30 It appears that the beer banana was a strictly secondary crop before 1900. Certainly in those parts of the Highlands organized along feudal kingship lines, sorghum was a sacred crop and the one used for making beer. Bananas were not allowed to be grown in the royal domaines of the mwami of Burundi. With European rule, banana cultivation expanded rapidly and without any efforts on the part of the new rulers, who were certainly disposed to discourage it. Bananas have become the crop that inspires Highland farmers to their best husbandry and soil conserving practices; being a perennial, banana "trees" cover the soil and prevent erosion. A quick look around the region shows, however, that they were not established for soil conservation and erosion control. Banana groves tend to nest in small folds in hillsides down to which soil nutrients have been washed from the annual-cropped soils above. Thus banana groves tend to occupy the more fertile and less steep hillside land (at altitudes of less than 1800 m), which are more fertile because they are supporting banana culture than they would have been if something else were planted there. Bananas give a high yield per unit of land -- usually about 10t/ha -- and have largely replaced sorghum as beer raw material. They are very little used as a starchy staple however.

1.31 The principal cropping pattern changes to displace sorghum as the dominant starchy staple have been introduction of three New World tubers and one grain. The grain is maize -- now the most important grain in the Highlands and dominant over sorghum in all but the most ancient seat of Great Lakes Highlands culture, the High Plateau in Rwanda. Sorghum has also retained a place beside maize where uncertain rains and risk of crop

---

6/ Farmer earnings from banana beer sales are greater, but most of these sales are inter-farm, not net earnings of the farm sector. That is because beer has to be brewed in at least a certain threshold quantity which is well beyond a family's immediate needs, and because it does not store well. Therefore, there is a large and constant trade of banana beer between farm households. Payment is as likely to be in friendship as in cash or kind. Families are not all self-sufficient in beer, however. Families who established their farms earlier have usually occupied more fertile land in the folds of hillsides and can grow more bananas; more recently established farms usually have less fertile lands and are net buyers of beer.

failure add value to sorghum's drought-resistant characteristics, such as in the Bugesera, the Bweru, and the Mutara (all Zone B).

1.32 Maize thrives at higher altitudes than sorghum can tolerate. Sorghum stops growing when the temperature dips below about 15°; maize, below 10°. Thus maize's introduction facilitated the colonization of higher altitudes along the Congo-Nile Divide (Zones 1,2, & 3). Also for the higher altitudes, Belgian authorities introduced wheat, originally a Mediterranean crop. At the higher elevations, nights are definitely cool enough for wheat. It has never become a primary crop, however, most production being destined for consumption by foreigners in the region's towns. In the highlands above Butembo in Zaire however (Zone 4), wheat has become a significant crop and has found a place in the local diet.

1.33 As population densities have increased, particularly where land is most scarce, farmers have turned to tubers as a starch source. Statistics show a consistent and continuous displacement of grains and legumes by tubers, which yield more starch per hectare. The mix of tubers depends on altitude, with sweet potatoes dominant, especially at middle altitudes of 1500-1800 m, partly replaced by potatoes, which grow only above 1800 m, and with more and more manioc at lower altitudes and lower soil fertility. Manioc, whose spread was rapid and spontaneous in Africa after its introduction from Brazil (see para 1.13 above), seems to have reached the Great Lakes Highlands only when introduced by Belgian authorities as an obligatory crop in the 1930s as an anti-famine precaution after the great Highlands famine. It continues to be an even more important component of the cropping pattern below the 1400 m elevation contour that defines the lower boundary of the Highlands than above it. The persistence of potato culture, particularly in the Ruhengeri area (Zone 2) but also in other parts of the higher areas (notably Zones 1 and 4), is remarkable in that farmers perpetuated this difficult culture without any outside assistance in pest control or planting material.

1.34 Legumes are the Highlands' principal source of protein and a major source of food energy too. Today beans (Phaseolus vulgaris) are dominant, except at altitudes over 1800 m where they do not do well and have to be substituted by peas. Beans are a New World crop and not part of the baNtu settlers' arsenal of crops. It is not known whether they spread to the Great Lakes Highlands between 1492 and the European conquest, but they probably did. Certainly, after 1900, beans spread rapidly, almost totally replacing voandzou and cowpeas. Not only are they indispensable for a viable diet on small Highland farms because of their protein contribution, but, as pressure on land has grown and fallows have shortened, beans have become ever more important for the nitrogen they fix in the soil too, making it possible to grow cereals and tubers.

1.35 Export crops make up less than 5% of the crop area, but they permit farmers to buy the things they cannot produce and, consequently, to live above the bare margin of subsistence. Four crops account for virtually all of the Highlands' agricultural exports: coffee for 84%; tea for 7%; cinchona for 7%; and pyrethrum for 1%. All four were introduced as part of very deliberate efforts by Belgian authorities. While Arabica coffee is native to the ecologically similar Ethiopian Highlands only about 1300 km away, it did not reach the Great Lakes Highlands until 1920. On the Kivu side of the Rift, it was a European estate crop; on the Rwanda & Burundi side, coffee was planted by regular farmers. Tea was only introduced experimentally in 1925. Initially it was a plantation crop only. Pyrethrum was introduced on Belgian settler plantations in the Masisi and above Gisenyi (Zone 2) in 1931-32 to have a locally produced insecticide for coffee. In the instance, DDT solved the coffee problem, but pyrethrum culture continued. Starting in 1943 around Ruhengeri (also Zone 2), efforts were made to involve smallholders on a tighly-controlled and centralized basis. Cinchona was introduced at the same time, also on an estate basis around Bukavu.

1.36 Coffee's adoption was earlier and more extensive than the other export crops. Moreover, until the last 20 years, tea, cinchona and pyrethrum had virtually no place in the farming systems of African farmers. So coffee's adoption east of Rift is an interesting farming-system modification. Now, on the High Plateau, to which is it best suited, the great preponderance of farmers grow some coffee. The number of trees per farm ranges from just a few to several hundred, averaging about 150 trees, less than 10 ares. This extraordinary diffusion was fostered by Belgian authorities working through the Bami of Rwanda and Burundi and their network of chiefs. Once the Belgian administration persuaded the Mwami of Rwanda or of Burundi to order that coffee trees be mulched, they would all be mulched. The administrative authorities did the research, selected varieties and produced planting material, and worked out the appropriate cultural practices. The feudal network ordered them to be carried out. The farmers did. The fact that farmers generally followed orders also indicates that they appreciated the purchasing power that cash from coffee sales gave them.

1.37 As for integration into existing farming systems, coffee culture was a supplement apart. No intercropping of coffee was permitted, so that this perennial grew on a small plot within the farm complex. Integration into the system came because the same family-members' labor was used to grow coffee as to grow other crops or to tend livestock. Also, coffee trees (which do not cover the soil and shade thoroughly as bananas do and thus do not increase soil fertility or prevent erosion) had to be mulched. The obligation to cut mulch for coffee from fallow land to supplement crop residues represented another facet of integration of coffee into the traditional system.

II. Ecosystems That Differentiate

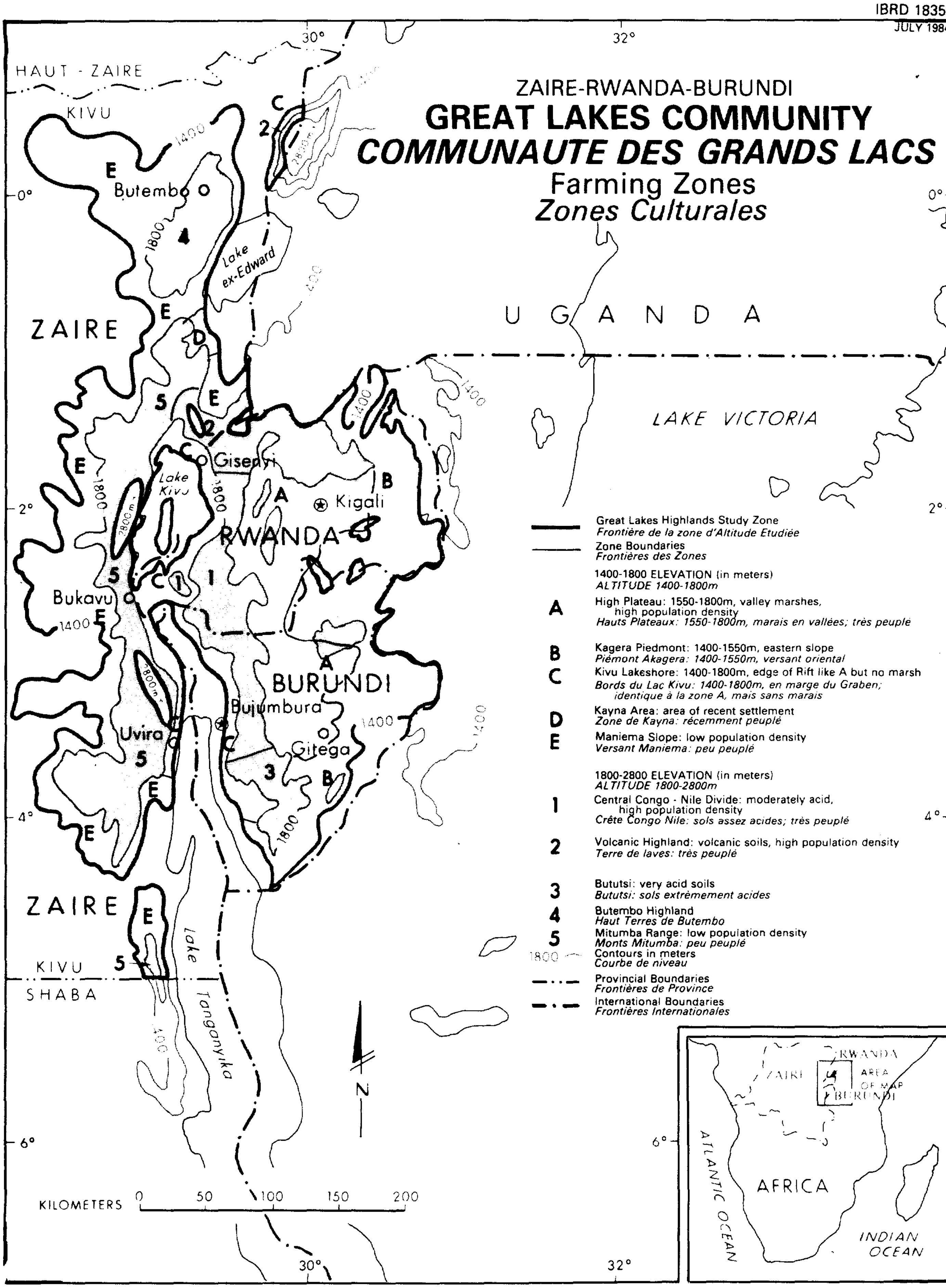
The Factors

2.01 Great Lakes Highlands' agriculture, that seems so uniform and to form such a distinct type when viewed from afar and when compared to agriculture in the rest of Africa, is remarkably diverse when one takes a closer look. These diversities are purposeful adaptations by farmers to different conditions. The chief differentiating factors are altitude, because it largely determines and correlates highly with rainfall and temperature; soil; population density (partly a variable dependent on altitude and soil, but also partly independent of them); and government (on which population density, but also certain other economic system characteristics are partially dependent). Below, we discuss the effects of these determinants on farming-systems. Then, chiefly on the basis of the first three determinants, we define ten agricultural zones and describe each briefly. (See paras 2.31-2.51 with salient charecteristics summarized in Table 1 on p. 27).

2.02 Chapter III marshalls the information we have on farming in each of these ten zones, begins the task of defining farm models for these zones, and describes patterns of variation within zones and patterns of change by zone over time.

2.03 The altitude factor. The most important differentiating factor for Great Lakes Highlands farming systems is altitude. The altitude of about 1800 m is an important transition point (See Map 1). Beer bananas grow very well below it; either not very well or not at all above it. Potatoes grow above it, but not below, while manioc does less well as altitudes climb above 1800 m. Sorghum fades out above 1800 m, while finger millet and wheat fade in; maize competes with sorghum for dominance among grains below 1800 m, but is clearly dominant above that altitude (although it takes quite a while for maize to mature at high altitudes). Beans do less well at altitudes over 1800 m and tend to be replaced by peas. Above 1800 m, coffee struggles and gives poor results, but tea and pyrethrum are well adapted. For these reasons, in dividing the Great Lakes Highlands into farming-systems zone (below), the 1800 m contour is used to make the most basic division.

2.04 As altitudes increase above 1800 m, agriculture becomes sparser and sparser until it disappears altogether in what remains of the tropical highland forests, prairies or glaciers that still cover the highest mountains. The agricutural fade-out stems partly from the inaccessibility of mountain peaks, partly from difficulty of growing useful plants at such high altitudes. Much of the area above 1800 m ranges from rather to extremely infertile and a good bit of it is devoted to pasture. Above 2300 m, most is forest (which may be somewhat degraded by cutting for firewood, charcoal and by use for grazing). Where soils are rich, however (see below), cultivation of potatoes, pyrethrum and maize is carried on even above 3000 m. To eliminate the area of the Highlands too high for agriculture, we have drawn its upper boundary at 2800 m.


IBRD 18355
JULY 1984
ZAIRE-RWANDA-BURUNDI
GREAT LAKES COMMUNITY
COMMUNAUTE DES GRANDS LACS
Farming Zones
Zones Culturales
HAUT - ZAIRE
KIVU
ZAIRE
UGANDA
LAKE VICTORIA
RWANDA
BURUNDI
SHABA
Butembo
Lake ex-Edward
Gisenyi
Lake Kivu
Kigali
Bukavu
Bujumbura
Uvira
Gitega
Lake Tanganyika
Great Lakes Highlands Study Zone
Frontière de la zone d'Altitude Etudiée
Zone Boundaries
Frontières des Zones
1400-1800 ELEVATION (in meters)
ALTITUDE 1400-1800m
A High Plateau: 1550-1800m, valley marshes, high population density
Hauts Plateaux: 1550-1800m, marais en vallées; très peuplé
B Kagera Piedmont: 1400-1550m, eastern slope
Piémont Akagera: 1400-1550m, versant oriental
C Kivu Lakeshore: 1400-1800m, edge of Rift like A but no marsh
Bords du Lac Kivu: 1400-1800m, en marge du Graben; identique à la zone A, mais sans marais
D Kayna Area: area of recent settlement
Zone de Kayna: récemment peuplé
E Maniema Slope: low population density
Versant Maniema: peu peuplé
1800-2800 ELEVATION (in meters)
ALTITUDE 1800-2800m
1 Central Congo - Nile Divide: moderately acid, high population density
Crête Congo Nile: sols assez acides; très peuplé
2 Volcanic Highland: volcanic soils, high population density
Terre de laves: très peuplé
3 Bututsi: very acid soils
Bututsi: sols extrèmement acides
4 Butembo Highland
Haut Terres de Butembo
5 Mitumba Range: low population density
Monts Mitumba: peu peuplé
1800 Contours in meters
Courbe de niveau
Provincial Boundaries
Frontières de Province
International Boundaries
Frontières Internationales
KILOMETERS 0 50 100 150 200
N
RWANDA
ZAIRE
AREA OF MAP
BURUNDI
ATLANTIC OCEAN
AFRICA
INDIAN OCEAN

2.05 The low-altitude boundary of the Highlands we have placed at 1400 m. Areas below this cut-off point are closer in character to either the savannah lowlands (the Ruzizi and Semliki plains, the Mosso in Burundi, the Akagera valley in Rwanda, and the Tanganyika and ex-Edward lakeside plains), or to the humid lowlands of the Congo Basin (the lower western slopes of the Mitumba Mountains). Below 1400 m, maize growing runs a significant drought risk, and farmers start to prefer sorghum for its greater dependability. Manioc becomes the overwhelmingly dominant tuber. Arabica coffee can no longer be grown and is replaced by Robusta coffee. Cotton, groundnuts, and the other familiar savannah crops appear in rotations. These areas are quite different from the Highlands and have been excluded, even though they may be part of the Highland system (as when cattle from the Barundi Bututsi area, over 1800 m, survive the dry season by transhuming to the Mosso or Imbo, below 1400 m). Moreover, they are unhealthy places for humans and cattle to live, malaria and sleeping sickness (human and cattle) being endemic. The 1,400 m or 1,500 m contour is the approximate upper limit for cattle trypanosomiasis, which virtually precludes cattle-raising in most of Africa, but not in the Highlands.

2.06 Another important altitude transition point occurs around 1550 m. Below this altitude, cultural systems of the Highlands heartland (1550-1800 m) have to be modified because of rising temperatures, slightly less rainfall and longer dry seasons, and increased drought risk, and because of the promixity of the diseases that occur at lower altitudes. For instance, below 1550 m on the eastern edge of the High Plateau, and below 1450 m in the Rift Valley, arabica coffee grows, but not so well as between 1550 and 1800 m. Below that transition point, coffee definitely has to be mulched to give reasonable results; above it, mulching may not be necessary if erosion and weeds can be controlled in other ways (this is also a factor of soil fertility). A proof of the difference is the sparser and more recent human settlement of the 1400-1550 m areas.

2.07 The soil factor. The African Rift and the highlands alongs its sides -- thus the entire Great Lakes Highlands--are geologically among the most active parts of the world. Nevertheless, the soil cover in most of the Great Lakes Highlands is composed from the decomposition of very ancient metamorphic rock -- mostly granites, schists and gneisses -- formed when the ancient African shield was subjected to heat and pressure as it buckled and the Rift formed. Only a small part of the area is covered with volcanic lava and basalt or, for that matter, covered with volcanic ash, the results of the outward manifestations of that great tectonic activity.

2.08 Volcanic soil covers the Volcanic Highlands (Zone 2) around the now dormant volcanoes of the chain that divides Rwanda from Uganda, and the bigger, active ones like Nyiragongo in Zaire (as well as that part of these volcanic ranges over 2800 m and therefore excluded from our study zone; see Map 1). This volcanic zone includes western and central Ruhengeri Prefecture and eastern Gisenyi Prefecture in Rwanda, plus the zone of Goma and most of the zones of Rutshuru and the Masisi in Zaire. There is also an area of older and less rich volcanic soils around Bukavu in Zaire, extending into Cyangugu Prefecture of Rwanda, as well as an area of volcanic soils on the border of the Burundian Mosso which defines the border of the Great Lakes Highlands, and the Zairian slopes of the Ruwenzori.

2.09 These volcanic soils are the Great Lakes Highlands' best, with excellent physical properties and chemically rich. Where they are the result of very recent volcanism, as on the Goma Plain, the lava rock is still unfarmable. However, as they weather, farming quickly begins. Short trips around Goma show that farmers are very good judges of when lava has weathered enough to be farmable. Like all recent volcanic soils, these are well drained -- often too well drained. The Goma Plain and the Rwanda communes of Rubavu and Rwerere, with annual precipitation of 1500-1800 mm, have no surface streams; human (and animal) water supply is a major problem because its lava cover is so well drained, creating the streams underground.

2.10 The volcanic-soil areas, less than 5% of the Great Lakes Highlands' area, support a disproportionately large population, particularly so in the case of the volcanic soils of recent origin (Zone 2), and this despite the fact that some area is unfarmable because its lavas are of such recent origin and elsewhere farmers have to work around huge boulders scattered through fields. In their case, the attractions of soil quality outweigh the disadvantages of high altitude.

2.11 Soils derived from the basic pre-Cambrian shield, principally of metamorphic rocks, must account for over 90% of the Great lakes Highlands' area. While there is a great deal of local variation, as a general rule, their structure -- that is, their physical properties -- are good; they are well drained. Chemically, they have major problems, some of which are still potential.

2.12 Availability of plant nutrients, nitrogen, phosphorus and potash plus trace elements, is the lesser of the two constellations of soil-chemistry problems. Even without bringing in these nutrients from outside, the dominant soils of the Highlands can maintain their long-term nutrient fertility under the traditional bush-fallow system of cultivation, provided enough fallow to restore nutrient levels after several years of cultivation. We know no research that shows what enough fallow is under different conditions, but the persistence of agriculture in Zone A, the High Plateau, for at least 1500 years, with reasonable soil-nutrient fertility into modern time, proves the sustainability of traditional Great Lakes Highland agriculture on these soils. The importance of nitrogen-fixing legumes in virtually all rotations (all annual-cropped land grows at least one legume crop every year) has helped sustain soil-nutrient fertility and made relatively short fallows consistent with its maintenance.

2.13 Population pressure, notably in Zones A, C, 2 and 4, has produced farming densities at which fallows have become very short indeed or at which they have even disappeared. It is reasonable to assume that such farming-system changes lead to long-term soil-fertility mining. This assumption is asserted frequently in Bank and other reports. It is supported by evidence, from statistics of dubious value, that national yields for certain crops in Burundi and Rwanda are declining over time. This evidence, however plausible, is not conclusive because of the locational shifts taking place in Great Lakes Highlands agriculture and described both above and below. Because the most desirable land is all occupied, especially on the High Plateau, farmers are farming less-desirable, more nutrient-leached and -eroded steep slopes on the same High Plateau, as well as moving to less desirable altitudes, both higher (Zone 1, of example) and lower (Zone B). Average yields in these less-desirable situations are certainly lower. There is no way of knowing, based on presently-available data, how much of the (putative) decline in yield per hectare is due to cultivation of less desirable land in less desirable situations, and how much stems from declining soil-nutrient status due to shortened fallows as a result of stress on the bush-fallow system.

2.14 If soil nutrients are being mined by the traditional farming systems as they have adapted to increased population density, there is no technical problem in restoring soil-nutrient levels and subsequently maintaining them by using chemical fertilizers. This is exactly what is done virtually everywhere worldwide as agriculture becomes intensive in its use of land. (Animal manure plays a role too, particularly in medium-intensity systems, but it is a difficult-to-impossible way of solving a nitrogen-deficiency problem because the proportion of available nitrogen in manure (2% by weight) is so low.)

2.15 Whether or not use of chemical fertilizer or manure is financially or economically justified in the Great Lakes Highlands is another matter what will be discussed below in Chapter IV. Because the Highlands are so hilly, manure has to be moved by head, an expensive proposition in terms of human effort for so bulky a commodity with such low nutrient value. And the Highlands' economic remoteness and the fact that fertilizer is imported from beyond the seas (and presumably always will be in the cases of nitrogen and potash) have a major bearing on the economics of fertilizer use.

2.16 The other constellation of soil-chemistry problems concerns acidity and aluminium toxicity. Indirectly, these affect nutrient-availability as well. The pre-Cambrian metamorphic-rock derived soils of the Great Lakes Highlands have been described as a time bomb waiting to explode -- or perhaps exploding. Chemically, the non-volcanic soils contain small amounts of aluminum and ferrous (as distinguished from ferric) salts. Over many centuries, without intensive human use for agriculture and/or animal husbandry, these amounts do not seem to have been great enough to cause agricultural problems. Soil exposure results in leaching and erosion as a result of direct exposure to raindrops, and in higher soil temperatures as a result of direct exposure to sun. Exposure may stem from intensive annual cropping, over-grazing, or perennial cropping of plants that give little cover (e.g. coffee) without mulching. Higher soil temperatures speed rotting of organic matter; when the rate of decomposition exceeds the rate of restoration through plant residues, soil organic content declines, with, below a certain point, negative consequences for soil fertility. Leaching and erosion take away organic matter, including plant nutrients, and other soluble material, but not the aluminum and ferrous compounds, which tend to get converted from salts to acids. Not only does aluminum start being toxic to many plants at levels that have already been exceeded in the more densely settled parts of the Highlands. But also, increasing acidity decreases availability of other nutritrients. In the long run, the process leads to typical, tropical bauxite and lateritic iron mines, but not to soils good for farming and grazing.

2.17 A significant portion of the basic, pre-Cambrian shield derived soils of the Great Lakes Highlands already manifest acidity and aluminum-toxicity problems. These problems appear to be most pronounced at higher altitudes (1800-2500 m) and in areas of higher population density. The extreme case is the Barundi Bututsi (Zone 3), where soil pH ranges around 4.0 to 4.5 and aluminum toxicity is evident. Most of the soils will no longer support agriculture, and even rangeland carrying capacity is extremely low. The Central Nile-Congo Divide (Zone 1) exhibits the same syndrome; which is also present, though less evident, on the Zaire side of the Rift (Zones 4 & 5).

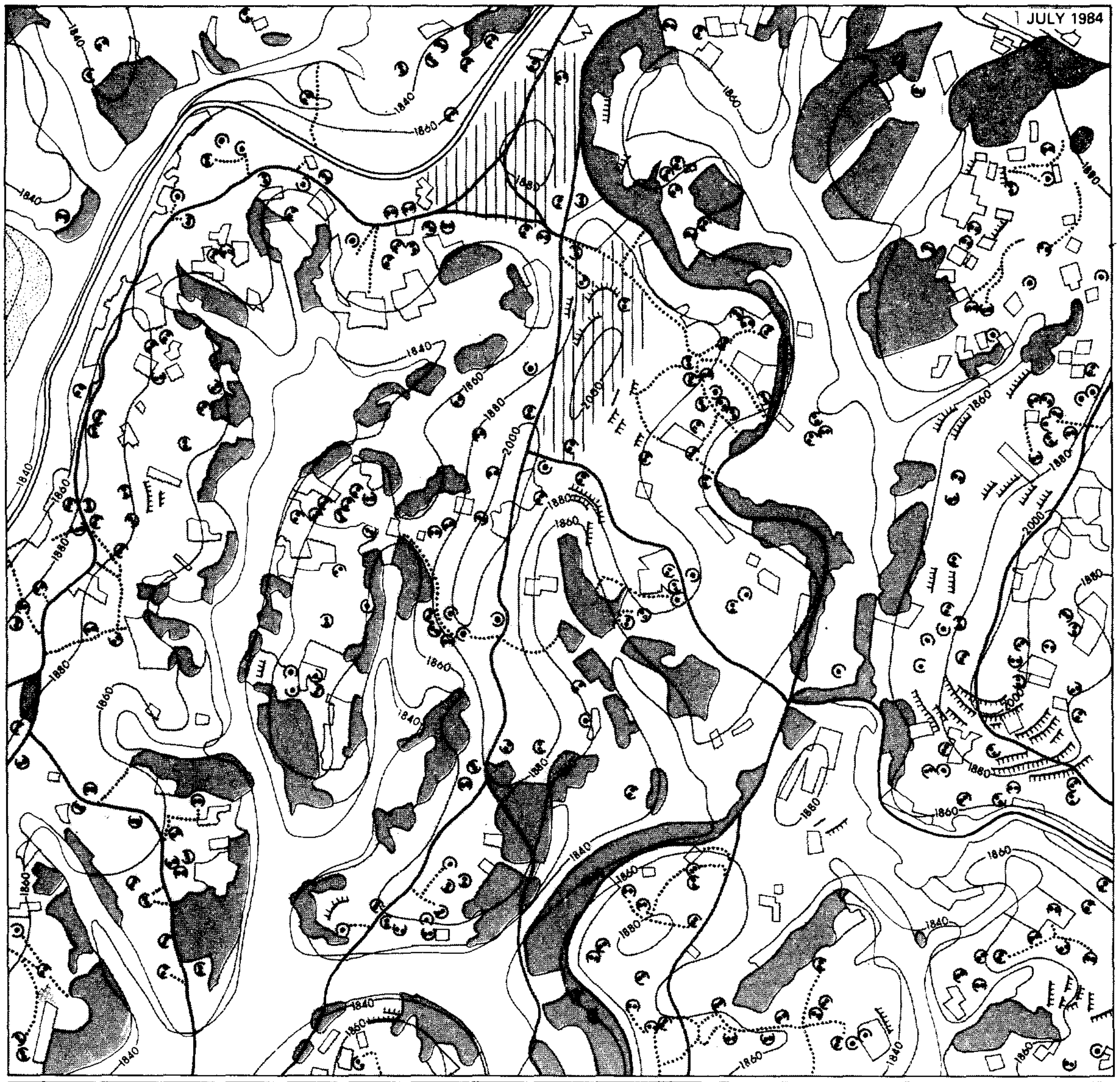
2.18 At altitudes between 1400 and 1800 m, acidity and aluminum toxicity seem less pronounced. Nonetheless, there is a remarkable gradation in soil fertility, probably based on these factors, between different sub-zones. Excluding the areas of volcanic soils, the soils derived from the basic shield seem to vary in fertility, in a general way, as a function of their distance from the volcanic zones. West of Rift, soils get gradually redder and less fertile as one travels south from Sake to Bukavu and beyond; soils progressively approach the rather infertile ferrosols of the lowland tropics: acid and probably a bit aluminum toxic. East of Rift, Kirimiro is less fertile than Buyenzi, which is less fertile than Butare Prefecture, etc. Whether this phenomenon is the result of differing fallout of volcanic ash or not is an untested hypothesis. The difference in soil fertility, however, is a given for Highlands agriculture.

2.19 A small portion of the Great Lakes Highlands (less than 5%) is <u>aluvial</u>. Since our altitude definitions exclude valleys below 1400 m, and since Lake Kivu is geologically new and has not had time to develop aluvial shores, most Great Lakes Highlands aluvions are the narrow marshes that divide hills. These can be seen on Maps 2 and 3.

2.20 Until the present century, the marshes were not used for agriculture. Their heavy, often peaty soils were covered with thickets, often of papyrus, which served to slow the run-off. There was no need to work these heavy, difficult, poorly drained soils so long as there was enough hillside land.

2.21 In this century, where coffee became a smallholder crop--that is east of Rift in Rwanda and Burundi--the marsh thickets started to be cut, partly to mulch the tiny family plots of arabica coffee. Manifestly, the bottom-land soils were nutrient-rich, having benefited from the erosion of the hillsides over centuries.

IBRD 18358



ZAIRE - RWANDA - BURUNDI
GREAT LAKES COMMUNITY
COMMUNAUTE DES GRANDS LACS

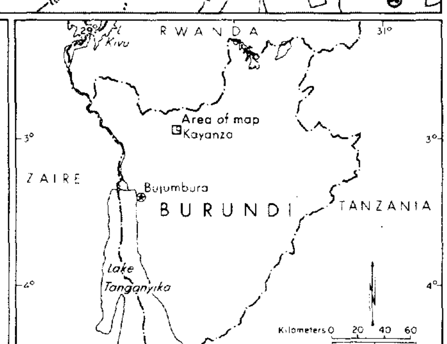
Land Use Pattern in Kayanza – Gatara (Zone A)
Utilisation du Sol des Kayanza – Gatara (Zone A)

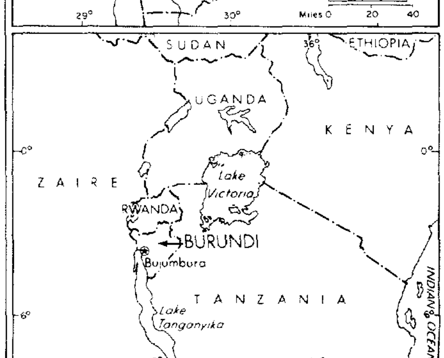
AREA FARMED:
ESPACE CULTIVE

- Itongo (hill cultivation for food) / *Itongo (cultures vivrières sur collines)*
- Coffee trees / *Caféières*
- Marsh cultivation / *Cultures de fond de vallée*
- Grasslands (pastured) / *Pâturage naturel*
- Forest plantation / *Boisement*

- —2000— Contours (20 meter intervals) / *Courbes de niveau (equidistance 20 metre)*
- Highway / *Route*
- Rural roads / *Pistes*
- Paths / *Sentiers*
- Houses / *Enclos familials*
- Antierosion ditches / *Fosses antiérosif*
- Quartz outcroppings / *Crêtes quartzitiques*
- International boundaries / *Frontières*

METERS 0 100 200 300 400 500
FEET 0 500 1000 1500





IBRD 18359

ZAIRE - RWANDA - BURUNDI
GREAT LAKES COMMUNITY
COMMUNAUTE DES GRANDS LACS
Land Use Pattern in Bururi (Zone 3)
Utilisation du Sol de Bururi (Zone 3)

AREA FARMED:
ESPACE CULTIVE

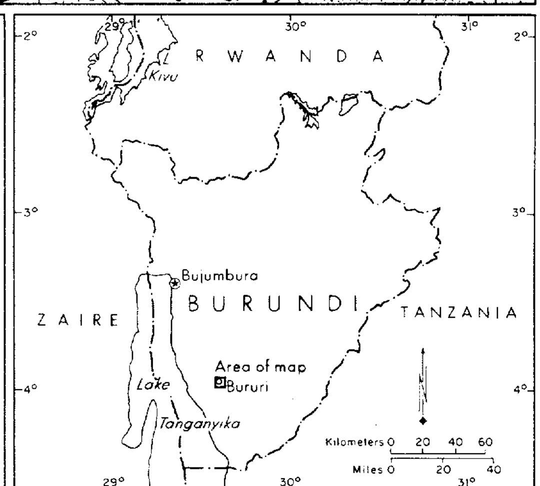
- Itongo (hill cultivation for food) / *Itongo (cultures vivrières sur collines*
- Marsh cultivation / *Cultures de fond de vallée*
- Grasslands (pastured) / *Savane herbeuse*
- Forest plantations / *Boisement*

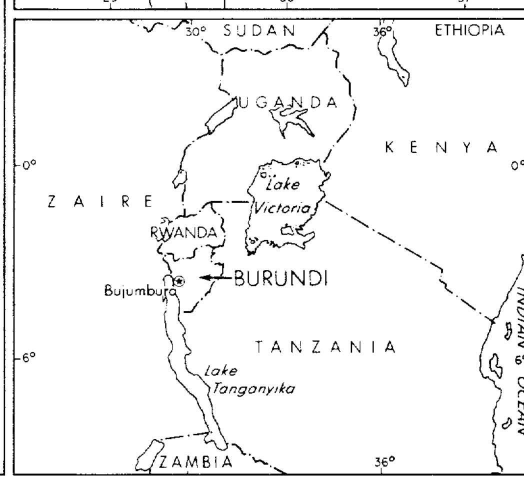
AREA NOT FARMED:
ESPACE NON-CULTIVE

- Brush thicket / *Taillis et arbustes*
- Marsh / *Marais*

- —1880— Contours (20 meter intervals) / *Courbes de niveau (équidistance 20 metre)*
- Rural roads / *Pistes*
- Paths / *Sentiers*
- Houses / *Enclos familials*
- Antierosion ditches / *Fosses antiérosifs*
- Quartz outcropping / *Crête quartzitique*
- International boundaries / *Frontières*

METERS 0 100 200 300 400 500
FEET 0 500 1000 1500





2.22 The shortage of farmland on the High Plateau (Zone A) has induced Highlands' farmers to clear, develop, and farm the swamps. This process began not too long ago, and continues. Papyrus or other cover is cleared. Soil is worked into ridges and drainage ditches with hoes. Crops are planted in the dry season (June-September) when they cannot be grown elsewhere, but not in the rainy seasons (October-January & February-May) when the marshes tend to flood. Beans and sweet potatoes are the principal marsh crops. While marsh cultivation is physically demanding, the results are impressive. The high nutrient content of the alluvial soils, concentrated there by long years of erosion from the hillsides, results in high yields. Thus, the production of the marshes is much greater than their proportion of cultivated lands would suggest. The "empirical" techniques of developing them and putting them into cultivation are effective and require no public intervention, in sharp contrast to the disastrous attempts to develop several marshes in southern Rwanda and northern Burundi with technical and financial assistance from France. These "modern" techniques, using heavy machinery, led to the dessication of the marshes and formation of hard pan which seems to preclude cultivation in future.

2.23 The population factor. Settlement patterns are partly explained by the way altitude and soil determine farming and health conditions. But not entirely. Soil and altitude do not explain why Rwandese, Barundi and peoples of kindred culture around Goma and Rutshuru in Zaire do not live in villages, while Highlanders in the rest of the Zairian Great Lakes Highlands do. They do not explain, given identical altitude and soil, the higher population densities in Burundi and Rwanda than in Zaire. In Zaire, they do not explain the high population densities in the Highland above Butembo (Zone 4) and around Kayna (Zone D) or in the ancient baShi kingdom around Bukavu relative to the almost empty areas around them.

2.24 The hypothesis has been presented in Chapter 1 above that the different settlement patterns (dispersed vs villages) between the eastern and western Great Lakes Highlands and, to some extent, the higher population density east of Rift than that west of Rift stem from different experiences with the economically and socially disruptive slave trade. The eastern Highlands' successful resistance to the slave trade can be attributed to its larger-scale, feudal, socio-political organizaton, reflected in military might, which made it a sort of pole of development in Nineteenth Century central African terms. The western Highlands' segmented socio-political structure led to heroic but finally unsuccessful struggles against the disruptions of the slave trade, hence a climate that did not inspire accumulation, innovation, or immigration, and which led to settlement in villages for protection. Such a hypothesis, like any historical hypothesis, is not testable, but it is at least as plausible an explanation for much of the difference observable between east of Rift and west of it at the beginning of this century (and today) as any other.

2.25 Whatever the reason, most of the Zairian Highlands were relatively empty at the turn of the century. That emptiness permitted the establishment of European settler plantations there. High population density east of Rift, particularly in Zone A, precluded that establishment. The difference is most striking in Zone C, the 1400-1800 m zone along the sides of the Rift, principally around Lake Kivu. On the Rwandese side and in the Barundi Mumirwa, very small farms and dispersed homes are the rule; on the Zairian side, European coffee and quinine plantations dominated until 1960. They fostered different farming and settlement patterns for the laborers they attracted. These patterns have been modified since the plantations' decline and fall, but the result is still far different from that on the facing slope of the Rift in Rwanda and Burundi.

2.26 The last two decades have seen major population shifts beyond those that can be explained by the search for a healthy place to farm (altitude and soil) or by historical factors (slave trade and socio-political organization). Very large towns have appeared on the escarpement west of Rift above the Ruindi Plain (Zone D). On examination, these town dwellers depend not only on agriculture but also on gold mining (that was clandestine until this year) and on the trade that accompanies it. Settlement of refugees has affected population density in Zones C, D and E in Zaire and in Zone B in Burundi. And the economic effects of politics affect population patterns, but they also affect farming patterns in other ways.

2.27 The government factor. We have not used political factors in delimiting the ten farming-system zones of the Great Lakes Highlands because government is somehow more ephemeral than altitude, soil type, or even population density. Yet government is manifestly a significant factor. As will be apparent in Chapters 3 and 4 below, it cannot be avoided. To take but one of the most salient facts, coffee farmers in Rwanda this year were paid US$1.16 /kg of coffee, those in Burundi

$1.07/kg, and those in Zaire $0.40 /kg 7/. Zaire's disastrous macro-economic management was reflected, inter alia, in the exchange rate, translated into a ridiculously low official price for coffee. This drove coffee exports underground. But smuggling across the lakes in small boats and head portage to buying stations in Rwanda is costly and risky. Lake piracy is a problem. Porters make "safe passage" payments to a variety of persons in countries they pass through and when they cross borders, much as must have occured in the 19th Century. These are real costs which have been reflected in the unofficial price for coffee in Zaire. But, also as a result of government macro-economic management, Zaire is short of vehicles, fuel, spare parts, and imported goods of all sorts. Vehicles plying the roads west of Rift are few and far between; they are always overloaded. East of it in Rwanda and Burundi, there is much more opportunity to move goods and people and at lower prices; you can sometimes even get a seat in minibuses. All of these factors lower the utility of money in Zaire. In Zaire, the incentives to produce anything for export have been considerably lower, relative to incentives to produce for one's own consumption, than they are in Rwanda and Burundi. The same has been true, to a lesser extent, of producing goods for sale on the local market vis-a-vis producing for oneself. The drastic and courageous economic reforms undertaken by Zaire in September 1983 are designed to correct these serious distortions. For the sake of the farmers in the Zairian Great Lakes Highlands, one hopes that they will succeed.

7/ In 1983, the official Rwanda producer price was 120 RF/kg delivered to OCIR-Café. Most producers sold to agents licenced by OCIR at less than that price. We estimate their average realization at RF 115. In Burundi, the official producer price delivered to Bujumbura was BF 118. Because of the distances and costs involved, we estimate the actual realization at BF 110. In 1982, during the mission, the average amount actually received by producers interviewed from Kayna, Rutshuru, and along Lake Kivu was Z 12/kg. In June 1983, another mission interviewed Zairian coffee porters in Kidaho (Rwanda) and confirmed that the price at Ishasha, Rutshuru (Zaire) was still Z 12/kg.

Whereas officially, at this time RF 93 = US$1, the equilibrium rate has been calculated at RF 99 = $1. While the official parity of the Burundi Franc was BF 90 = $1, the equilibrium rate was BF 103 = $1. The official value of the Zaire was Z 5.63 = $1, but the almost universally practiced rate was ca.Z 30 = $1. Subsequent devaluation of the Zaire to Z 29.9 = $1 in September 1983 suggests that this approximates equilibrium. These calculations are based on estimated equilibrium rates.

Official prices (except Zaire, for which actual price) and official exchange rates gave the following, totally misleading comparison: Rwanda - $1.29/kg; Burundi - $1.31/kg; Zaire - $2.13/kg.

2.28 And roads, both primary and secondary, are far worse in the Zairian part of the Great Lakes Highlands than they are in the Rwandese or Barundi parts. Not only is the Zairian government far less effective in maintaining primary roads than the other two, but Rwanda and Burundi have functioning local governments that organize repair of secondary roads, while Zaire does not. Umuganda labor in Rwanda and travail communautaire in Burundi do sometimes function to maintain local roads, whereas salongo labor in Zaire, whose concept is almost identical, is almost nonexistent.

2.29 In a very general sort of way, local government in Rwanda enjoys some sense of legitimacy, despite petty corruption, poor book-keeping, thin resources, and a sometimes peculiar (to planners) sense of priorities. In Burundi and in Zaire, local government enjoys little or no sense of legitimacy. However, in Burundi, central authorities oblige local authorities to do something about local road up-keep, enforcement of agricultural directives, and the like. In Zaire, performance of tasks of direct economic relevance is not among the things that central authorities effectively demand of local ones.

2.30 The non-functioning of local government can have good or bad consequences for economic development. When it fails to get roads repaired or to keep soldiers and police from setting up toll gates to extort from travellers and goods transporters, the consequences are bad. But when it fails to apply a misdirected agricultural directive, e.g. that nothing should be intercropped with coffee or that coffee should be sold to a state company at a low price, its non-functioning is an economic blessing. Either way, as the models in Chapter 3 occasionally show, it has consequences.

The Zones

2.31 High Plateau (A). This zone is the cradle of Great Lakes Highlands civilization. Between 1550 and 1800 m altitude, it is east of the Congo-Nile Divide. It covers about 12,600km^2 or 14% of the Great Lakes Highlands (and 20% of the land area between 1400 and 1800 m). Yet it supports probably about 3.2 million people or 26% of the population of 12 million for a density of 250/km^2, and must have supported a much higher proportion a century or more ago when population was smaller and hence able to chose the ecological zones of its preference.

2.32 The High Plateau receives from 1000 to 1200 mm of rainfall annually; the main dry season lasts 95 to 110 days. This zone is ideally suited for beans, beer bananas, sorghum and arabica coffee, as well as sweet potatoes, cassava, maize, and many other crops. Because of the prevalence of steep slopes, too much soil exposure through intensive annual cropping (or growing permanent crops that don't cover well, e.g. coffee) risks soil leaching and erosion as well as loss of soil organic matter. Because the ancient plateau is dissected into many and small hills, there are many small, marshy streams that separate them. There are 0.75 km or more of these watercourses per km^2 in Zone A.

Table 1. Zones by Area, Population and Country

Zone	All Highlands: Area (km^2)	All Highlands: Area (%)	All Highlands: Population Density	All Highlands: Population (units)	All Highlands: Population (%)	Rwanda: Area (km^2)	Rwanda: Population (units)	Burundi: Area (km^2)	Burundi: Population (units)	Zaire: Area (km^2)	Zaire: Population (units)
A High Plateau	12,600	14	250	3,170,000	26	7,700	2,010,000	4,900	1,160,000	-	-
B Kagera Piedmont	16,900	18	115	1,970,00	16	7,800	970,000	9,100	1,000,000	-	-
C Kivu Lakeshore	7,300	8	210	1,540,000	13	2,200	570,000	2,900	630,000	2,200	340,000
D Kayna	400	0	100	40,000	0	-	-	-	-	400	40,000
E Maniema Slope	26,400	28	60	1,580,000	13	-	-	-	-	26,400	1,580,000
Sub total for bean-banana-coffee zone	63,600	68	130	8,300,000	69	17,700	3,550,000	16,900	2,790,000	29,000	1,960,000
1 Central Congo-Nile Divide	9,300	10	200	1,840,000	15	5,900	1,180,000	3,400	660,000	-	-
2 Volcanic Highlands	2,900	3	240	700,000	6	1,450	440,000	-	-	1,450	260,000

2.33 Kagera Piedmont (B). The High Plateau waters drain to the Nile through Lake Victoria and, most immediately, the Kagera River, most of which lies to the east of the Great Lakes Highlands at altitudes of less than 1400 m. Between the High Plateau and the 1400 m contour, thus at 1550 to 1400 m, is an area drained by the Kagera and, in the south, by the Malagarasi River to Lake Tanganyika and the Congo River. The Kagera Piedmont covers 16,900 km^2 or 18% of the Great Lakes Highlands (and 26% of the land area between 1400 and 1800 m). Its population density is lower than that of the High Plateau, but growing rapidly, probably about 115/km^2 for a total population of 2.0 million or 16% of the Great Lake Highlands total.

2.34 The Kagera Piedmont is somewhat drier than the High Plateau. Its total annual rainfall ranges from 850 to 1000 mm with a dry season of 105 to 115 days, with considerable variation from year to year. Thus, while similar to Zone A, Zone B is less well suited for coffee, which has to be mulched or shaded to get good results, beer bananas, for which it is a bit dry, and maize, for which there starts to be a significant drought risk. Sorghum and cassava resist drought well and do well. Inter-hill streams and marshes are bigger, being downstream, but generally not farmed since population pressure does not yet require them to be.

2.35 Kivu Lakeshore (C). Also at 1400-1800 m elevation, this zone is on the east and west facades of the Rift. Its most important component is around Lake Kivu, where it is the lakeshore because that lake lies at over 1400 m. Arms of this zone, however, also extend down the two sides of the Ruzizi Plain and Lake Tanganyika, particularly on the Burundi side, where they are known as the Mumirwa, and there is a small patch at the appropriate altitudes on the Zairian slope of the Ruwenzori. Other parts of the western facade of the Rift between 1400 and 1800 m, notably above Lake Tanganyika south of Uvira and above Lake ex-Edward and the Ruindi and Semliki Plains, have been disqualified from Zone C as too sparsely settled. Though like it in other ways, they have been placed in Zone E.

2.36 The Kivu Lakeshore covers about 7,300km^2 or 8% of the Great Lakes Highlands (12% of the land area between 1400 and 1800 m). It supports a population of about 1.5 million, 13% of the Great Lakes Highlands total, for a density of about 210/km^2. Ecologically, it is identical to Zone A with two important exceptions. Firstly, while the High Plateau are a highly dissected plateau, most of Zone C is the side of an escarpment. Consequently, there are few meandering streams with swamps to be developed. Secondly, the rainfall, about the same as Zone A, is better distributed throughout the year. Zone C and Zone A crop suitabilities are similar, but Zone C is a little better adapted for coffee (and, of course, swamp development is not an option.)

2.37 Kayna Zone (D). There is a small area at elevations between 1400 and 1800 m on the west facade of the Rift overlooking Lake ex-Edward and the Ruindi Plain which, unlike adjacent areas of similar altitude, is densely settled. Most of this settlement is recent--within the past quarter century--and is concentrated in very large towns along the Goma-Butembo road or two branch roads. Towns are too large to permit most families to walk to their fields; therefore, a system of fields 10 to 20 km from the homestead has evolved, with temporary shelters by the fields where families live during important agricultural periods. This system apparently stems from the fact that agriculture shares its economic importance with gold mining (clandestine until this year's liberalization) and with the many commercial activities it spawns. It is unusual enough to warrant treatment as a separate zone.

2.38 The Kayna Zone covers 400 km^2 or 0.5% of the Great Lakes Highlands (0.5% of the land area between 1400 and 1800 m). It supports a population of about 40,000 for a density of about 100 km^2. Its rainfall, temperature and soil patterns are not significantly different from those of Zones A, C and E. Population density, though high compared to Zone E, is low compared to Zones A and C. And population is concentrated near the principal (and virtually only) road. Therefore, the Kayna Zone has experienced less soil exposure and for a lesser time than Zones A and C. There is more forest cover, particularly away from the road where it has hardly been disturbed.

2.39 Maniema Slope (E). Zone E is a residual category of lands between 1400 and 1800 m, to wit, those that have little human settlement. For the most part, they lie on the western slope of the Mitumba Mountains, away from the Rift and towards the Maniema, a humid to sub-humid tropical forest at lower altitudes. Zone E also includes low-population-density portions of the western facade of the Rift; those above the Semliki Plain, Lake ex-Edward, part of the Ruindi Plain, and Lake Tanganyika south of Uvira.

2.40 The Maniema Slope zone covers 26,400 km^2 or 28% of the Great Lakes Highlands (41% of the land area between 1400 and 1800 m). This large area supports a population of only about 1.6 million, 13% of the Great Lakes Highlands total, for a density of about 60 km^2. This is very low compared to other zones at this altitude but, of course, high compared to the rain forest lowlands to the west or to the savannah lowlands to the east.

2.41 Most of the Maniema Slope has its forest cover which is disturbed only where there are isolated human settlements and people are practicing bush-fallow cultivation with plenty of fallow. Only in those rare places where Zone E is crossed by roads is human settlement significant. Yet the zone's rainfall, temperature and soils are not dissimilar to those of the other (lettered) zones of the 1400-1800 m altitude. At its western limit, it phases into the insalubrious and agriculturally difficult humid lowlands (the analog to the High Plateau's (A) Kagera Piedmont (B)). But this does not explain paucity of development at 1550-1800 m.

2.42 Central Congo-Nile Divide (1). This zone lies at altitudes over 1800 m between the High Plateaux (A) and the Kivu Lakeshore (C). It forms part of the mountain chain that also includes Zones 2 and 3 and which extends beyond the boundary of our study area into the Kigezi and Ankole parts of Uganda. It is differentiated from the parts of the Divide to its north and south by soil characteristics. At the Mutura Pass, the volcanic soils of Zone 2 give way to granites and schistes and, at the higher altitudes, the Gishwati forest begins. From that point southward, through central and southern Rwanda and northern and central Burundi, the Divide is generally farmed from 1800 to 2300 m and forested above that. Since many of the traditional mainstays of Highlands agriculture do not thrive at these altitudes, farming systems are different--adapted to the altitude, temperatures, and more acid soils. Agriculture is harder, has spread into these zones more recently, and lower farming density than in Zones A and C leaves more vestiges of forest cover than in Zones A and C. Between 1800 and 2300 m, agriculture is gradually taking land from grazing, and above 2300 m, grazing is degrading and taking land from forest. Somewhere between central and southern Burundi, the Divide's soil fertility becomes so low and its acidity so high that little farming is possible. This marks the dividing line between the traditional zones of the Mugamba and the Bututsi, and we made it the boundary between Zones 1 and 3.

2.43 The Central Congo-Nile Divide covers 9,300 km^2 or 10% of the Great Lakes Highland (and 31% of the area between 1800 and 2800 m). It supports a population of 1.8 million, 15% of the Great Lakes Highlands total, for a density of about 200/km^2. Annual rainfall varies from 1400 to about 2000 mm, with a dry season of 85 - 90 days. Where soil fertility is adequate, maize, potatoes, peas, as well as finger millet, wheat, tea and pyrethrum do well. Tea even puts up with aluminum concentration that would stunt most other plants, not a rare occurrence in Zone 1.

2.44 Volcanic Highlands (2). The area of Rwanda and Zaire between 1800 and 2800 m which is covered by or in which soils are derived from recent lavas--the Volcanic Highlands--covers 2,900 km^2 or 3% of the Great Lakes Highlands (10% of the land area between 1800 and 2800 m). The peaks area, excluded from the Zone by reason of altitude, consists of active or recently active volcanoes in Zaire, and of dormant volcanoes covered with montane forests or alpine prairies that are home to mountain gorillas in Rwanda. The area also includes a small area on the Zairian side of the Ruwenzori at the appropriate altitudes. It has natural extensions into Uganda both in Kigezi and in the Ruwenzori. Zone 2, thus surrounds the highest peaks in the area. If forms a saddle between the Mitumba Mountains (Zone 5) west of Rift and the Congo-Nile Divide (Zone 1) east of Rift (and it forms part of the Congo-Nile Divide itself, since it blocks Lake Kivu from the Ruindi-Lake ex-Edward-Semliki-Nile system and diverts it into the Ruzizi-Lake Tanganyika-Congo system). At lower altitudes, it adjoins the High Plateau (A), the Rift facade that faces the Ruindi Plain (part of E) and the Goma Plain (part of C, but with lava soils).

2.45 The Volcanic Highlands support a population of 700,000, 6% of the Great Lakes Highlands total, for a density of about 240/km^2. Rainfall is often over 2000 mm with a dry season of two months or less. There are considerable variations in population density within the zone, principally between the Rwandese part and the Zairian part. Around Ruhengeri, densities are over 350/km^2 - among the highest in the Highlands; agriculture is intensive and there is little grazing for cattle, which are confined to the borders of the national park. In the Masisi and the Buito in Zaire, cattle raising on pastures of Kikuyu grass and clover is the economic mainstay, and farmers are just beginning to compete with cattlemen for land; density is probably about 100/km^2. In Zaire in the Buisha near the Rwandese and Ugandan borders, population densities are in between these extremes, and there is a little more agriculture (including cultivation of strawberries, artichokes, and other exotic vegetables and fruits) and a little less room for livestock.

2.46 <u>The Bututsi</u> (3). South of Zone 1, the Congo-Nile Divide gets a bit lower, drier, and hotter. In Zone 1, some mountains are denuded outcrops of granite, unsuitable for agriculture and nearly unsuitable for grazing. In the Bututsi, Zone 3, almost all of them are. The Bututsi covers 1,200 km^2 or 1% of the Great Lakes Highlands (and 4% of the land area between 1800 and 2800 m). It supports a population of about 0.1 million, about 1% of the Great Lakes Highlands total, for a density of about 90/km^2. This is certainly declining through forced out-migration. Rainfall is about 1300 to 1500 mm per year and the dry season three months or a little more. Soils, which are quite acid and aluminum toxic in Zone 1, are more so in Zone 3.

2.47 As a result of these conditions, cattle-raising is the principal economic activity of the Bututsi. It has one of the highest cattle densities in the Great Lakes Highlands -- more than 75/km^2 -- for nine months of the year. From June to September, the dry hills of the Bututsi will not support even livestock raising and the cattle are transhumed to dry-season pastures in the Mosso or the Imbo. Even when it rains, the carrying capacity of the poor pastures, Ergostatis divasia and Hyperrenia philipindula with no legumes, is low -- 0.2 to 0.4 animal units/ha. Farming is practiced where soil fertility permits, usually in creases between hills where erosion has deposited nutrients and organic matter. The Bututsi has marshy streams much as the High Plateaux has, but these are only beginning to be developed for agriculture; much of the population is absent with the cattle in dry-season pastures just when they can be cultivated. (see Map 4).

2.48 <u>Butembo Highlands</u> (4). North of the Volcanic Highlands saddle and west of the Rift, there is a break in the Mitumba Mountains. Their extension rises again above 1800 m west of Lake ex-Edward (and, after another, larger break around Beni, reappears in the Ituri Highlands, which are outside the Great Lakes Highlands). This northern area above 1800 m, which is also just above the town of Butembo, covers 3,500 km^2, 4% of the

Great Lakes Highlands (and 12% of the area between 1800 and 2800 m). Given its altitude and the fact that its soils are not volcanic, that is, not particularly rich, the Butembo Highlands are quite densely settled: 0.5 million or 4% of the Great Lakes Highlands total, for density of 150/km^2.

2.49 These highlands are a bit less high, less rainy, and less gloomy than Zones 1, 2 and 5, but only a little bit. While all the crops found in the rest of the Highlands at similar altitudes are found, the Butembo Highlands are noteworthy for the importance of wheat, which has gained a significant place in the local diet, and of European vegetables, of which only leeks have become part of the diet. Some of these vegetables are sold to missions or exported to Kinshasa; the rest rot.

2.50 Mitumba Range (5). The main mountain chain west of Rift, the Mitumba Range, is relatively empty. Between 1800 and 2800 m, it covers 12,400 km^2 or 13% ofthe Great Lakes Highlands (and 42% of the land area between 1800 and 2800 m). Its total population is probably about half a million, 4% of the Great Lakes Highlands total, for a density of only 45/km^2. Rainfall, dry season, temperature, soils, etc. are about the same as at similar altitudes in the Central Congo-Nile Divide (Zone 1) on the other side of the Rift.

2.51 Lower population density means that there is much more vegetative cover, including forest, in the Mitumba Range than there is in other 1800-2800 m (numbered) zones of the Great Lakes Highlands. Since the 1400-1800 m zones below the Mitumba Range (Zones C, D & E) are not "filled-up" agriculturally, there has been little compulsion to move up into Zone 5. The principal exceptions that confirm this rule are behind Bukavu, where population densities are quite high, and where there are tea estates. (Mining population is not counted since we are examining farming systems.)

2.52 With the above agricultural geography in mind, the farming systems described in Chapter 3 below become more comprehensible.

III. Farm Models

3.01 For the ten zones described above, approximate farm models have been established. Each is based principally on field observations made by the mission and, to a lesser extent, on the scant published information available. These models are intended to give an approximate picture of agricultural output and of land use, but there is no data to specify the other, more critical production input -- labor. It is important to bear in mind, when interpreting the caloric and protein totals for instance, that the models do not give a complete picture of family enterprises, excluding, as they do, livestock raising, wage employment, and gathering activities. It is also important to recognize that area-cultivated and yield figures are converted to show the pure-stand-equivalent of cultivation where, very frequently, different crops are inter-cropped, relay-cropped, or both.

3.02 Throughout the study area, there is a bi-modal rainfall pattern. The long rainy season (urushana) lasts about from February to May. The short rainy season (agatasi) lasts from about September to December. Cultivation in the dry summer months (ici), roughly June to August, is limited to perennials and to the recently-developed cultivation of marshes.

Zone A -- High Plateau

3.03 This zone, about 2/3 in Rwanda and 1/3 in Burundi, has an average population density of 250/km^2, reaching 500 in some places. So land is scarce and intensively used. (See Map 4). Its extensive marshlands in the valley bottoms have virtually all been developed for dry-season cultivation. (See Map 2). Although it can only be cultivated during that one season, it makes a significant contribution to the food supply because it is more fertile than hill land. As the model below shows, marsh cultivation, which accounts for 9% of the hectare-months of land use in the agricultual year, generates 18% of the food energy and 22% of the calories. The importance of legumes -- 54% of protein and 20% of food energy -- and of tubers -- 49% of food energy and 27% of protein -- is apparent. Grain is of secondary importance. Assuming that 90% of bananas are converted into beer, their contribution is still significant; the calories and protein "lost" because beer bananas are grown and made into beer instead of growing edible bananas is equivalent to 5% of the farm's energy production and 10% of its protein production. Coffee is the predominant source of cash.

IBRD 18357

JULY 1984

ZAIRE - RWANDA - BURUNDI

GREAT LAKES COMMUNITY

COMMUNAUTE DES GRANDS LACS

Land Use Pattern on Gatovu Hill (Zone A)

Utilisation du Sol sur la Colline Gatovu (Zone A)

Farm boundaries
Limites des propriétés familiales

Windbreaks
Haies vives

Field boundaries
Limites temporaires des champs

Buildings
Construction

Coffee
Caféiers

Food crops
Cultures vivrières

Trees
Boisement

Fallow land
Jachère

Fruit trees (avocados, oranges, papayas)
Arbres fruitiers (avocatiers, orangers, papayers)

Bananas (1 dot represents 2 trees)
Bananiers (1 point représente 2 souches)

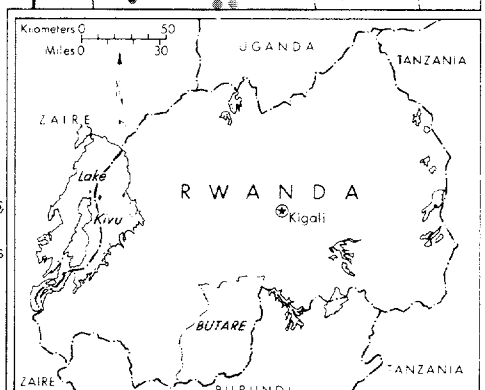
Roads
Routes

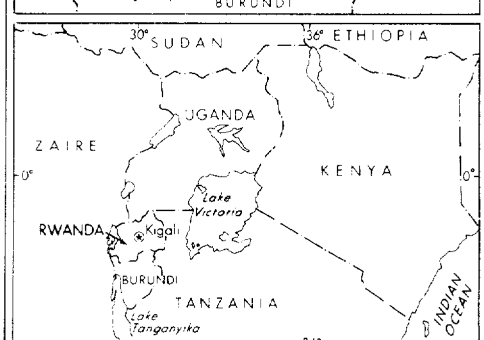
Prefecture boundary
Limite de préfecture

International boundaries
Frontières

METERS 0 20 40 60 80 100

FEET 0 100 200 300





Crop	Land Use			Yield	Output
	Spring Rains (ha)	Dry Season (ha)	Fall Rains (ha)	(T/ha)	(kg)
Bean (urushana)	0.2			0.6	120
(ici)		0.1		0.9	90
(agatasi)			0.2	0.6	120
Total					330
Sorghum			0.3	1.0	300
Sweet Potatoes					
(urushana)	0.3			5.0	1,500
(ici)		0.1		7.5	750
Total					2,250
Cassava, taro, other	------------0.1-------------------			6.0	600
Banana	------------0.2-------------------			10.0	2,000
Coffee	------------0.1-------------------			0.8	80
Land Available					
Hill land	0.9	0.9	0.9		
(of which cropped)	0.9	0.4	0.9		
Marsh land	0.2	0.2	0.2		
(of which cropped)	-	0.2	-		
Total	1.1	1.1	1.1		
(of which cropped)	0.9	0.6	0.9		
Seasonal cropping intensity	0.82	0.55	0.82		
Yearly cropping intensity				2.19	

Food Output

		Energy (K Cals.)		Protein (g)		Fats (g)	
Legumes (beans)		946	(20%)	65.3	(54%)	3.3	(16%)
Grains (sorghum)		782	(16%)	19.5	(16%)	9.9	(48%)
Tubers		2,334	(49%)	31.8	(27%)	7.4	(36%)
of which:	sweet potato	(1764)		(27.0)		(6.8)	
	other	(570)		(4.8)		(0.6)	
Bananas		682	(14%)	3.4	(3%)	0.2	(1%)
of which:	beer	(592)		(1.8)		-	
	direct consumption	(90)		(1.6)		(0.2)	
Total		4,744		120.0		20.8	
From hill culture		3,898	(82%)	93.2	(78%)	17.6	(85%)
From marsh culture		846	(18%)	26.8	(22%)	3.2	(15%)

Land is used as fully as available techniques permit. Of the 13.2 hectare-months available, all are used except 2.4 hectare months when hill land cannot be used due to the dry season and 1.6 when marsh land cannot be used during the rains. Beyond these, there are no fallows.

Zone B -- Kagera Piedmont

3.04 This zone, half in Rwanda and half in Burundi, has an average population density of $115/km^2$, roughly half that of the High Plateau. Correspondingly, average farm size is about double that on the High Plateau and cropping intensity about half. Very little marsh land is developed; fallows are present. The legume-grain-tuber balance is not too different from that of the High Plateau. The beer-banana "loss" amounts to 3.5% of available energy and 10% of available protein. Coffee is the main cash crop.

Crop	Land Use			Yield (T/ha)	Output (kg)
	Spring Rains (ha)	Dry Season (ha)	Fall Rains (ha)		
Bean	0.3			0.5	150
Groundnuts			0.05	0.8	40
Maize	0.3			0.9	270
Sorghum	0.05			0.8	40
Cassava	------0.2------			10.0	2,000
Banana	------0.2------			6.0	1,200
Coffee	------0.1------			0.6	60
Fallow	0.85	1.5	1.45	-	-

Land Available

	Spring Rains (ha)	Dry Season (ha)	Fall Rains (ha)	
Hill land	2.0	2.0	2.0	
of which cropped	1.15	0.5	0.55	
Marsh land	0.1	0.1	0.1	
of which cropped	-	-	-	
Total	2.1	2.1	2.1	
of which cropped	1.15	0.5	0.55	
Seasonal cropping intensity	0.54	0.24	0.26	
Yearly cropping intensity				1.04

Food Output

	Energy (K Cals.)	Protein (g)	Fats (g)
Legumes	550 (15%)	37.7 (47%)	2.3 (16%)
of which: beans	(430)	(29.7)	(1.5)
groundnuts	(120)	(8.0)	(0.8)
Grains	928 (24%)	24.2 (30%)	9.9 (69%)
of which: maize	(824)	(21.6)	(8.6)
sorghum	(104)	(2.6)	(1.3)
Tubers (cassava)	1,900 (50%)	16.0 (20%)	2.0 (14%)
Bananas	409 (10%)	2.1 (3%)	0.1 (1%)
of which: beer	(355)	(1.1)	-
direct consumption	(54)	(1.0)	(0.1)
Total	3,787	80.0	14.3

Zone C -- Kivu Lakeshore

3.05 Burundi has about 40% of this zone's area and population; Rwanda, 30% of the area and 37% of the people; and Zaire, 30% of the area and only 22% of the people. These differences in population density, and the differences in the higher-altitude zones above, make it useful to distinguish two models for this zone.

3.06 For one, east of Rift in Rwanda and Burundi, fallow has virtually disappeared, except in the dry season. Agriculture is very similar to that practiced in the High Plateau Zone, except that there is no marsh land to be developed and farmed in the dry season. Population density is $235/km^2$. Farm size is even smaller than in the High Plateau (no marsh land available) and cropping intensity just about as high. The legume-grain-tuber balance is similar to that in Zones A & B. Beer banana "loss" is estimated at 5% of available energy and 12% of protein.

East of Rift

Crop	Land Use: Spring Rains (ha)	Land Use: Dry Season (ha)	Land Use: Fall Rains (ha)	Yield (T/ha)	Output (kg)
Beans (urushana)	0.2			0.7	140
(agatasi)			0.2	0.7	140
Total					280
Sorghum	0.3			1.2	360
Sweet potatoes			0.3	6.5	1,950
Banana	------0.2------			10.5	2,100
Cassava, taro, other	------0.1------			0.6	600
Fallow	0.1	0.6	0.1		
Land Available					
Hill land	0.9	0.9	0.9		
of which cropped	0.8	0.3	0.8		
Marsh land	-	-	-		
of which cropped	-	-	-		
Total	0.9	0.9	0.9		
of which cropped	0.8	0.3	0.8		
Seasonal cropping intensity	0.89	0.33	0.89		
Total cropping intensity				2.11	

Food Output

	Energy (K Cals)	Protein (g)	Fats (g)
Legumes (beans)	803 (18%)	55.4 (50%)	2.8 (13%)
Grains (sorghum)	939 (21%)	23.4 (21%)	11.9 (56%)
Tabers	2,099 (46%°)	28.2 (26%)	6.5 (30%)
of which: sweet potatoes	(1,529)	(23.4)	(5.9)
other	(570)	(4.8)	(0.6)
Bananas	716 (16%)	3.6 (3%)	0.2 (1%)
of which: beer	(622)	(1.9)	-
direct consumption	(94)	(1.7)	(0.2)
Total	4,557	110.6	21.4

3.07 For the other model, west of Rift in Zaire, more land is available per farm, cropping intensities are lower and fallow is still very much present, with figures being similar to those in Zone B. Population density is around 150/km2 on average for the sub-zone. Legume-grain-tuber balance is similar to the preceeding zones. Beer banana "loss" is estimated at 10% of available energy and 27% of protein because of the greater importance of banana culture.

3.08 In this sub-zone in particular, the averages hide major differences based on population density and history. The buShi, centered on Bukavu, has higher population densities, less fallow, smaller farms and more intensive land use more similar to Zone C/East of Rift.

West of Rift

Crop	Land Use			Yield	Output
	Spring rains (ha)	Dry season (ha)	Fall rains (ha)	(T/ha)	(kg)
Beans			0.3	0.6	180
Sorghum	0.2			1.0	200
Sweet potatoes			0.3	6.0	1,800
Bananas	--------0.3 ----------------------			11.0	3,300
Coffee	--------0.1 ----------------------			0.9	90
Fallow	1.4	1.6	1.0		

Land Available

	Spring rains (ha)	Dry season (ha)	Fall rains (ha)	
Hill land	2.0	2.0	2.0	
of which cropped	0.6	0.4	1.0	
Swamp land	-	-	-	
of which cropped	-	-	-	
Total land	2.0	2.0	2.0	
of which cropped	0.6	0.4	1.0	
Seasonal cropping intensity	0.3	0.2	0.5	
Total cropping intensity				1.0

Food Output	Energy (K Cals)	Protein (g)	Fats (g)
Legumes (beans)	516 (14%)	35.6 (47%)	1.8 (13%)
Grains (sorghum)	522 (15%)	13.0 (17%)	6.6 (47%)
Tubers (sweet potatoes)	1,411 (39%)	21.6 (28%)	5.4 (38%)
Bananas	1,125 (31%)	5.6 (7%)	0.3 (2%)
of which: beer	(977)	(3.0)	-
direct consumption	(148)	(2.6)	(0.3)
Total	3,574	75.8	14.1

Zone D -- Kayna

3.09 This small zone, entirely in Zaire, has a population density of about 100/km2, plenty of land available, ample fallows, and low cropping intensity. The peculiarity of the farming system stems from the high concentration of population in large towns, so that land near towns is intensely used but land away from towns is largely unused. If all land available for farming in the zone is taken into account, the fallow figures listed below largely understate the case. And although the model suggests an adequate production of food energy and protein, there is evidence that many Kayna Zone residents are not full-time farmers. Grains are more important than in the preceeding zones. Beer banana "loss" is estimated at 6% of available energy and 11% of protein.

Crop	Land Use			Yield	Output
	Spring rains (ha)	Dry season (ha)	Fall rains (ha)	(T/ha)	(kg)
Beans (away from town)			0.5	0.8	400
Maize (away from town)	0.5			1.2	600
Sorghum (house plot)	0.1			1.2	120
Banana (house plot)	---- 0.2 ----			12.0	2,400
Fallow	1.0	1.1	1.1		

Land Available

	Spring rains	Dry season	Fall rains	
House plot	0.3	0.3	0.3	
of which cropped	0.3	0.2	0.2	
Hill land away from town	1.5	1.5	1.5	
of which cropped	0.5	0.0	0.5	
Total	1.8	1.8	1.8	
of which cropped	0.8	0.2	0.7	
Seasonal cropping intensity	0.34	0.11	0.39	
Total cropping intensity				0.84

Food Output

	Energy (K Cals)	Protein (g)	Fat (g)
Legumes (beans)	1,147 (28%)	79.2 (57%)	4.0 (15%)
Grains	2,143 (52%)	55.8 (40%)	23.2 (85%)
of which: maize	(1,830)	(48.0)	(19.2)
sorghum	(313)	(7.8)	(4.0)
Bananas	819 (20%)	4.1 (3%)	0.2 (1%)
of which: beer	(711)	(2.2)	-
direct consumption	(108)	(1.9)	(0.2)
Total	4,109	139.1	27.4

Zone E -- Maniema Slope

3.10 This large Zairian zone is perhaps the least characteristic of the rest of Great Lakes Highlands' culture. Population density is relatively low--60/km2--allowing plenty of land for farming under current techniques and ample fallows. Climate is influenced by the humid rain forests to the west; rice is grown. Unlike the previous models, however, this model's output is preponderantly from tubers. Legumes are not important. The result is an output mix that is heavy on starch and short on protein. This model presumably does not reflect the actual diet of Maniema Slope residents for two reasons. Firstly, where protein is short and cassava is present, people eat the leaves, which become an important protein source. Secondly, animal protein from hunting supplements the diet. Still, a physical anthropologist can immediately see that the diet is a starchy one. In addition to the food sources indicated, palm oil from natural or semi-natural oil-palm stands, which is very calorie rich, is important. The Maniema Slope is the only zone of the Highlands where there is a significant amount of vegetable fat in the diet. And, just as if to prove the point that the zone is outside the Great Lakes Highlands cultural sphere, beer bananas are absent from the model.

Crop	Land Use			Yield	Output
	Spring rains (ha)	Dry season (ha)	Fall rains (ha)	(T/ha)	(kg)
Rice	0.5			0.9	450
Cassava	----- 0.3	-----	-----	12.0	3,600
Sweet potatoes	0.2			8.0	1,600
Sweet potatoes			0.2	8.0	1,600
					3,200
Fallow	3.0	3.7	3.5		
Land Available					
Total	4.0	4.0	4.0		
of which cropped	1.0	0.3	0.5		
Seasonal cropping intensity	0.25	0.075	0.125		
Total cropping intensity				0.45	

Food Output

	Energy (K Cals)	Protein (g)	Fat (g)
Grains (rice)	947 (14%)	18.0 (21%)	1.4 (10%)
Tubers	5,929 (86%)	67.2 (79%)	13.2 (90%)
of which: cassava	(3,420)	(28.8)	(3.6)
sweet potatoes	(2,509)	(38.4)	(9.6)
Total	6,876	85.2	14.6

Zone 1 -- Central Congo-Nile Divide

3.11 This zone, nearly 2/3 in Rwanda and just over 1/3 in Burundi, has the largest population of the higher-altitude, "numbered" zones. Population density is about 200/km2, much higher than most of the rest of the over-1,800 m areas, except for Zone 2 with its rich volcanic soils. Nevertheless, farms are relatively large, fallow is used, and cropping intensity is low. That is because virtually all land is used and, at the altitudes of Zone 1 and with its soils, there would be no crops at all without fallowing. Above 1,800 m, temperatures are lower and everything matures more slowly. Farmers do not have the option of growing cassava, which can turn low-fertility soils to some profit. So grains, principally maize, dominate farm output. Not because the zone is ideally suited for maize; it is not; maize struggles and matures slowly--often over as much as ten months--at Zone 1 temperatures, but it does better than other grains, notably sorghum, which will not grow at all at these temperatures.

3.12 The difficulty of farming at these altitudes is indicated by the low caloric and protein output per farm, even though just about all available slopes, even very steep ones, are cropped (with fallowing). There is significant erosion loss and, even with fallows, soils are kept at a low fertility equilibrium at best. (At worst, they are being mined and driven toward the infertile, highly acid, aluminum-toxic and basically unfarmable situation in Zone 3). If the hard life is not sufficient proof that Zone 1 has been recently settled, the beer situation is. Zone 1 residents come from the High Plateau culture sphere, and beer is an important part of their social life. Despite their obvious poverty, they "import" banana and sorghum beer from Zones A and C. It is carried up in pots and on bicycles. The fairly obvious technique of brewing Zone 1 maize into beer is, seemingly, just being discovered. With meager farm output and a need for cash, a significant number of Zone 1 residents are willing workers on tea estates. For most residents, however, tea is not a part of the farm nor of the model.

Crop	Land Use: Spring rains (ha)	Land Use: Dry season (ha)	Land Use: Fall rains (ha)	Yield (T/ha)	Output (kg)
Peas or pole beans			0.4	0.4	160
Maize	0.4			1.2	480
Finger miller & wheat	0.2			0.8	160
Sweet potato			0.2	3.0	600
Fallow	1.4	2.0	1.4		
Land Available					
Total	2.0	2.0	2.0		
of which cropped	0.6	0.0	0.6		
Seasonal cropping intensity	0.3	-	0.3		
Total cropping intensity				0.6	

Food Output

	Energy (K Cals)	Protein (g)	Fat (g)
Legumes (peas, beans)	467 (16%)	31.7 (36%)	1.5 (8%)
Grains	1,930 (67%)	48.6 (56%)	16.0 (83%)
of which: maize	(1,464)	(38.4)	(15.4)
finger millet & wheat	(466)	(10.2)	(0.6)
Tubers (sweet potato)	470 (16%)	7.2 (8%)	1.8 (9%)
Total	2,867	87.5	19.3

Zone 2 -- Volcanic Highlands

3.13 This small but important zone is half in Zaire and half in Rwanda, but Rwanda has nearly two-thirds of the people. It might have been appropriate to make one model for the Rwandese part (population density over 300/km2) and another of the Zairian part (population density about 180/km2), but, in fact, the situation on the Zairian side is too complicated for a single model. The Buito and Bwisa have quite high population densities and grow potatoes and vegetables rather like the Rwandan part; the Masisi's rich lands are largely owned and fenced by large-scale cattle raisers. Therefore, one farming model will do for the zone.

3.14 As compared to Zone 1, the Volcanic Highlands are extremely short of land, but that land is exceptionally fertile, is neutral in pH, is both easily worked and well-drained, yet sufficiently water-retentive to give good crops. This factor helps overcome the land scarcity and the difficulties of farming at low temperatures. Nevertheless, as the model shows, the caloric and protein output of Volcanic Highlands farms is meager. Like Zone 1 residents, the people buy their beer from lower altitudes. They derive cash from work on tea estates, from producing vegetables on tiny parcels for sale in Gisenyi and Goma, from pyrethrum and potatoes. Pyrethrum has disappeared on the Zairian side and is in regression on the Rwandan side as well, the victim of competition from synthetic pyrethroids and consequent falling world prices, as well as mismanagement of the parastatal that handles pyrethrum promotion and processing. However, even with superb parastatal management, it is likely that pyrethrum would be a marginal or sub-marginal proposition for farmers.

3.15 The main difference in food-crop model between Zones 1 and 2, other than the latter's more intensive use of smaller amounts of better farmland, is the greater importance of potatoes and wheat in Zone 2. Potatoes and wheat, temperate-zone crops, grow well at higher altitudes in Eastern Africa, but they encounter massive problems with fungal diseases, undoubtedly because the altitudes high enough to be cool enough for them are also quite wet. Potatoes and wheat were introduced in Belgian times. With independence, introduction and local testing of new varieties stopped (there never was a breeding program in the area), and the varieties that were used succumbed to fungi. Potato culture disappeared from the Great Lakes Highlands except for Zone 2, where farmers continued to get new planting material unofficially from the breeding-program in southern Uganda. Now, the Centro Internacional de la Papa breeding-program in Ruhengeri, in the heart of Zone 2, is providing new, resistant planting materials and potato culture is expanding rapidly. Perhaps as a result of Belgian influence, potato is a high-prestige starch source bringing a high price, hence a cash crop for Volcanic Highlands' farmers. Wheat is much less important, but new introductions are also contributing to a resurgence.

Crop	Land Use			Yield	Output
	Spring rains (ha)	Dry season (ha)	Fall rains (ha)	(T/ha)	(kg)
Peas or pole beans	0.3			0.8	240
Maize	0.2			1.1	220
Finger millet, wheat	0.1			0.9	90
Potato			0.3	4.0	1,200
Pyrethrum	----- 0.1 ----------			0.8	80

Land Available

	Spring rains (ha)	Dry season (ha)	Fall rains (ha)	
Total	0.7	0.7	0.7	
of which cropped	0.6	0.1	0.7	
Seasonal cropping intensity	0.86	0.14	1.00	
Total cropping intensity				2.00

Food Output

	Energy (K Cals)	Protein (g)	Fat (g)
Legumes (peas or beans)	701 (31%)	47.5 (56%)	2.3 (21%)
Grains	933 (41%)	23.4 (28%)	7.3 (68%)
of which: maize	(671)	(17.6)	(7.0)
finger millet & wheat	(262)	(5.8)	(0.3)
Tubers (potato)	630 (28%)	13.2 (16%)	1.2 (11%)
Total	2,264	84.1	10.8

Zone 3 -- Bututsi

3.16 This zone is a southern extension of Zone 2. Soils are so acid and aluminum-toxic that agriculture is possible only in folds of the hills where erosion has concentrated soil nutrients or in plots around rugo where animal manure and household wastes serve the same purpose. Soil fertility has certainly been declining over the past century, and population is now migrating out of the zone. Population density is now estimated at 90/km^2, which allows about 6 ha per average-sized family. Only a small portion of that is farmable, however, the rest being poor quality pasture of exceptionally low carrying capacity, and that only during the rainy seasons.

3.17 It is true that the Bututsi has the highest concentration of pastoral baTutsi in the Highlands. But the baTutsi's penchant for livestock-raising rather than farming is not the product of ethnic predilections but of physical imperatives. As the farming model below eloquently indicates, Zone 3 residents do not live primarily by farming. Cropping intensity of those small arable areas is high. During the dry season, animals must be moved to dry-season pastures in the Imbo or the Mosso, and most of the rural population is absent.

Crop	Land Use			Yield	Output
	Fall Rains (ha)	Dry Season (ha)	Spring Rains (ha)	(T/Ha)	(kg)
Beans			0.1	0.4	40
Sorghum, Finger Millet or maize	0.2			0.6	120
Sweet Potatoes			0.1	2.5	250
Land Available					
Arable	0.2	0.2	0.2		
of which cropped	0.2	-	0.2		
Pasture	5.0	5.0	5.0		
of which grazed	5.0	-	5.0		
Seasonal Cropping Intensity of Arable Land	1.0	-	1.0		
Total Cropping Intensity of Arable Land				2.0	
Seasonal Cropping Intensity of all Land	0.04	-	0.04		
Total Cropping Intensity of all Land				0.08	

Food Output

	Energy (K Cals)	Protein (g)	Fats (g)
Legumes (beans)	115 (18%)	7.9 (42%)	0.4 (11%)
Grains	342 (52%)	7.7 (41%)	2.6 (68%)
Tubers (Sweet potatoes)	196 (30%)	3.0 (16%)	0.8 (21%)
Total	653	18.6	3.8

Zone 4 -- Butembo Highlands

3.18 This Zairian higher-altitude zone is cut off from the other above 1800 m, "numbered zones". At a population density of about 150/km^2, it is much more densely peopled than the bigger Zairian higher-altitude zone to the south (Zone 5). The reasons for this greater development are not clear. Farm size, intensivity of land use, and land availability are only moderate compared to the Highlands as a whole, but they are high compared to the Mitumba Range.

3.19 Butembo Highland farmers had more success in sustaining wheat cultivation between 1960 and the re-appearance of outside help with rust-resistant varieties in the 1980s than did farmers elsewhere in the numbered zones. Wheat has a bigger place in the rotation and in the local diet than elsewhere. Growing European vegetables is important; with the exception of leeks and cabbage these have not been accepted into the local diet; since the zone's transport links to the outside are tenuous and expensive, a significant portion of the vegetables are wasted through spoilage (a Canadian cooperative project has succeeded in marketing the semi-perishable ones: onions, garlic, potatoes and beans, in Kinshasa, but at great effort). Possibly minor differences in humidity and in rainfall distribution account for the region's development, e.g. the fact that wheat rusts have been slower to develop and wipe out traditional wheat varieties than elsewhere in East Africa.

Crop

	Land Use			Yield	Output
	Fall Rains (ha)	Dry Season (ha)	Spring Rains (ha)	(T/Ha)	(kg)
Beans or peas	0.2			0.7	140
Beans or peas			0.2	0.7	140
					280
Sorghum or maize	0.4			1.0	400
Wheat	0.2			0.8	160
Sweet potato			0.4	4.5	1800
Potato	----		-0.2--	3.0	600
Fallow	0.8	1.8	1.0		
Land Available	1.8	1.8	1.8		
of which cropped	1.0	-	0.8		
Seasonal Cropping Intensity	0.56	-	0.44		
Total cropping intensity				1.00	

Food Output

	Energy (K Cals)	Protein (g)	Fat (g)
Legumes (bean/peas)	818 (20%)	55.4 (44%)	2.7 (12%)
Grains	1600 (39%)	41.8 (33%)	14.1 (62%)
of which: sorghum or maize	(1132)	(29.0)	(13.0)
wheat	(468)	(12.8)	(1.1)
Tubers	1726 (42%)	28.2 (22%)	6.0 (26%)
of which: sweet potato	(1411)	(21.6)	(5.4)
potato	(315)	(6.6)	(0.6)
Total	4144	125.4	22.8

Zone 5 -- Mitumba Range

3.20 This zone has the lowest average population density of the Great Lakes Highlands, 45/km2. Soils retain much of their fertility built up under generations of forest cover, but they are not comparable to the recent lavas of the Volcanic Highlands. There is no population pressure in Zaire comparable to that in Rwanda and Burundi that would induce migrants to take up farming in these cold lands above 1800 m, where maize matures slowly, and where bananas, sorghum, coffee, and un-staked beans will not yield. There is adequate land available, and cropping intensity appears moderately high only because the ample, uncleared forest is not counted as fallow. Grains have an important place on the farms' food production.

Crop

	Land Use			Yield	Output
	Fall Rains (ha)	Dry Season (ha)	Spring Rains (ha)	(T/ha)	(kg)
Peas or Beans	0.5			0.6	300
Maize	0.3			1.5	450
Finger millet	0.3		0.3	0.7	420
Sweet potatoes			0.3	3.0	900
Fallow	0.3	1.4	0.8		
Land available	1.4	1.4	1.4		
of which cropped	1.1	-	0.3		
Seasonal cropping intensity	0.79	-	0.21		
Total cropping intensity				1.0	

Food Output

	Energy (K Cals)	Protein (g)	Fat (g)
Legumes (peas, beans)	876 (21%)	59.4 (47%)	2.9 (15%)
Grains	2589 (62%)	56.2 (44%)	14.4 (72%)
of which: maize	(1373)	(36.0)	(14.4)
finger millet	(1216)	(20.2)	-
Tubers (sweet potatoes)	706 (17%)	10.8 (9%)	2.7 (13%)
Total	4171	126.4	20.0

Summary

3.21 Some information from the models is summarized below. The caveats cited in 3.01 should be borne in mind.

Model	Land Available (ha)	Cropping Intensity	Energy (K Cals)	Protein (g)	Fats (g)
A High Plateau	1.1	2.2	4744	120	21
B Kagera Piedmont	2.1	1.0	3787	80	14
C Kivu Lakeshore					
East of Rift	0.9	2.1	4557	111	21
West of Rift	2.0	1.0	3574	76	14
D Kayna	1.8	.84	4109	139	27
E Maniema Slope	4.0	.45	6876	85	15
1 Cen. Congo-Nile Divide	2.0	.60	2867	88	19
2 Volcanic Highlands	0.7	2.0	2264	84	11
3 Bututsi	0.2	2.0	653	19	4
4 Butembo Highland	1.8	1.0	4144	125	23
5 Mitumba Range	1.4	1.0	4171	126	20

Percent of Energy from:

	Legumes	Grains	Tubers	Bananas
A High Plateau	20	16	49	14
B Kagera Piedmont	15	24	50	10
C Kivu Lakeshore				
East of Rift	18	21	46	16
West of Rift	14	15	39	31
D Kayna	28	52	86	20
E Maniema Slope	-	14	86	-
1 Cen. Congo-Nile Divide	16	67	16	-
2 Volcanic Highlands	31	41	28	-
3 Bututsi	18	52	30	-
4 Butembo Highland	20	39	42	-
5 Mitumba Range	21	62	17	-

Percent of Protein from:

	Legumes	Grains	Tubers	Bananas
A Highland Plateau	54	16	36	1
B Kagera Piedmont	47	30	20	3
C Kivu Lakeshore				
East of Rift	50	21	26	3
West of Rift	47	17	28	7
D Kayna	57	40	-	3
E Maniema Slope	-	21	79	-
1 Cen. Congo-Nile Divide	36	56	8	-
2 Volcanic Highlands	56	28	16	-
3 Bututsi	42	41	16	-
4 Butembo Highland	44	33	22	-
5 Mitumba Range	47	44	9	-

3.22 From the foregoing, it should be apparent that our knowledge of farming systems in the Great Lakes Highland is extremely general and lacks the specificity and detail that would provide definitive answers on the economic and financial viability of proposed changes. At present, not a single well-structured and scientifically designed and executed farm-management survey has been completed in the region. The closest to that description is the 1967 survey of farms in Ngosi and Gitega in Burundi (cf. 5.10 to 5.11).

3.23 At the moment, some farm management surveying is going on or about to start. The Nyabisindu-pastoral Project in Rwanda has been conducting a large and rather well-designed farm management study in seven communes. Sampling has been done in such a way that results should be representative of the communes as a whole. These have a population of about 270,000 or about 5% of that of Rwanda. More importantly, they cover three of the most important of our 10 zones: Nyabisindu, Kigoma and Murama are mostly Zone A; Ntyazo and Ntongwe are characteristic of Zone B, except that their character and results are heavily influenced by the importance of settlement 'paysannats' there, making them atypical of Zone B as a whole; and Ruknodo and Karama mostly have Zone 1 characteristics. Results have been published in German by the project's leader, Dr. Jurgen Dressler. Publications to date in French are extremely fragmentary 8/.

8/ Our guessmates above owe something to Dressler and to other staff of the Nyabisindu project, especially Wolf Dieter Kruger, who, however, only gave us their best guesses and cannot be held responsible for our errors.

Nevertheless, these results are far from giving a complete picture. They give planting material inputs and outputs per crop (except for cassava output!) and information about animals and animal products kept and sold and about tools owned. They do not provide information on the most important production input -- family labor -- and will provide very little indeed on land use. In short, they will be far from adequate for the elaboration of whole-farm budgets.

3.24 In 1983-84, the Rwandese Ministry of Agriculture is carrying out farm-management surveys in all of that country's 36 ecological zones with assistance from the US Bureau of the Census and Finance from USAID. Members of this mission have been in touch with Rwandese and Americans associated with this project. There is hope that results, which should begin to become available in late 1985, will fill major gaps in our knowledge 9/.

3.25 In Burundi, ISABU, the national agricultural research organization, has agreed to supplement its current research, which is heavily oriented towards genetic improvement, with a farming-systems research program. USAID will fund the program, slated to begin in 1983/84, but USAID and ISABU have not yet entirely agreed on the definition and goals of the program 10/.

3.26 The mission is not aware of any similar plans for farm managment research in Kivu Province of Zaire.

3.27 It is perhaps a bit surprising to find such a paucity of farm systems research in the Great Lakes Highlands. In many parts of the Third World, and even of the First and Second Worlds, governments and planners have often judged, rightly or wrongly, that agriculture could take care of itself. This has particularly been the case in land surplus areas. In most of Zaire, for instance rural population densities have been extremely low; the colonial government was not entirely entirely unreasonable in its judgement that, if it concentrated on persuading or obliging farmers to grow crops of utility to government and to the colonizing country, that "subsistence" agriculture would take care of itself. That judgement, though not unreasonable, proved not to be wise, however, because of the complicated relationships between "cash" and "subsistence" crops that affected the production of the latter. It is always important to recognize that farms are units, and that modifying a part of farm modifies all of it.

9/ Contacts: Serge Rwamasirabo, Project Chief, Ministry of Agriculture; Don Clay, US Bureau of the Census.

10/ Contacts: Joseph Kafurera, Directeur Général, ISABU; Abbie Fessenden, Program Officer, USAID Bujumbura.

3.28 In Great Lakes Highlands, governments recognized early in the colonial period that "subsistence" agriculture would not take care of itself. It was unlike agriculture in the land surplus areas of the tropics. Particularly following the 1929 famine in the High Plateau, the Trusteeship governments of Rwanda and Burundi consciously and deliberately modified the "subsistence" parts of the farming systems, e.g. by introduction of manioc as a protection against such famines. And, early in the Trustee period, government realized the threat that hillside farming systems posed to the region's soil capital; the mandated soil conservation measures which farmers implemented but which they found onerous. Nevertheless, there never was any systematic effort to study and understand the farming systems as systems.

3.29 One reason is probably that Great Lakes Highlands farming systems--tropical farming systems where land is scarce and hilly -- are extremely complicated and defy analysis by the farm management economist's traditional tools. These tools were designed for British agriculture where one and only one crop occupies each plot of ground for a discrete block of time and, incidentally, where land, rather than labor, is considered the scarce good, so that yields are all measured per unit of land. In Great Lakes Highlands farming systems, especially for the more traditional crops, the crop mixtures and the timings of multiple cropping of land are extremely intricate. Not only is more than one crop frequently growing on one plot at one time, but also crop seasons may only partly overlap because they were planted and will be harvested at different times. Moreover, the different crops are sometimes unevenly distributed in the same field. And even what seems to be one crop may not be uniform; most farmers plant a mixture of varieties of beans, for instance. Each variety in the mixture will do well in different rainfall conditions, minimizing the risk of failure. But the components of the mixture are actually somewhat different crops with different yields. Farm management economics has never found a satisfactory way of dealing with such multi-cropping and relay-cropping situations, which are almost universal in the Great Lakes Highlands, as they are on the small, hillside farms of the Caribbean and elsewhere.

3.30 As Chapter 4 will show, an acceptable understanding of the Great Lakes Highlands farming systems actually requires a quite intimate understanding of the crop combinations and relays <u>because</u> of the importance of soil protection. On the Great Lakes Highlands' slopes, at its temperatures and given its rainfall, <u>soil cover</u> is an important aspect of the farming systems closely related to how sustainable agriculture is. In short, in addition to knowing the inputs in land, labor, tools and other inputs for each kind of cropping pattern, and the output in crops, it is important to know the effects of each on soil nutrient composition, leaching and erosion.

3.31 The utility and priority of further research to fill gaps in our knowledge will be discussed in Chapter 5.

IV. Proposed System Changes

4.01 Most changes in farming systems, in the Great Lakes Highlands just like anywhere else, are unplanned and the result of myriads of micro decisions by the region's roughly two million farmers in response to their family situations. They follow a pattern of change determined largely by (a) population growth and resultant changes in the man/arable-land ratio, and (b) access to external markets resulting from changes in transport infrastructure, world markets, and government interference with them through taxes or subsidies. As population growth decreases the arable area available per farm, there is progression along the familiar pattern of transition from bush-fallow cultivation to grazed leys as fallows shorten to continuous cultivation [11]/. In the highest population density parts of the Great Lakes Highlands -- Zones A and 2 -- the permanent cultivation stage is already established. The characteristic low soil fertility of such systems has been slower in coming to the Great Lakes Highlands than to most tropical areas because, at high altitudes, lower temperatures slow down the process of soil mining (and the recent volcanic soils of Zone 2 are extraordinarily fertile).

4.02 Nevertheless, the beginnings of the process which Clifford Geertz called "agricultural involution" [12]/ are clearly discernable: caloric value of diet per farm is maintained as farms grow smaller by substituting higher yielding tubers for higher food-quality grains; food crops for home consumption crowd out cash crops; livestock is reduced to small animals that live on crop and household waste; and emigration is needed to maintain a low-income equilibrium.

4.03 Projections of present systems' trends for the Great Lakes Highlands suggest that the "successful" adaptation of farmers to changing circumstances will drive ever enlarging areas to the low-income equilibrium now coming into view in parts of Zones A and 2 as man/arable-land ratios increase and farm sizes decrease. In farming-system terms, the destiny of ever larger portions of the Great Lakes Highlands and of its farmers would seem to be something like the extremely intensive, intricate system Ludwig

---

11/ The best explanation of this process, by authors with abundant experience in East Africa, is Hans Ruthenberg. Farming Systems in the Tropics. Oxford: Clarendon, 1980 (3rd edition), chapters 3 through 6.

12/ Clifford Geertz. Agricultural Involution: the process of ecological change in Indonesia. Los Angeles: University of California, 1963.

analyzed on Ukara Island in Lake Victoria 13/ and the extremely low income that goes with it. At the low income levels stemming from such small farms and such low soil fertility, food demand becomes preponderant in total demand; the share of purchased articles in total demand declines. Consequently, farmers devote great ingenuity to wresting their subsistence needs, primarily of tubers, from their small plots; cash crops progressively disappear.

4.04 This pessimistic prognosis is a formula for survival -- little more. Its "development" is not development in the sense of progress in human welfare and consumption power but involution in Geertz' sense. And this scenario is not a simple projection based on current techniques -- the usual kind of projection of the Club-of-Rome type which inevitably leads to disaster in the not too distant future because it ignores the capacity of necessity to generate human invention 14/. This scenario builds in the assumption that farmers will modify their cropping patterns and will intensify their cropping systems within the limits of their ability.

4.05 We are interested, in this chapter, not in lamenting the human consequences of the fixed-techniques scenario nor even of the scenario that assumes quite a bit of farmer inventiveness. These are both sobering enough. And no realistic economic projections have the Great Lakes Highlands turning into a high-income "Switzerland of Africa". All scenarii indicated that, to sustain or increase income per head, there will have to be some combination of emigration, lower population growth, and transfer of increasing portions of the population into economically-productive non-agricultural jobs. Planners find the development of manufactured exports from the Great lakes Highlands a daunting task, although mountainous, land-locked, remote Switzerland succeeded in doing so. Such exercices in projections and planning all highlight the importance of

---

13/ D.H. Ludwig. Ukara -- Ein Sonderfall Tropischer Bodennutzung im Raum des Victoria-Sees. Munchen: IFO Institut (Afrika-Studien, No.22), 1967 (translated in Smallholder Farming and Smallholder Development in Tanzania. Hans Ruthenberg (ed.). Munchen: IFO Institut (Afrika Studien, No. 24), 1968. Also see Johannes Lagemann. Traditional African Farming Systems in Eastern Nigeria. Munchen: IFO Institut, Weltforum Verlag. (Afrika Studien, No.98), 1977.

14/ There is just such a projection exercise for farming systems in the Great Lakes Highlands: W. Wils, M. Carael and G. Tondeur. Le Kivu montagneux. Surpopulation, sous-nutrition, erosion du sol. Bruxelles: CEMUBAC-IRS, 1978. By projecting present practices into the future with present population growth, all of Kivu, but particularly the most densely populated BaNande and BaShi areas around Butembo and Bukavu, will wash away and will have farms so small that people will be unable to produce enough to keep themselves alive by early in the next century (exact date varies with assumptions and present farming population density).

improving the efficiency of land and labor use in the Great Lakes' Highlands' overwhelmingly predominant sector. Is there anything to recommend to the Highlands' farmers now to improve their lot, their incomes, to improve the value of the soil capital they will be passing to their children (or often to reduce the rate of its destruction)? Yes.

4.06 Before the independence of the three present day states, the Bami (plural of Mwami) of the people and their colonial rulers had ideas about how farmers could improve; today, agricultural research technicians, Agriculture Ministry civil servants, politicians and foreign aid employees, not to mention international financiers, have ideas too. Methods of getting farmers to take these ideas seriously range from fiat to intervention in markets to trying to convince them through extension and in other ways.

4.07 This mission reviewed various non-farmers' recipes for improving farming in the Great Lakes Highlands (and added one or two of its own). In view of the paucity of our knowledge of how farmers allocate their labor and their land, such a review is, perforce, subjective and tentative. In making judgements, we try to assess proposed system changes from farmers' points of view -- a combination of farm family financial analysis and psychology -- all without completely losing sight of society-wide (i.e. economic analysis) considerations. In most instances, unfortunately, our judgement about a proposed system change turns out to be hedged: more research is needed. Where we are able to conclude that a given system change is of proven worth to certain kinds of farmers in a certain zone (or of proven worthlessness), it is not because a quantified analysis has been possible comparing results under the proposed change with results without it. Rather it is usually a judgment based on which way the wind is blowing, as indicated by what farmers are doing.

4.08 We arbitrarily divide proposed system changes below into: soil conservation; changes in culture of existing crops; changes in cropping pattern; and changes in livestock systems. These four categories are not mutually exclusive. Consequently, there will be frequent cross-references. And even so, taking proposed changes in detail will not give an adequate picture of the whole. But they will be considered in detail anyhow, because that is how the farmers of the Great Lakes Highlands usually consider them. And soil conservation is broken out as a separate category because it appears to us and to governments to be of such great importance in the middle to long run -- a time horizon which extremely poor farmers with a preemptive need to feed their families for the next year often cannot permit themselves the luxury to consider.

Soil Conservation

4.09 From colonial times, a major, perhaps the major concern of administrators and experts has been to get Great Lakes Highlands' farmers to practice soil conservation. Certainly this has been the case for the densely settled zones (A, C, 2, and increasingly 1, 3, and 4 as well). Reviewing governments' concerns, a recent Clark University study of the Highlands concludes by agreeing that:

> "Soil management appears to be the major critical environmental problem in Rwanda, Burundi and Kivu and is an essential part of farming systems research [15].

4.10 Soil conservation is a peculiar category because it is not an end in itself; you cannot eat it or sell it; as an intermediate product, it is useful only to the extent that it results in some future flow of agricultural production that would not have existed without it. Consequently, farmers evaluate soil conservation ideas thrust at them according to the work and money required to carry them out and their expectations of the stream of future benefits these efforts will bring them in the form of additonal crops or of crop losses avoided (less whatever crop losses will be caused by having to devote land to soil conservation works). It is the nature of most soil conservation measures that most of the costs occur now, while most of the benefits are some years away (and perhaps dangers are not fully appreciated by farmers). In weighing mainly present costs against mainly future benefits, Highlands' farmers take into account the very high preference for present income over future income (personal discount rate) which very poor people must have. In assessing proposed system changes designed to promote soil conservation, we should too.

4.11 The panoply of possible soil conserving (and soil enriching) measures is large. They can be broken down into:

(a) measures to improve soil cover and prevent erosion before it starts, by planting perennials, or annuals that cover the soil during critical rainy periods, or by mulching;

(b) measures to restrain erosion by shortening the length of slope over which it takes place, by digging contour ditches, or planting anti-erosion contour strips; and

---

15/ Eileen Berry, Leonard Berry, David J. Campbell & David C. Major. Regional reconnaissance of Rwanda, Burundi, Kivu Province of Zaire (final report) (prepared by USAID). Worcester (Mass.): Clark University, International Development Program, June 1982, Vol. I, p. 82).

(c) measures to improve soil tilth and nutrient status by growing nitrogen-fixing plants, by applying chemical fertilizers, by applying compost or uncomposted manure, household waste or plant residues [16/].

4.12 Mulching was introduced for small coffee holdings during the colonial period by fiat. Coffee, though perennial, provides little soil cover. Smallholder coffee growers in Zones A and C generally plant coffee on the steeper slopes of hillsides, with the itongo where they grow their food on less-steep parts of the hillside. Soil-covering mulch both prevented erosion at the source (the raindrop hitting the naked soil) and controlled weed growth, particularly of "chiendent" (coach grass) and other grasses that can kill coffee trees by taking their water. In colonial times, mulching was universal on smallholder coffee. This excellent soil conservation measure was not used on other crops however, except for the dense beer-banana groves which, in effect, mulch themselves.

4.13 Today, mulching of coffee is no longer universal. Although the majority of farmers certainly mulch their coffee, the percentage who do not is growing. Also, among those who do, the thoroughness and adequacy of the mulching seems to be declining, since the amount of mulch used is frequently insufficient to cover the soil continually. There seem to be national variations as well. According to the mission's observations, a higher percentage of coffee plots is mulched in Burundi's Zone A (mainly Buyenzi and Kirimiro, and also in Rwanda's Zone C) than in Rwanda's Zone A, where the percentage was nevertheless higher than in Zaire's Zones C and D.

4.14 Zairian coffee farmers' lack of attention to mulching can be explained by two facts. Firstly, low real prices of coffee are related to less interest in intensifying the crop and to a relaxed attitude towards labor inputs (see para 2.27 above). Secondly, unlike Rwanda and Burundi, Zaire does not prevent farmers from intercropping coffee. Many Zairian farmers do just that, intercropping coffee with bananas and/or annuals like beans and sweet potatoes. (The pros and cons of this practice is discussed below under "Changes in Culture of Existing Crops.") This intercropping, particularly that with bananas, improves soil cover and reduces erosion, making mulching less critical. Bananas provide mulch of their own.

16/ For an excellent review of the soil conservation problem in the Highlands by two of the rare experts who undertand the basis of the problem, see Jurgen Dressler & Irmfried Neumann. Agriculture de couverture du sol (ACS); un impératif pour la lutte contre l'érosion au Rwanda. Projet Agropastoral de Nyabisindu, 1982, 20 pp.

4.15 In Rwanda and Burundi, intensity of coffee mulching is largely a factor of mulch availability. Population density is a pretty good proxy for mulch availability. In Zone A, the most important in population and in coffee production, there is a close relationship between population pressure and the development of the swamps for farming. In the most densely populated parts of Kigali, Gitarama and Butare Prefectures and of the Buyenzi -- all Zone A -- swamps have been almost completely developed for farming. These are the areas where there is a tendency not to mulch coffee, or to mulch it very sparingly, because mulch is scarce.

4.16 But more strikingly, everyone agrees that all swamps in Rwanda and Burundi will be converted to cropping within a few years. Estimates differ, but the differences are hardly important because the longest is ten years. Thus, the mulch shortage that now obtains in the most densely settled parts of Zone A will obtain very soon indeed in the remainder of Zone A and soon thereafter in other coffee growing zones east of Rift (C and B).

4.17 A partial budget analysis to determine the return to farmers from mulching coffee could be made if we could judge the response of coffee to mulching, the value of soil conservation from mulching in the stream of additional crops produced (or losses avoided), and the cost of getting and applying the mulch. Responses of coffee to varying amounts of mulching have been estimated by Dressler and Zublin of the Nyabisindu Agropastoral Project (Zone A) and the Kibuye Coffee & Foodcrops Project (Zone C) 17/ for "good" and "poor" soil. Their estimates are:

Mulch applied (t/ha)	40	30	21	18	15	12	9	6	3	0
Coffee yield/tree (g):										
Rich soil	810	800	750	720	670	600	500	360	320	300
Poor soil	610	600	570	550	500	300	180	100	70	50
Incremental coffee/ha (t):										
Rich soils	.02	.10	.06	.10	.14	.20	.28	.08	.04	
Poor soils	.02	.06	.04	.10	.40	.24	.16	.06	.04	
(base yield w. no mulch)										.60
Incremental coffee/ incremental mulch (kg/t)										
Rich soil	2	11	20	33	47	67	93	27	17	
Poor soil	2	7	13	33	133	80	53	20	13	

Source: Dressler & Zublin. Op.cit., p.5, adapted.

17/ Jurgen Dressler & Hans Zublin. "Enquête caféicole dans la région du projet agropastoral de Nyabisindu, mai 1982", unpublished paper, 9 pp.

These valuable estimates enable us to estimate the farmers' (i.e. financial) interest in mulching coffee only if we also know the differential effects of mulching or not mulching on soil fertility, the costs of getting and applying mulch, and the opportunity cost of farmers' family labor from their own point of view as determined by their alternatives.

4.18 As for cost of mulch, Dressler concludes that growing it is not competitive with foodcrop alternatives:

> "...la production de paillis sur des champs réservés à ces fins n'est guère rentable dans les conditions prévalantes du petit agriculteur au Rwanda..." 18/

But growing mulching material is the only way to have enough for the average coffee holding in the densely-settled parts of Zone A where there is no longer enough "natural" mulching material that can be collected. Mulching coffee

> "...n'est judicieux que dans la mesure où l'agriculteur dispose d'un matériel de paillage en quantité suffisante et bon marché. A partir du moment où la surface d'exploitation diminue et que le marais ne peut plus fournir de matériel pour le paillage, ce dernier se fait au détriment des autres cultures." 19/

Zone A farms that are pinched for land and without access to unexploited marshes, therefore, are limited to mulch that is generated as a by-product by the farm itself. The low value of mulching material per ton makes seeking it far afield and transporting it prohibitive. Dressler and Zublin estimate that a typical Zone A farm generates 500 kg of mulching material as a by-product from harvesting, weeds, banana trunks and leaves, and household waste 20/. This would seem to be the economic limit of mulch supply for coffee farms in the Highlands east of Rift.

18/ Dressler & Neumann, Op. cit., p.15.

19/ Ibid. p. 8

20/ Dressler & Zublin, Op. cit., p.5.

4.19 If the model Zone A farmer has 160 coffee trees on 0.08 ha, then 500 kg of mulch would allow 6.25 t/ha per year of mulch in the coffee grove. But a good bit of this mulching material is left in the banana grove, which, by all appearances, farmers consider more important and more profitable than their coffee. And even if all were used on coffee, 6.25 t/ha is well below recommendations, which are usually 20 t/ha or more [21/]. While these high doses of mulch may be desirable for high coffee yields, there is some evidence that lesser mulching -- 4-6 t/ha -- would reduce soil loss per hectare by 95-99% compared to annual crops like grains, manioc or beans [22/].

4.20 Mulching recommendations. When and how much should farmers mulch? That depends on their Zone, on the availability of mulching material, on soil fertility, and on farm size (as well as on preferences and location).

4.21 For farmers in Zone A and, soon, in C and B as well, profitable use of mulch is or soon will be limited to what can be supplied as by-products of farm and household -- ca. 500 kg/farm. On larger (more than 1.5 ha) farms on good soils, Dressler and Zublin argue that it makes more sense to use family or even hired labor to expand the coffee planting with little or no mulch than to intensify a smaller area of coffee by mulching intensively [23/]. These farmers can get 300 g/tree even without mulch. Presumably, however, the farm by-product mulching material will not be wasted. Smaller farms on rich soils do not have the option of expanding and, in fact, the smaller that are, the greater the pressure to abandon coffee for food crops. However, to the extent that they can feed themselves and have land to spare for coffee -- and that takes about 0.6 ha for the average-sized family of 5 or 6 -- they should use their farm by-product mulch on that coffee. Use would be limited by by-product supply. If coffee groves are .04 to .06 ha (80 to 120 trees), then 500 kg of mulching material will give application rates of 8-12 t/ha, at which the marginal impact of mulching on coffee yields is near its maximum and at which mulching cover is enough to prevent all but a tiny amount of erosion.

21/ See, for example, Ibid., p.3, which implies 22 t/ha.

22/ See E. Roose. Erosion et ruissellement en Afrique de l'Ouest - Vingt années de mesures en petites parcelles expérimentales. Paris: ORSTOM, 1977. Results are from experimental station and from West Africa. Similar figures for the Great Lakes Highlands and for farms, as distinguished from research stations, are not available.

23/ Dressler and Zublin. Op. cit., p.6

[.22 For farmers in Zones A, C, and B who have poor soil, mulching coffee would seem to be even more important. According to Dressler and Zublin's estimates, marginal returns are highest up to about 15 t/ha of mulch, 2.4 times more than the typical farm would have available. Dressler and Zublin speculate, however, that these poor soil farmers would be better advised to use available mulch on other crops because of its soil improvement qualities.

> "...il est probable que le paillage sera mieux valorisé par d'autres cultures, parce qu'il améliore peu à peu le sol... et finalement son rendement y est plus élevé."24/

One might suppose that farmers would not take such a long-term view of the situation as that taken by these two devotees of "sustainable" agriculture, but Dressler and Zublin indicate that farmer behavior in the communes around Nyabisindu confirms their hypothesis. Farmers in the poor soil Busasamana Commune cease to care for coffee, allowing it to wither and die, so that they can get permission to uproot it and replace it with food crops.

4.23 If mulching crops other than coffee is so attractive, why is it virtually never practiced? The only exception to this rule is the banana groves, and these cannot properly be said to be mulched; trunks and leaves are simply left, and these are not that critical anyhow because groves are dense and leaf cover protects and cools the soil. There are two parts to the answer. One is that, until recently, annual crop fields covered a small portion of the land at a given time with plenty of time and land left for fallowing. Thus there was little erosion danger. To the extent that times have changed, mulching annual crops ought to be worth some comparative trials at least. But, secondly, mulching annual crops is more difficult than mulching perennials. It can only be done after they have emerged, lest mulching prevent germination. Consequently, mulch will not be in place at the onset of the rains, when much soil erosion takes place. Moreover, annual plants being lower to the ground than perennials, mulch, with its micro-environment that harbors insects and molds, is closer to the leaves. The techniques of annual crop mulching are proving to be extremely demanding. Most experimental work along this line is being conducted by the International Institute for Tropical Agriculture (Ibadan, Nigeria), which has generally had to resort to pesticides. Therefore, it seems safe to conclude that it is premature to recommend annual crop mulching to Highlands farmers. They are doubtless already experimenting with it themselves. Also, formal research, such as that being conducted at IITA, definitely ought to be encouraged.

24/ Loc. cit.

4.24 What recommendations on mulching are appropriate for farmers in the less-peopled coffee-bean-banana zones (D & E), and in the higher-altitude tea-pea-potato zones (1-5)? Zones D & E do not have the same marsh characteristics as Zone A but, being far less peopled -- especially so for Zone E -- they are not short of material for mulch. Bush-fallow agriculture, with livestock, creates derived savannah from forest under Zone D and E conditions. While fallows are ample, plenty of grass is available. But just as mulching material is more available, its use is less critical. Farmland that has recently been forest or which has had a long fallow period is more fertile, so that mulching is less essential for fertility enhancement. And, erosion does not get so far when annual-cropped plots are small and constitute a small percentage of land, separated from one another by bush or by derived savannah that is not overgrazed. As population densities rise and fallows shorten, the importance of mulching for soil protection increases. Perhaps the basis for its future adoption should be laid now in certain zones through extension. However, it is precisely in Zones D and E that no effective extension service exists. Moreover, the technics of mulching are worked out only for perennials: coffee and bananas. And bananas mulch themselves, while coffee in Zones D & E (and in the Zairian part of Zone C) is fairly likely to be protected from erosion by interplanting with bananas and/or beans. Therefore, mulching does not seem to be a high priority for Zones D & E.

4.25 Mulching is scarcely practiced at all in the higher altitudes zones (1-5). Tea covers the soil well, once established, preventing erosion. It needs no mulch. As at lower altitudes, the technics of mulching annual crops: peas, potatoes, beans, finger millet, wheat,...; are not worked out. In the case of peas, culture is often so extensive, with peas growing among the grasses that are re-establishing themselves for a fallow, that mulching would be neither feasible nor helpful. Granted the above, however, the potato-pea-tea zones do have crucial soil conservation problems. Research on farming systems that might alleviate them presumably ought to include research on mulching.

4.26 Perennials for soil cover. The ideal soil conservation measure is a permanent vegetative canopy. Before the conversion of the Great Lakes Highlands to human use, native forests performed this function. In isolated areas, they still do. These residual forests are found east of Rift, where human population density is higher, at altitudes generally between 2500 and 2800 m (Zones 1, 2, 3) and west of Rift, where population is lower, down to much lower altitudes, even to 1400m in zone E. Native forests allow virtually no soil loss and maintain what soil fertility there is. Unfortunately, value-added per hectare of indigenous foret per year is extremely low. The fact that it is constantly being cleared and converted to other uses by the local population indicates that they appreciate this fact. The remaining forests in Rwanda (Gishwati and Nyungwe) and in Burundi are protected from the people with varying degrees of vigor by government; their superior productivity under other uses is sufficient that some people risk government harassment and punishment to cut, graze and farm them. Almost all alternative land uses, of course, are less conserving of soil.

4.27 It is, of course, a general, world-wide rule that value-added in forestry is lower than in farming and also usually lower than in animal husbandry. Spatial distribution of the world's forests shows that they are on land that is below the margin for other uses either because it is so remote or because it is so infertile. Great Lakes Highlands' population densities -- at least in Zones A, 2, and C -- practically preclude reserving land for forests. The exceptions are and will continue to be extremely rocky hillsides on infertile soils where trees will not grow that well either. A projection of present trends will extend the proportions of the Highlands where tress are confined to such patches and to the borders of farm plots. The normal evolutionary development would be gradual replacement of fuelwood by other energy sources, e.g. peat (and by charcoal in large towns), and of other wood uses by substitutes too, with some import of wood from less settled areas (e.g. Zone E).

4.28 Indigenous forests have far lower value-added per hectare than forests need have. In the ecologically similar Kenya highlands at altitudes of the pea-potato-tea zone, indigenous forests have a mean annual increment of roughly 0.1 m^3 per hectare, compared to 15.0 m^3 for exotic pines and eucalyptus. Plantations of exotic species can radically increase the productivity of forests. Moreover, they have the same soil conservation characteristics as their indigenous predecessors [25/]. If forests are a justified land use at all, plantations of exotic species are a far better use than indigenous species [26/]. Planting exotic forests, however, is usually carried out on a large scale and by governments, not by small farmers.

4.29 To the extent that the Highlands' farmers grow trees, these are likely to be on field boundaries, preferably, for soil conservation purposes, on contoured field boundaries, or around houses or along roads. Official advice, both in the colonial and independence periods, has been to plant contoured erosion breaks with grasses. As population density rises and firewood and charcoal get scarcer and more expensive, one would expect to see farmers starting to produce some of their own firewood in field boundaries. This development is quite evident in densely-peopled Kakamega

---

25/ This is not so for eucalypts and, to a lesser extent, for grevilleas, which cover poorly and/or suppress competing vegetation, permitting erosion. It also assumes equal exploitation rates, since erosion inevitably occurs when forest is felled before replacements are established, even when logging is carried out in an ecologically optimal manner.

26/ This observation is constrained only by whatever antiquarian interest there may be in preserving ecosystems for their own sake, or interest in their tourist potential. The genetic bank represented by existing species should, of course, be preserved, whether their original habitat is changed or not.

District in Kenya. Choice of species is a difficult technical problem, because the trees with the highest production of wood also use the most soil nutrients. Eucalypts are attractive because of their high mean annual increment and their thin leaf canopy, which reduces the extent to which they shade and inhibit growth of other crops 27/. However, eucalypts need a lot of nutrients for their ample growth. Leguminous, nitrogen-fixing trees, relatively speaking, have low mean annual increments. For instance, while eucalypts are capable of yielding 30 to 35 m^3/ha/year, grevillea may yield 15 to 20. Yet farmers often prefer grevillea because they appreciate its soil-improvement qualities and the fact that it does not shade their crops too much. Discovering the optimal species in the midst of these trade-offs will not be easy for farmers or researchers, but an effort would seem to be in order, followed by efforts to produce tree seedlings and to sell them on demand.

4.30 An interesting use of tree planting along boundaries can be seen in the Bututsi (Zone 3). The Mugamba Sud Project, with Belgian support, has divided 300 km^2 of previously unrestricted communal grazing land into rectangular "paddocks" by planting rows of eucalyptus trees along the new boundaries. Eucalyptus was chosen because it will grow in the exceptionally poor soils of the Bututsi and will rapidly establish visible divisions. The project also touts the anti-erosive effect of the tree rows, particularly their effect against aeolian erosion in the windy Bututsi.

4.31 The mission believes that the direct soil conservation effect of the eucalyptus lines is likely to be minor. The trees are not lush, not very close together, and have few leaves close to the ground. Their effect as wind breaks cannot be very great. And, since eucalyptus are not very leafy, the mulch from their leaf drop is not great. And, since they grow rapidly, they have to take a commensurate amount of nutrient from the soil, and without being able to replace the nitrogen, as leguminous trees would. (The project has already experimented with other species, notably black wattle, which fixes nitrogen, forms a better leaf litter, and a good wind break. Black wattle does not establish well on open fields, but might be planted into eucalyptus rows once these were established).

4.32 But the indirect soil conservation effects of the eucalyptus on paddock boundaries are likely to be very great. Firstly, by establishing ownership of grazing lands, the paddocking gives livestock owners, for the first time, an interest in improving pastures. Lush and properly-managed pasture is excellent for soil conservation and erosion prevention, as Charles Pereira's research in the Kenya Highlands demonstrated. For these purposes, properly managed pasture is virtually equivalent to forest or established tea or bananas. Converting the Bututsi's miserable Eragrostis grasslands and the acid, aluminum toxic soils underneath into lush pastures

---

27/ There is some evidence, however, that eucalypts emit a chemical that retards competition.

is a task that goes beyond all but the most vivid imaginations. However, the necessary first step is getting the number of animals down to the optimal carrying capacity of the range. A pastoralist with secure tenure over the grazing land will take an interest in the future of that grazing land and will gradually adjust the herd size. Slowly but surely, the pastoralists of the Mugamba-Sud area are doing just that. Very very slowly, the productive capacity of the land should start to recover.

4.33 Secondly, dividing paddocks by lines of eucalyptus trees has turned the Mugamba-Sud part of the Bututsi from a firewood importer to a firewood-surplus area. This spares crop residues and manure from use as fuel and makes them available to enrich the soil.

4.34 Studies in Kenya and in Mauritius by Pereira show that established tea bushes are as effective a soil conservation measure as forest. In the Highlands' areas suited for tea -- those from 1800 to 2800 m, Zones 1-5 -- tea could have a special place in soil conservation and watershed management. In addition to its soil conservation virtues, tea will thrive on acid and aluminum toxic soils where few other plants will. And particularly in the densely-settled pea-potato-tea zones (Zones 1, 3, and 4) soil mining from over-grazing and exploitation of annual crops without sufficient fallow and/or erosion control is creating more and more areas of low fertility, highly acid, aluminum toxic soils 28/. Burundi's Bututsi (Zone 3) is the most advanced along this unfortunate road.

4.35 Tea has a much higher value-added per hectare than even intensive forestry with exotic species. However, the nascent tea industry in all three countries of the Highlands' region is in deep financial trouble due to various combinations of declining world market prices, high fuel costs, and poor internal organization. While declining world markets cannot be overcome by local action, poor organization can, and fuel costs can often by reduced by conversion to hydropower (or fuelwood). Such actions are beyond the scope of the small farmer who produces tea however. Before encouraging such farmers to grow more tea, public officials ought to assure that steps are taken to improve the efficiency of tea processing, and that prices to the small farmer can and will be set at levels to assure tea's competitiveness with competing crops in the 1800-2800 m zones.

4.36 Tea must be processed very soon after plucking. Consequently, the industry is organized around processing factories, currently nine in Rwanda, seven in Zaire, and three in Burundi. Traditionally, tea growing as well was a large-scale activity, but, within the past three decades,

---

28/ Zone 2's soil chemistry is different. Soil is neutral and not aluminous or ferraginous, and, for now, is fertile.

east Africans have shown that small farmers can supply tea factories efficiently and can maintain quality. Because of the industry's tradition, however, even where small farmers are involved, most tea is grown on big blocks of land. Since tea is such a good soil conservation and anti-erosion perennial, it could be further integrated into traditional Highlands' farms. Planted on contours, tea will not serve as an erosion break because it is a bush which shades and kills vegetation under it. But bands of tea, six or more bushes wide, could serve as erosion breaks on small farms.

4.37 Bananas, the other perennial that provides good soil cover, thrive where tea does not, between 1400 and 1800 m. Densely-planted banana groves are almost completely effective in arresting run-off and erosion; the leaves and trunks they shed form a kind of mulch and maintain soil organic-content levels. The importance of bananas for soil conservation is obvious.

4.38 Nevertheless, colonial authorities discouraged banana production, and research on the unique varieties of beer bananas that predominate in the Highlands' has been non-existent, before and after independence. Beer drinking has been considered anti-social by political authorities, and attention has been called to the waste involved in fermenting bananas. However, while Highlands' farmers have frequently been accused of being drunk all the time [29]/, it is clear that the low alcoholic content of banana beer does nothing of the sort. And, while losing caloric energy in fermentation is certainly a luxury for people as short of calories as the Highlands' population, and while there is disagreement over the extent of these losses, it is probable that they constitute about 41% of the bananas' food energy value -- less than often alleged [30]/.

29/ See or instance, J. C. Nwafor. "Agricultural Land Use and Associated Problems in Rwanda, "Journal of Tropical Geography (1979), IIL, pp.58-65.

30/ See FAO. Per Caput Food Supplies and Food Balance Sheets, section for Rwanda, pp.767-771. For rwanda, 21% of banana production is waste (skins, spoilage). Every kilogram of bananas consumed directly furnishes 751 cal. plus small quantitites of protein (9 g) and fat (2 g). Every kilo of banana fermented into beer furnishes 438 cal. (plus 1 g of protein). The other 313 cal. of energy and 8 g of protein are lost in fermentation. Calculations based on the farm models in Chapter 3 indicate that banana fermentation loss is equal to 2.75% of the farm-produced calories and 6.5% of the protein for the Great Lakes Highlands as a whole.

4.39 There may not be scope for radically expanding the place of bananas in farm production (the area's demand for bananas and beer is met and development of an export market is unlikely), but there would seem to be scope for re-arranging the physical place of the banana trees in farming patterns. Instead of being crowded together in compact groves, bananas too might be planted along contours. Or, they might be thinned out and intercropped with coffee, beans, or other crops, developments that are already taking place in Zone C of both Rwanda and Zaire. These possibilities, which appear to be of proven value and immediately attractive, are further discussed below.

4.40 Coffee is perennial but provides little soil cover. Consequently, it is not an asset for soil conservation, as the official urging to have it mulched demonstrates.

4.41 There are many other possible perennials that might find a niche in Great Lakes Highlands' farming systems for soil conservation. None of them now do. Experiments are in progress as part of the Nyabisindu Agro-pastoral Project to identify the appropriate species.

4.42 Perennial-cover recommendations. Forests of exotic species -- especially pines and cypresses -- are as good for soil conservation as local tree species and vastly more productive. Where there is severe pressure on the residual forests because alternative uses of land have become more attractive, at high altitudes and in remote areas of Rwanda and Burundi, establishing forest plantations with the optimal tree species would greatly improve the ability of forestry to compete with alternative land uses. If forests make sense at all as a land use, then converting indigenous forests to improved forests is desirable, subject only to the constraints dictated by tourist development, preservation of examples of primitive ecosystems, and the pace dictated by finances and organizational capacity.

4.43 Forests are better able to sustain themselves without government intervention in the less-settled parts of the Highlands, in Zones E and 5 of Zaire. As population grows, however, they will become subject to the same pressures as the high altitude forests of Zones 1, 2,and 3; the same recommendations would then apply. Indeed, foresight suggests that they should apply before the forests of Zone 5 get to the present state of the forests of Zones 1 and 2, or, worse, of Zone 3, where they have disappeared.

4.44 In higher population density areas of the bean-banana-coffee areas (Zones A and C and, increasingly, Zones B and D too), and at the 1800-2500 m elevations of the densely settled pea-potato-tea zones (Zones 2, 1, 3, and, increasingly, 4), it appears that forestry simply cannot compete as a land use with cropping and/or grazing alternatives. If it does, it does so on steep and infertile land which has usually been rendered infertile by cropping and grazing. Therefore, in these regions, such permanent tree cover as remains will and should be around houses and along field boundaries. Governments should encourage such plantings by arranging to have tree seedlings produced and sold widely. (Rwanda is already doing so). Extension services should demonstrate and encourage planting trees on contours. Further experimentation on appropriate species for different conditions, such as that now taking place at Nyabisindu, is desirable.

4.45 Tea is valuable as a soil conservation and anti-erosion crop at high altitudes and on very steep slopes. While market conditions and the efficiency of organization of local tea industries will determine its spread, its virtues for soil conservation should be recognized. Extension should encourage individual small growers to plant tea, further integrating it into their farming systems. Tea can often be an effective rehabilitation crop on steep hillsides that are so acid and aluminum-toxic that they cannot otherwise be reclaimed.

4.46 Bananas can play much the same soil-conservation role as trees and tea at the 1400-1800 m elevations of the bean-banana-coffee areas where most Highlanders live (with the proviso that they require much better soil than trees or tea). They already do. Their soil conservation role could be enhanced by interspercing them among other crops and planting them along contours as part of anti-erosive hedges and bands.

4.47 Annuals and grasses for soil cover. Most of the farmed land in the Highlands (and most of the land in the densely-settled parts) is used to grow annual plants: beans, peas, sweet potatoes, cassava, potatoes, sorghum, maize, et al. Prospects for switching the basic economy to agro-forestry based on breadfruit trees or the like are remote at present. (However, for prospects for deriving more food from bananas by switching from beer bananas to cooking bananas, see paras 4.104-4.106 below). Therefore, most farm land will go on being devoted to annuals.

4.48 Their difficulty from a soil conservation point of view, is that a) they leave soil exposed during the dry season, so that direct sunlight and resulting high soil temperatures acelerate decomposition of soil organic matter, and b) they have just been planted when the autumn rains are at their most severe, so that they do not cover the soil. This soil exposure is the principal source of erosion, which is limited by the small size of plots so that gullies do not usually develop, but which is happening and is severe nonetheless. These major problems could be solved by growing annual plants that cover the itongo plots during the dry season and into the autumn rains, while allowing the autumn season crops (mainly beans) to emerge before disappearing. They could be made less severe by growing annual crops or combinations of annual crops that cover better.

4.49 The worldwide pattern of intensification of temperate zone and subtropical agriculture has been from bush fallow through spontaneous grazed fallow through planted grazed fallow (leys) to continuous cultivation. Tropical areas, including notably Zones A and 2 in the Highlands, often move from spontaneous grazed fallow to continuous cultivation, skipping the stage of leys. This is probably because, tropical plant growth being so vigorous, getting rid of the ley when it is time to plant crops again is a major chore, particularly without mechanical aids 31/.

4.50 For Zones A, C, and 2, where pasture is practically absent or soon will be, increasing cover using annuals involves using crops that will cover through the dry season and into the first rains. The best hope at present would seem to be the sweet potato. Experiments at ISAR Rubona show that a number of varieties can be planted towards the end of the spring rains, and will survive and continue to provide cover during the dry summer. Varieties differ widely in ability to cover and are being selected for this characteristic or could be. Sweet potatoes are uprooted for harvest. Ideally, techniques could be found for planting beans and/or maize into nearly-mature sweet potatoes, which would be harvested after these crops had established themselves, but such farming systems appear to be far from worked out. (Indeed, no such research is now going on, except for ISAR/Rubona's efforts to select sweet potatoes that cover better).

4.51 Of course, given the importance soil cover, the main season annuals: beans, maize, sorghum, etc. might be selected with covering properties being one of many in mind. Covering ability has long been a selection criterion for groundnuts because dense stands resist an important disease better. It could be for other Highland annuals because of the importance of soil cover.

4.52 For less densely-settled zones, the problem is different. Where fallows are long enough, as in much of Zones E and 5, perennial bush provides cover. In the in-between zones, fallow is increasingly limited to grasses 32/, rather than woody plants as fallows get shorter. Grasses can

---

31/ See various works of C. Kevers in the Bulletin agronomique du Congo Belge in the 1950s and notably C. Kevers & P. Ostyn. "Les cartes d'utilisation des sols dans l'Est du Congo Belge", Bulletin agronomique du Congo Belge (1955), Vol. 46, pp. 1361-1366. Classification also used in M. Carael, G. Tondeur & W. Wils. "Le Kivu montagneux: surpopulation, sous-nutrition, erosion du sol", Les cahiers du CEDAF, No.2-3, 1979, 73 pp.; see p.7.

32/ Wils, Carael & Tondeur, Op. cit.

be either a very good cover and soil conserver or an extremely poor one, depending on the state of the grasses and on the species.

4.53 At one extreme are the severely over-grazed Eragrostis Olivasia grasslands of the Bututsi. These grasses survive on the extremely poor soil to which these hills have been reduced by overgrazing and overexposure, but their cover is not enough to prevent serious erosion. They are mixed with no pasture legume that might improve these soils by fixing nitrogen, and no known pasture legume will grow under these conditions. Consequently, soil organic matter is very low, acidity, aluminum toxicity, and erosion very high, most soils will not support crops, and livestock carrying capacity is exceptionally low; on the really run-out soils, 50 kg of live weight/ha. Attempts to plant soil improving grasses and legumes on these lands (at ISABU/Luvyrondza) have all failed to date.

4.54 At the other extreme, notably in the Zone of Masisi (part of Zone 2), there are extremely lush pastures of Kikuyu grass mixed with white clover that manifestly provide excellent soil cover, reduce erosion to negligible amounts, fixing enough nitrogen to maintain nitrogen levels and permit a much higher carrying capacity than in Zone 3. Those pastures are easy and cheap to establish. These high quality pastures have three important characteristics. Firstly, they are not overgrazed; the stocking rate is adjusted to the carrying capacity. This is so because, invariably, they are fenced and controlled by a family, small group of relatives or a company, with an exclusive interest in the land in question. Secondly, they are all over 1800 m in elevation. Kikuyu grass does not thrive below that altitude. Thirdly, they are pretty much limited to rich soils of recent volcanic origin.

4.55 Are high quality, soil conserving pastures possible in the Great Lakes Highlands where these three conditions do not obtain? As regards the first condition of exclusive control by a small group of users, the mission believes that they are not possible. (Further discussed below at paras 4.141-4.142). Below 1800 m, no similarly proven pasture cover exists, although the FAO livestock project in Goma is working on combinations of Bracharia grasses and Stylosanthes legumes. Outside Zone 2 (recent volcanic soils), the Kikuyu-clover combination is much less used, but there are examples of fenced, large, private cattle farms in Zaire in Zone 5 that prove that the technology is not entirely limited to Zone 2. This extendability is important because it seems likely that, attracted by the excellent soils, farming will expand in the Masisi, Buito, and Buisa -- the Zairian parts of Zone 2 -- until it reaches the population densities found on the Rwandan side. This process will slowly but surely eliminate pastures from Zone 2.

4.56 Annuals for cover recommendations. Dressler and Neumann confirm 33/ that use of annuals and combinations of annuals that would improve soil cover and improve soil conservation in the Highlands is far from being worked out. This ought to be a research priority. Research would explore annual covers during the dry season and through the establishment of the annual crops during the autumn rains; selection of annuals for early and more complete cover; and annual crop associations for improved soil cover and other aspects of soil conservation. For less populated areas where pasture is still prevalent, agrostological research is needed on soil requirements for the Kikuyu-clover combination, and to find a similar combination with equivalent ease of establishment, ability to sustain itself and good nutritional qualities for the 1400-1800 m altitudes. Also, by whatever means, pasture tenure should be apportioned to users in small groups.

4.57 Contour ditching. In colonial times, major efforts were directed to seeing that the farmers practiced soil conservation by digging anti-erosion ditches where the authorities judged that it was needed. The rule was that ditching or terracing was needed for slopes between 15 and 25%; that slopes between 25 and 45% were suitable for grazing but not for cultivation, with slopes over 45% for forests only 34/. If ditching is used at 15-25% slopes and if there is enough land to fallow annual crop land two years out of five, then there is no long-term loss of soil fertility 35/. During colonial times, such ditching was generally enforced, and during most of colonial times, population density was low enough to permit the needed fallow almost everywhere in the Highlands.

4.58 Since independence, the cumulative effects of population growth have virtually eliminated fallows from much of Zones A, 2, and C. Slopes over 25% are now cultivated. And, throughout the Highlands, farmers have shown little enthusiasm for maintaining contour ditches, let alone digging new ones. This is accepted by all and is evident from a casual inspection.

4.59 Why? Making or even maintaining contour ditches is a laborious process. Before farmers were free, they could be ordered to dig without worrying about farmers thoughts about the reservation price of family labor. Now that farmers have more freedom to decide how to allocate their labor, many of them show that they believe that the benefits to be gained

---

33/ Op. cit.

34/ Wils, Carael & Tondeur, Op. cit.

35/ Ibid.

from the ditches (appropriately discounted to the present for comparative purposes of course) are not worth the work involved. In 1983, it makes little sense to explain farmers' non-maintenance of ditches as an emotional reaction to colonial oppression. Farmers have a pretty good idea of the cost in labor of digging and maintaining ditches. But do they have accurate information about the benefits of contour ditches?

4.60 Contour ditch recommendations. The mission believes that past recommendations about ditching were somewhat facile, stop-gap measures recommended to attack an urgent problem but never supported by adequate research on costs and effects. Unless research can demonstrate that farmers perceptions are wrong, it would be wise to use contour strips (below) insted of ditches. Proposals like that now being advanced by the FAO in Rwanda for extensive mechanized ditching in Zones 1 and 2 should be subjected to careful scrutiny on technical, economic, and financial grounds in the light of what farmers' behavior suggests.

4.61 Contour strips are easier to build and maintain than ditches. If they are then devoted to useful crops, cultivating the crops can also serve to maintain the strips. Indeed, often it gradually turns them into mini-terraces. Therefore, they require less farm labor; if properly used, they can probably achieve all the soil conservation that ditches can, and sometimes more.

4.62 Under what conditions are strips effective? And how can they be made most interesting to farmers, because strips are also frequently neglected, through less so than ditches? For strips to be effective, the plants growing on strips have not only to provide cover for the strip itself, thereby breaking the force of raindrops and preventing erosion on the strip. They must also have a dense ground cover to catch soil dislodged on and eroded from annual crop fields above them before it gets any farther. Thus, not all plants that conserve soil and prevent erosion where they grow are good enough for contour strips. Tea, for instance, covers well, but leaves bare soil underneath and cannot catch soil eroding from other plots above.

4.63 Grasses form a dense ground cover. They were the plants recommended for contour strips in the colonial period and are still today. Setaria, Tripsacum, and Pennisitum purpureum are the most common grasses used. They are cut and used as mulch for coffee, as fodder, as roofing material or, in the case of Pennisitum purpureum, for staking pole beans. This system is satisfactory as erosion control. It is practiced spontaneously by farmers in parts of Zones A and C where population density is quite high. Notably, in Gisenyi Prefecture, where farmers have switched from ground beans to pole beans to increase yields, Pennisitum purpureum is quite common. Nevertheless, grass contour strips face difficulties, particularly as population density mounts.

4.64 Land devoted to grass strips is lost to food and cash crops. The grass has a value, but, as Dressler and Neumann have noted (see Para 4.18 above), under the high population densities of Zone A, dedicating fields that might produce food or cash crops to producing mulch or fodder is not profitable to farmers. This doubtless accounts for the quite common sight of abandonned contour strips in densely-settled hill zones where some kind of protection against erosion generated by annual cropping is clearly urgent. Additionally, although grasses can be grown continuously on the same spot, they, like annual food crops, use soil nutrients without replacing them. Soil fertility declines under this system and grass yields decline too. In short, intensive use of grasses for fodder or mulch would require either inputs of fertilizers, organic or chemical, or fallowing to sustain high yields and soil fertility, just the way most other crops do. And if producing mulch and fodder is not profitable in Zone A, intensifying that production by using manure and/or chemical fertilizers is likely to be even less so.

4.65 Is there a superior alternative to grasses for contour strips? A desirable alternative would have the following characteristics: produce something of value to the farmers; have deep roots to tap deep soil fertility missed by annuals and grasses and to improve soil tilth; fix nitrogen; and not compete too much with adjacent crops.

4.66 Contour strip recommendations. Research is underway for alternatives to grass, with the Nyabisindu Agro-forestry Project concentrating on trees and two IDA-financed projects (Kirimiro in Burundi and Lakeshore Coffee and Foodcrops in Rwanda) working principally on legumes. Bushy legumes like pigeon pea (Cajanus cajan) and nitrogen-fixing trees like black Wattle and Leucena leucocephala [36/] can provide fodder and firewood which should be increasingly in demand in the most densely settled areas. Pigeon pea is a valuable food, but not yet one that Highlanders appreciate. Use of these and other plants (e.g. Calyandra eulothyrus) has already been shown to be technically feasible [37/]. What remains to be ascertained is the acceptability of these plants to farmers. To that end, trials under farmers' conditions are a priority. Researchers

---

36/ The latter thrives only up to about 1500 m.

37/ See P.K.R. Nair. Some promising agroforestry for hilly and semi-arid regions of Rwanda. Nairobi: ICRAF, 1983.

at the Nyabisindu Project know that shade from trees planted in fields severely reduces maize and sorghum yields. Before planting these species, farmers will want to know by how much. 38/

4.67 Nitrogen-fixation is not just valuable on contour strips or as part of other soil-conservation measures discussed above, but in its own right. As agriculture becomes more intensive, the off-take, particularly of nitrogen and phosphorus, exceed natural replenishment, reducing soil fertility and yields, unless compensatory action is taken. There is something a farmer can do to increase available nitrogen short of using fertilizer (or getting lightning to strike his field). Principally, it is growing nitrogen-fixing legumes, and, as the models of Chapter 3 show, Highland farmers in the populated zones already do quite a lot of that. For a culture already so much based on the bean, exhortation to grow more legumes would seem superfluous.

4.68 Nevertheless, worldwide, research on grains has been making more dramatic progress than legume research; the same is probably now occuring with tubers. As average grain yields have surged, while legume yields have not, there has been a shift from legumes. In South Asia, this is documentable; the result is more food than before, but not as good a balance between food energy and food protein. The same shift is not documentable in the Great Lakes' Highlands due to lack of adequate statistics, but it is probably occuring. And this despite the fact that available "improved" varieties of maize, potatoes and cassava are not that dramatic, because researchers really have nothing to offer in the way of better beans and peas. Very little effort has been made in the Highlands in bean and pea improvement.

4.69 Where population density is highest, there may be a case for nitrogen-fixing trees that will both provide fuel and improve soils by not only fixing nitrogen, but also bringing deep nutrients to the surface and improving tilth. Where population density is lower, thus where there is still room for fallow and grazing, nitrogen-fixing plants can make the fallow shorter and/or the grazing better, as with the Kikuyu-clover association in the Masisi in Zone 2 already discussed (see Para 4.55).

4.70 Nitrogen-fixing crops recommendations. Improved beans and peas for farmers' conditions should be a research priority. The interactive effects of nitrogen-fixing trees and crops should also be a priority (as mentioned above). And so should the search for appropriate leguminous cover crops for fallows and/or grazing.

38/ For a summary of what is already known, see T.H. Zeuner & J. Neumann. "Contribution à la réunion du groupe forestier national, Projet Agropastoral Nyabisindu." 1981.

4.71 Beyond conducting research, there is little public authorities can usefully do with respect to nitrogen-fixing crops. Farmers are already growing leguminous food crops in quantities appropriate to their demand and to the yield potential of available varieties. At elevations over 1800 m where there is enough room for long fallows and/or permanent grazing and where soils are reasonably rich (i.e. the Masisi in Zone 2 and most of Zone 5, the Mitumba Range), use of Kikuyu-clover pasture is already expanding. Government could play a useful role in propagandizing this innovation and in helping to make clover seed more available. Throughout the Highlands, more farmers might try pigeon peas if seed were more readily available.

4.72 Green manure (with recommendations). Researchers and missionaries sometimes tout green-manure as an answer to soil-fertility problems. There is no doubt that a green-manure crop, grown in place of uncontrolled fallow on run-out soil and subsequently turned under, will restore soil fertility much more quickly than traditional methods, also improving tilth and adding to available nitrogen. This is especially the case where a legume like stylosanthes or crotelaria is used. However, while this operation may be practical for a research station or large farm with mechanical implements, the labor requirements for farmers who must turn and bury the green manure with a hoe are prohibitive. While there are no farm-management studies to prove this, we believe that farmer behavior is conclusive proof. High labor requirements seem to exclude such practices for hoe farmers even where uncontrolled brush fires are not practiced.

4.73 Chemical fertilizers. Very little fertilizer indeed has been used in the Highlands area, and almost all of that little bit on coffee and tea. Use on those crops is clearly economic in many Highlands' circumstances, particularly in the case of tea, where it is indispensable for reasonable production levels. Use on food crops is confined to the trials of the FAO Fertilizer Programme in Burundi and Rwanda. The Burundi program has been going since 1972, longer than that in Rwanda, and has progressed to the stage of selling small quantities to farmers for use on food crops through a farmers' cooperative in Gitega. It was anticipated that farmers might be reluctant to pay cash for an input to a crop that would be eaten and, hence, would not generate cash income. However, demand has been very strong. Apparently, farmers recognize that fertilizer use on food crops is an attractive proposition and sell part of their food-crop production to finance fertilizer purchase. The fertilizer price is subsidized by the Burundi Government, in spite of the fact that demand clearly far outstrips supply at the prices practiced. As a result, fertilizer is allocated to farmers who meet all the other standards of good cultural practices as perceived by extension workers: keeping a compost pile and using organic manure; mulching and pruning coffee trees; and maintaining contour strips and anti-erosive ditches principally. Thus the attractiveness and scarcity of fertilizer has been used as a tool to get other, less-popular extension themes accepted. This FAO program has now been taken over by the IDA-financed Kirimiro Rural Development Company (SRD).

4.74 Is fertilizer use on food crops economic in the Highlands? A number of policy statements, including several recent Bank documents, assert that, largely because of high transport and handling costs from East African ports, it is not. However, to our knowledge, there is no empirical justification for these statements, nor have any of the policy statements attempted to quantify the costs and benefits of fertilizer use in the Highlands.

4.75 The only attempts to analyse the economic and financial profitability of fertilizer use on food crops in the Highlands are the trials carried out by the FAO Fertilizer Programme in Burundi and Rwanda. Trials are carried out on the fields of progressive farmers who already use compost and manure. They have been carried out on a wide variety of crops: sorghum, maize, beans, peas, wheat, soybeans, among others in Burundi; and those plus potatoes in Rwanda. The results indicate that fertilizer use on food crops is economically and financially viable under a number of conditions. In sum, a) use of phosphates pays on legumes, but nitrogens do not, b) use of nitrogen and phosphate pays on grains and sometimes on tubers, even in relatively poor soils, and (presumably) in areas close to markets for these crops, c) in Zone 2 (Volcanic Highlands), use of phosphate pays, but nitrogen does not, and d) there is no demonstrable response to potash. Details are available in the FAO Fertilizer Programme annual reports for the two countries 39/.

4.76 It stands to reason that fertilizer use on food crops, which was traditionally not economic in the Highlands, has probably become so. In real terms, the world price of fertilizer has fallen dramatically over the past century and over the past two decades. And, during the same time frame, substantial parts of the Highlands have reached the stage of agricultural intensity where, without fertilizer, soil fertility is reduced to a low-fertility equilibrium, or further to a level where agriculture cannot be sustained at all. Costs of fertilizer delivery from Mombasa or

---

39/ While the annual reports (available from Fertilizer Programme, FAO, Rome) are the most complete source of information, the most comprehensive single source, despite its 1980 date (!), is: Programme des Engrais et des Intrants Annexes (Phases I et II). Burundi: Conclusions et Recommandations du Projet. Rome: FAO, 1980, 121 pp. (AG: GCPF/BDI/014/BEL Rapport Terminal).

Dar es Salaam to Highland farm are very high --probably higher than the cif East African port price of the fertilizer. But the responses, at least where composting and other soil-improvement techniques are already used, appear to be high enough to offset this high cost. The Kasai Oriental in Zaire presents a similar case, where high responses and high foodcrop prices easily outweigh the high cost of fertilizer.

4.77 Governments already painfully short of foreign exchange cannot unambiguously welcome the prospect of a new demand for imports. The Rwandan Minister of Agriculture, when discussing the possibility of having to start importing fertilizer and hybrid maize seed with the Mission, noted that it would probably come to importing these or importing food, which would be far more expensive. Nevertheless, the foreigh-exchange constraint should be recognized by eschewing subsidies and selling fertilizer at least at a price that fully costs its foreign-exchange cost, recognizing the overvaluation of the currency if any. Such a policy would make sure that fertilizer use was confined to situations where it really does pay, financially and economically.

4.78 There are various proposals to produce fertilizer in the region in lieu of importing it. The closest to commercial feasibility appears to be making phosphatic fertilizers from Burundi's Matongo deposits. Feasibility is now being studied with IDA financial assistance. High energy costs of benefication are a problem.

4.79 <u>Fertilizer recommendations</u>. In view of foreign-exchange constraints in all three Great Lakes Highlands countries, fertilizer should be priced to reflect its full, real foreign-exchange cost, thus preventing its use where it is not economically justified. With such a policy, price would severely restrict demand. But with such a policy, traders and projects should be allowed freely to import fertilizers for use on any appropriate crop. Farmers and projects would then be free to find out the circumstances under which fertilizer use pays, whether on food or on cash crops. More projects could promote fertilizer use while, at the same time, using fertilizer to promote other desirable farming practices, as the Kirimiro and Buyenzi SRDs in Burundi already do.

4.80 <u>Manure and compost</u>. Those who assert that chemical fertilizer is too expensive for Highlands' farmers urge them to rely on locally available manure and compost to replenish soil nutrients. Great Lakes Highlands' farmers do use manure and compost. The fertility of fields immediately around the rugo shows it. On the volcanic soils of Rwanda's Zone 2, farmers practice an elaborate system of cultivation that amounts to composting. Farming is done on broad-bed ridges (usually horizontal); plant residues are placed in the ditch between the ridges and next year's ridges formed by hoeing the lava soils to where last year's ditch was. This may not be an ideal composting system, for decaying plant residues will first reduce available nitrogen before increasing it when they are "ripe" as compost, but it is a way of adding to available nitrogen and soil humus and improving tilth that uses labor quite efficiently.

4.81 Most of the Highlands' farmers are not so diligent in using composting and manure as the baKiga of Rwanda's zone 2. If the value of the practices is widely recognized, what is surprising is that average techniques are not better. Manuring and composting are an important part of the official extension themes in Rwanda and Burundi, a part of the "fermette" concept, so that diffident adoption is not for want of official exhortation. Most likely a part of farmers' lack of enthusiasm for the practices stems from tradition; until recent years, population density was low enough that fallowing would do the job. And then, non-hoe-farmers should remember that collecting manure and composting it and plant residues and household wastes and distributing them are extremely labor intensive and dirty jobs. A man or woman who carries a 20 kg. load of manure to the field adds less than half a kilogram of available nitrogen, part of which will escape into the atmosphere before his crops can use it. Distributing less than one kilogram of urea would add as much nitrogen, though it would do less than the manure for soil tilth. And collecting manure or plant wastes to a central point is extremely labor-using under present farming and livestock systems, except in the rare instances where goats are stall-fed (see Para 4.132, below). Recommendations that fail to calculate the return to incremental farmers' labor do so at their peril.

4.82 Recommendation for manure and compost. There is little to add to the present official enthusiasm for composting and manure use, except a plea for understanding of the reluctance of the man or woman who carries the residues to do all that the extension messages urge. Since organic manure and chemical fertilizer are clearly synergistic, it seems wise to promote their use together and, ultimately, to allow farmers to decide on the combination they prefer.

Changes in Cultural Practices of Existing Crops

4.83 Mulch coffee. This common extension theme has been discussed above at Paras 4.12-4.25.

4.84 Prune coffee. There is universal agreement that pruning coffee trees improves yields. There are some different theories about the optimal method of pruning, and these are not academic, but following any one of the recommended pruning regimes would give an appreciably better result on virtually all Highlands' coffee farms than they obtain now. Evidence from IDA Highlands' projects that deal (inter alia) with coffee (Ngozi and Kirimiro in Burundi, Lakeshore Coffee and Foodcrops in Rwanda) indicates that output improvements are significant.

4.85 Why don't Great Lakes Highlands' farmers prune their coffee trees as the experts recommend? In other instances, we have argued that experts failed to take account of the value farmers' assign to their own labor. This is less likely to be the case for coffee pruning. The work is not onerous. It can be done at any time over a long period following harvest. Figures are lacking, but returns per day of labor must be high --higher than the reservation price of all but the most self-indulgent farmers. And the capital investment in a pair of pruning shears is minimal compared to the investment in the trees. The only reasonable explanations are: failure to recognize the value of pruning, or non-availability of shears, or confusion over how to prune and/or which system to use.

4.86. Coffee-pruning recommendation. The economic and financial viability of this cultural practice is proven beyond doubt. Farmer reluctance to practice it stems from ignorance of its beneficial effects or of how to do it. These circumstances are a clear mandate for extension. Care should also be taken to assure that pruning shears are actually available for purchase.

4.87 Improve coffee cover. As agronomically adequate mulching becomes more and more expensive and less and less likely to be carried out, it becomes more important to find substitutes for mulching. The purposes of mulching are to inhibit erosion, to suppress competing vegetation, and to lower soil temperatures. These purposes can be partially achieved by increasing the extent to which the coffee trees themselves cover and shade the soil. ISAR Rubona has been working on planting coffee trees closer together, with or without use of dwarf varieties. Results are not definitive enough to warrant their use in extension. However, such trials recognize that most Highland farmers will be growing their coffee with small amounts of mulch, so that varietal selection and cultural-practices trials do well to take this into account. (Alternative approaches through inter-cropping are discussed at Paras 4.109-1.112 below; also see Para 4.39).

4.88 Coffee-cover recommendation. Research should continue to find ways of improving the ability of coffee trees to shade and cover, thus reducing the amount of mulching required, through increasing stand density and use of dwarfs.

4.89 Spray coffee, with recommendation. The mission finds that there is ample evidence that disease control on coffee can be effective and economic. Failure of most farmers to adopt this practice presumably stems from a) failure to appreciate the beneficial effects of treatment, b) non-availability of pesticides and applicators in many areas, and c) probably, in some instances, shortage of cash to purchase products and to rent or buy sprayers. The first constraint is a mandate for extension. Lack of strong demand probably aggravates constraints b) and c), making traders and government authorities reluctant to import the necessary products, and farmers less likely to seek financing from friends and relatives. While interventions in the credit and marketing system might help overcome the constraints, the mission feels that extension is paramount.

4.90 Sweet potato cover, with recommendation. The potential use of sweet potatoes to bridge the dry season, covering the soil when the fall rains arrive, was discussed above at Para 4.50. ISAR Rubona's work on sweet potato selection for better cover and drought resistance should be continued.

4.91 Improved maize varieties. Maize is now the most important cereal crop in the Great Lakes Highlands, and its importance is growing still relative to sorghum, the traditional grain. The exception is the densely-settled High Plateau -- the cradle of Highlands' civilization -- where sorghum still reigns; ironically, it is this area which has, agronomically, the highest potential for maize, but the other areas where maize is grown also have high potential. Some of the highest- potential maize lands are the lower altitudes of the higher-altitude zones (1,2,4 and 5) and the upper altitudes of the lower-altitude zones (A,C,D and E). These areas are very similar to the "high-potential" maize zones in Kenya. Yet Great Lakes Highlands' farmers' average yields are just over one ton per hectare, while average maize yields in Kenya's high-potential zone are 3.5 T/ha. The generalization of these high yields in Kenya is a recent phenomenon dating from the mid-1960's and closely associated with the diffusion of Kitale maize hybrids [40], which have yield potential of 8-10 T/ha when optimally cultivated.

4.92 Maize seed used by Highlands' farmers is preponderantly saved from the previous harvest. The variety available from research stations and seed multiplication services and hence sometimes through extension services in Rwanda and Burundi is bambu, originally bred at the Ndihira INEAC station in the (then) Congo before 1960. Bambu has impressive yield potential, though significantly below that of Kitale hybrids and synthetics; however, most of the "bambu" that reaches farmers comes from degenerate breeding seed which has been multiplied and handled improperly, so that it is not remarkably better than "traditional varieties". Only the most summary and unsystematic attempts have been made to try Kitale maize material at Highland research stations, and these usually at the wrong altitudes and rainfall conditions. French and Russian hybrids have been given more extensive trials by ISAR, but they have proved poorly adapted to East African conditions.

4.93 Maize-trial recommendation. It seems obvious that greater efforts should be made to conduct adaptive trials of existing maize varieties that are adapted to areas with conditions identical or very

---

40/ Of course, spread of hybrids has been associated with increased use fertilizer and better husbandry practices, and was used to spearhead extension of these practices. For more information, see John Gerhart, The diffusion of hybrid maize in Western Kenya: abridged by CIMMYT. Mexico: Centro Internacional de Mejoramiento de Maiz y Trigo, 1975. Also see W. I. Jones, "Small farmers and the green revolution in Kenya," African Economic History, No. 4, Fall 1977, 182-4, and "Kenya's maize hybrids: effects of their introduction -- a preliminary statement," Nairobi: Institute of Development Studies Discussion Paper, 1972.

similar to those of the Great Lakes Highlands. The effort required would be modest. The probability of success in isolating varieties that could be multiplied and sold to farmers in only a few years is high. Such an effort is presently planned in Rwanda and is a candidate for financing under the International Fund for Agricultural Development's Birunga Maize Project. and/or under the IDA-financed National Agricultural Research Project. Prior to such trials, it would be premature to recommend improved maize varieties to farmers (although some baRundi farmers around the ISABU Kisozi station are growing Kitale synthetics against the recommendations of the station, coping with their 10-month growing season by interplanting with beans.)

4.94 Improved potato and cassava varieties. The new potato varieties already released and soon to be released by the National Potato Improvement Program (PNAP) in Ruhengeri [41]/are dramatically superior to their predecessors in both yield and disease resistance. Some of the new cassava varieties now being released by the National Cassava Program (PRONAM) at Mvuasi [42]/,Bas Zaire are likely to prove adapted to Great Lakes Highlands conditions.

4.95 Potato & cassava variety recommendations. Highlands' farmers who can grow potatoes are well advised to use the new varieties. Adoption is occurring very rapidly as they become available. The system in Rwanda of multiplying them through projects and through entrepreneurial "paysans multiplicateurs" is working well. But the crop also merits re-introduction to the "numbered" zones of Zaire and Burundi where it was once grown (see Para. 3.15). This could probably be accomplished with a modest multiplication and extension effort. Most of what needs to be done would be covered by International Potato Center proposals for a PRAPAC, involving the three countries and, perhaps, Uganda as well. New cassava varieties from PRONAM require more local testing before they can be extended with confidence. The Highlands' research stations of INERA, ISABU and ISAR ought to be able to handle this task, possibly with coordination through the three-country regional Agronomic and Zootechnic Research Institute (IRAZ) in Gitega. Once varieties' suitability is confirmed, as with potatoes, multiplication and distribution of cassava cuttings is not likely to be a major task.

4.96 Potato fungicides. Agronomic evidence and farmer behavior in the Rwandan part of Zone 2 indicate that fungicide application to potatoes is highly profitable. Fungicides are difficult to come by; smuggled in from Uganda, they cost double or more what they would cost if supplied through more normal channels. IDA's recent appraisal mission of the Birunga Maize

---

41/ Assisted by the Centro Internacional de la Papa, El Molina, Peru.

42/ Assisted by the International Institute for Tropical Agriculture, Ibadan, Nigeria.

Project, slated for IFAD financing, estimates that the average potato farmer, by expending $6 to rent an applicator for 6 treatments and $108 for 14.4 kg. of fungicide, plus 10 days of labor to spray his potatoes, would increase his production by 6.16 T worth $493 at current farm prices. The family would also have to provide an additional 59 days of labor to harvest and store the incremental production, but clearly the effort and expenditure would be amply repaid, even if the price of potatoes fell considerably, which it undoubtedly will as new varieties and fungicide use continue to spread. The current benefit/cost ratio -- 2.7 -- is similar to that for fertilizer use found in FAO Fertilizer Programme field trials.

4.97 Potato-fungicide recommendation. Farmers should be encouraged to use potato fungicides. This could best be accomplished if national authorities would allow commercial import of sprayers and fungicides. Eschewing subsidies and allowing commercial margins would assure that potato fungus control was practiced only where it actually pays to do so. In Rwanda, the TRAFIPRO cooperative, the largest commercial firm in the country, has already expressed interest in marketing fungicides and sprayers through its shops in Zone 2. Similar developments might prove more difficult, though not impossible, in Burundi and in Zaire. Financing the high initial cost of the practice would prove to be a major problem for most potato farmers, particularly in Burundi and Zaire where, in practice, there is no formal credit available to small farmers. In Rwanda, there is no apparent reason why the cooperative People's Banks, already established in numerous communes of the potato-growing area and with an excess of savings over loan demand, could not finance such operations. After the initial season, potato fungus control should obviously be self-financing.

4.98 Improve marsh cultivation. Planners and foreign advisers often speak of the importance of improving marsh cultivation (principally in Zone A). By the mission's observations, the standards of cultural practices in existing marsh cultivation are high; the selection of crops appears to be rational. Their importance could be seen from the Zone A model above. Although these marshes have been developed "empirically" without aid from engineers or agronomists, the mission has not heard any convincing suggestions as to how their productivity could be improved (unless, see Para 4.99).

4.99 Multiple-crop marshes. Marsh cultivation, as now practiced, is excellent within the constraint that marshes give only one crop per year with cultivation in the dry season only. If these heavy but rich soils could be double or triple cropped, the impact on agricultural output and family income in Zone A would be considerable. That would mean that marsh-cultivation would compete with itongo-cultivation for labor in the two rainy seasons. Whether or not the returns to farming labor are higher for marsh-cultivation than for itongo-cultivation (and the facts are not obvious), there would be labor for marsh cultivation in the rainy seasons because Zone A farms are small and there is redundant labor. While there must still be a reasonable return to such labor to interest family members in working, the redundancy will clearly increase over time as population grows and farm sizes decrease.

4.100 Apparently the principal reason marshes are not now cultivated in the rainy season is that they flood, and there is no water control. There may, however, be other reasons as well since not all marshes flood. Perhaps labor demand from itongo-cultivation is a factor. Since the opportunity cost of farm labor is lowest in the dry season, it is reasonable that the laborious job of developing and cultivating marshes should be done first at that season.

4.101 Moved by the considerations mentioned in Para 4.99, Burundi and Rwanda have tried to develop marshes with the help of "modern" techniques in conjunction with French FAC to intensify cultivation and multiple cropping. In both cases, these experiments have been costly failures. Once allowed to dry, the peaty soils of the marshes hardened and became unfarmable. To date, there have been no successful applications of foreign technology to Zone A marshes. Efforts continue, and a small FAO project in Bujumbura is monitoring them and seeking a solution to the problem.

Changes in Cropping Patterns

4.102 Thin banana groves and interplant beans. This intensifying innovation is being promoted with great success by the IDA-financed Lakeshore Coffee and Foodcrop Project in Kibuye (Rwandan Zone C). More impressive, it is being adopted spontaneously by Zone C farmers in Zaire without any urging from anyone. Traditionally, dense banana groves can usually be thinned out enough to let sunlight penetrate to the ground without reducing banana yields. At least, this is the case where there is no problem of wind damage to the leaves of the banana trees, more exposed after thinning out; strong winds shred banana leaves and interfere with conversion efficiency; this may be why the practice is more adopted in Zone C, which is completely encircled by mountains, than in Zone A. Also, of course, a thinned-out grove is not so effective as a dense one for soil conservation, including erosion control. Nevertheless, farmers can and do plant beans and often other crops as well within the thinned-out grove. Since, under most conditions and in Zone C at least, there is no diminution in banana production, the additional cultivation of beans and sometimes other crops is just like having additional land. As the models of Chapter 3 show, this is something that the farmers of Zones A, C and 2 badly need.

4.103 Banana-thinning recommendations. At least in Zone C, the attractiveness of this innovation is proved. In all probability, little extension is needed, since diffusion is occurring spontaneously, but extension would do no harm. Research efforts will be needed to find out whether banana groves can be thinned but without loss of production in Zone

A. Even if wind proves to be a factor, there will be locales where the gain in beans will outweigh the loss in bananas. Zone 2 and other "numbered" zones are too high and cold for bananas.

4.104 Shift from beer-bananas to cooking-bananas. In a sense, the 2.75% of the Highlands' farming calories and the 6.5% of its farming protein thatare lost in fermenting bananas into beer are a hidden reserve that could be tapped by growing different kinds of bananas and eating them directly. However, human beings do not buy nutrition; taste plays an immense factor in food consumption, and Great Lakes Highlanders are no exception. They value beer more than bananas just as the Scotsman values whisky more than barley. Driven to the wall of bare subsistence, however, Zones A, B, C and D have the capacity of changing to plantains or sweet bananas and increasing their food availability.

4.105 In some areas, like densely-settled Ruvabu and lower Rwerere communes just outside of Gisenyi, which are almost wall-to-wall banana groves and which have substantial banana-beer "exports", there has already been appreciable replacement of beer-banana trees with direct-consumption types close to the rugos as families aim to meet their own food needs. This innovation is being encouraged by the Prefectural agricultural authorities, which distribute free planting material of direct-consumption banana types. Elsewhere in the Highlands, from Zone E near Butembo to southern Burundi, farmers are aware of and grow small numbers of direct-consumption bananas.

4.106 Cooking-banana recommendations. No one should expect a rapid shift from beer-bananas to direct-consumption types, although a slow, secular shift is probably going on, particularly in the most densely-peopled and perhaps the most desperate regions below 1800 m. Extension is unlikely to speed the shift, since farmers are already well aware of the possibilities. Availability of good-quality planting material at district headquarters may have a marginal effect on the rate of change. Should a tax on banana-beer ever be levied, that too might provoke a significant shift at the margin.

4.107 Intercrop beans with grains. For all the intercropping Great Lakes Highlands farmers do, it is surprising that the intercrop that is the backbone of American Indian culture is relatively rare. One finds climbing beans climbing maize occasionally in Rwandan Zone 2, but beans are planted at the same date as maize. Consequently, they seriously compete with and reduce the maize yields, which would be much less the case were they planted a month later and allowed to ripen on the dead maize stalks after the ears had been removed. The practice may exist elsewhere in the Highlands, but the mission did not see it. One would expect to find grains used as poles for climbing beans wherever land is scarce, but especially at densely-settled altitudes over 1800 m., where the only beans that thrive are pole beans and poles are scarce.

4.108 Bean-grain intercrop recommendation. Maize is a relatively new crop to the Highlands, and current farming densities are new too. The mission suspects that Highland farmers have something to learn from Amerindian traditional bean-maize associations, further, that these innovations will be adopted first in Rwandan Zone 2 and will spread to other maize and sorghum areas later. But how this association will fit into local farming systems has not yet been worked out sufficiently to risk its extension. A priority under the proposed IFAD-financed Birunga Maize Project is to conduct just such trials and to extend the results.

4.109 Intercrop coffee with bananas, beans. This adaptation is spreading spontaneously in Zairian Zone C along the west shore of Lake Kivu. It is a response to the local situation, the key elements of which are low real coffee prices, (relatively) expensive labor, and presumably a shortage of mulch. Since Zairian producers' prices for coffee have been (at least until the recent devaluation) much lower than those in neighboring countries, it was less attractive to labor or to hire labor to mulch, to otherwise control coach grass, or to prune. Pesticide treatments were excluded by non-availability of the products. Farmers, therefore, sought a less intensive way of growing coffee, with lower yields, but also lower inputs. Pure-stand coffee, left unmulched, is invaded by coachgrass and dies. This is happening to most plantations in the Zairian Zone C because owners cannot or will not afford labor for mulching and other grass control.

4.110 When coffee is intercropped with bananas, beans, and/or other crops, yields are much reduced vis-a-vis pure stands. However, these associated crops control other competing vegetation. Bananas provide their own mulch; beans offer less-devastating competition to coffee than grasses do. And, you can eat bananas and beans.

4.111 The idea of allowing intercrops with coffee is shocking to officials in Rwanda and Burundi. There is a universal expectation that, if permitted to do so, farmers would interplant their coffee and neglect it to the benefit of the inter-planted food crops. This fear, in itself, is extremely instructive! Nevertheless, in Zaire, the practice has not led to abandonment of coffee cultivation, even in circumstances where the producer price is much lower than it is in Rwanda and Burundi. In fact, even under these circumstances, smallholder coffee in Zaire is clearly increasing, with a lot of new planting going on.

4.112 Coffee-intercrop recommendation. Therefore, coffee intercropping, especially with bananas and beans, clearly warrants more investigation. It may be that such intercrops, while giving less coffee per hectare, give higher overall returns to use of land and labor. They may, finally, represent the integration of Arabica coffee cultivation into Great Lakes Highlands farming systems, an integration which has heretofore been forbidden. And given that population densities will go on increasing for the foreseeable future, thus constantly making food production ever more attractive relative to coffee production as the Highlands head for a Geertzian agricultural involution, then allowing farmers to intercrop coffee might just make them willing to produce it at lower prices relative to food crops than they otherwise would. There would be less coffee per hectare, but there would be some. An innovation with such massive implications for the region's macroeconomy is worthy of research priority.

4.113 Expand sweet potato, soya, wheat. It is arguable that a number of crops that Highlands' farmers already grow ought to have greater importance than the farmers give them, not for the good of their countries, but for their own good. The prime candidates for these arguments, in the eyes of the mission, are sweet potatoes, soya, and wheat. Sweet potatoes are already a major crop and one that is expanding its place in farming systems as tubers replace grains and legumes in Zones A and C. In Zone A, it already exceeds beans in importance in the spring rainy season and is their equal during dry-season marsh cultivation, so it may appear superfluous to argue for expansion.

4.114 The argument rests on the sweet potato's drought resistance -- its ability, once its root is developed, to survive the dry season on itongo land, thereby providing cover as the fall rains set on. This is the time of maximum and serious erosion of itongo land in Zones A and C. Sweet potatoes may have the capability to cover and hold the soil until there had been enough of the new rains to get the newly-planted sorghum and other crops to the point where they could cover the soil. Then the sweet potatoes could be harvested. (See also Paras. 4.50 and 4.90). ISAR Rubona is screening sweet potato varieties for their ability to cover, but no farming-systems work is underway to try the integration of better-covering varieties into rotations. It should be.

4.115 Soyabeans are a crop so beloved of international plant scientists and missionaries that they usually receive a disproportionate amount of research and extension attention. Frequently it comes to light only afterwards that people do not like soya and that missionaries are the only ones that will buy it to put in those nutritious little cookies that they give out at dispensaries and schools. To the mission's surprise, soybeans seem to have been accepted into the local diet in several widely disparate parts of the Highlands. When asked how they happened to have started incorporating this new product into their alimentary regime, housewives and their husbands usually answered that what mission dispensaries gave out against mal- nutrition with such good effect must be good! This idea surfaced in Butare and Gisenyi Prefectures and in Beni and Kalehe Zones in Zaire.

4.116 Soyabeans do have nutritional virtues, and if there is demand for them too, their promotion by Governments and adoption by farmers may have useful effects. In the Highlands, a major obstacle to more rapid development of soybean markets appears to be milling them.

4.117 Wheat can thrive in Zones 1, 2, 4 and 5, but so do wheat diseases. Production problems are very much the same as those in the Kenya Highlands, except that wheat-potential areas of the Great Lakes Highlands are a bit more humid, and the mode of production is completely that of very small farms, as vs. mostly large, mechanized ones in Kenya. There is a little wheat produced in Zones 1 and 2, but only in Zone 4 (Butembo) has wheat really taken hold, and even there not on a large scale (see Para. 3.19).

4.118 Wheat production has not been a high priority for governments. World prices have been low, and a good bit of demand, especially in the case of Rwanda, has been met by food aid, which has no opportunity cost since, in practice, wheat donations cannot be converted into some other form of aid more stimulative of development. Consequently, until recently, there has been little official support for wheat farmers. National research institutes carry out their local trials in collaboration with CIMMYT-directed international comparative trials, but no more. For the Great Lakes Highlands wheat farmer, or potential wheat farmer, the principal difference in environment from that of his Kenyan cousin is not the wetter climate or the lack of mechanization, but the absence of a program of varietal imports and local comportment trials that would enable him to cope with ever-mutating rusts and other diseases.

4.119 Even in the presence of food-aid disincentives, there is now increasing official interest in stimulating local wheat production, especially in Zaire, where food-aid wheat is not significant relative to national consumption. In Ndihiro and Butembo, Zaire's largest grain mill, the private Minoteries de Matadi, is collaborating with INERA and CIMMYT to import promising wheat varieties, do comportment trials, multiply seed, and provide extension. In Rwanda, the ETIRU mill in Ruhengeri has now started a campaign to purchase local wheat instead of limiting itself to milling imported, food-aid wheat. Wheat will continue to be a relatively minor, specialty crop for most of the Highlands, but these developments offer more Highland farmers a chance to add wheat to their crop repertory. With a very small amount of coordination and guidance from an organization like IRAZ (see Para. 4.95), wheat varietal introduction and screening for the three countries could become much more systematic.

4.120 New crops. Great Lakes Highlands farmers have proved innovative over the past century and more in adopting new crops and incorporating them into their farming systems. Under the increasing stress of population pressure and of their countries' increasing appetite for foreign exchange, they will have to continue to do so to survive. The mission has picked a few crops which may hold promise.

4.121 Highlands' diets are particularly short on fats and oils. A plant that grows well, is rich in fat, and whose taste is particularly appreciated by Highlanders is the avocado. Proof is the high propensity of farmers to steal avocado seedlings from nurseries of the Lakeshore Coffee and Foodcrops Project. A larger public effort to multiply and sell seedlings would seem worthwhile.

4.122 Citrus seems to offer little promise, at least until a remedy is found to the tristessa disease, which virtually wiped out Highlands' citrus groves in recent years.

4.123 Tobacco is a crop that is both extremely labor-using -- an important consideration for the labor-surplus parts of the Highlands -- and technically demanding. Tobacco is grown on a small scale for local consumption, especially in the Rwandan Volcanic Highlands, where a public project also attempted to promote tobacco production for industrial processing, without success, and in Highland Burundi. Decent quality cigars have long been produced by a mission, but on an artisanal scale.

4.124 The experience of a large number of other countries suggests that the best way to get tobacco production going is to involve large, private-sector manufacturers in the promotion. Burundi is following this route, involving British American Tobacco. The interest of such manufacturers in the quality and price of the product leads them to take proper care in selecting the ecological niches where tobacco will do well, in advising farmers on proper cultural practices and harvest and curing -- all technically tricky matters. The world market for tobacco may be relatively weak, but there should still be plenty of room for Highlands' farmers to fill local demand and to enter that market in a small way, displacing producers from high-wage, high-income countries. Obtaining the participation of private-sector manufacturers seems the best way to do it.

4.125 Most macademia nuts are produced in Hawaii, a high-wage economy which has little scope for expanding production due to land limitations. Macademia nuts are a high-value, transportable product, able to support the high transport costs between the Great Lakes Highlands and the rest of the world. The world market for the product, though still small, appears strong. The trees have grown well at the ISAR Rubona station. In Malawi, tea estates at the lower margin of the altitude range for tea are diversifying into macademia. A large-scale farm at Thika in Kenya is successfully producing, but Kenya's disasterous attempt to involve smallholders in the 1960's should serve as a lesson of what to avoid [43]/. If this can be done, macademia might take a modest place alongside coffee and tea as a smallholder crop generating export earnings.

43/ The variety selected for smallholders grew well but was unmarketable. See A Report on the Macademia Nut Industry in Kenya. Nairobi: Ministry of Agriculture/Economic Planning Division, February 1973. Also, Lora Berg, "Cost/benefit analysis of proposed macademia nut farms for Meru, Kenya.", unpublished, Washington, April 1983.

4.126 Papaya is a minor Highland crop often grown around rugo to meet family demand; local hotels buy small quantities. Supplying the rich countries' markets for papaya poses formidable problems for the Highlands countries of transport and handling of this very delicate and perishable product. But the papaya extract, papayeen, is not perishable and has high value per unit weight, so that air freighting it to distant markets is economic. If processing and export can be managed, the production possibility is certainly there.

4.127 Before 1960, papayeen was extracted and exported from Beni Zone. The mission heard that firms have started up again in Butembo and Beni, but was unable to contact those involved. A British firm has started a papayeen operation in western Kenya. The possibilities would seem to warrant more investigation. Such an industry would be dependent on backward linkages to large numbers of small-farmer suppliers, who would be able to diversify their farms and add another source of cash.

4.128 Passionfruit (maracuja), cape gooseberries, and other fruits that are exotic for the rich countries grow well in the Highlands. Production possibilities exist if a regular and profitable market for the products could be developed. On this point, in Kenya, processer-marketers with sophistication and world-market knowledge well beyond that of any such operators in the Highlands have made a major effort to process and develop markets for such products, notably juice drinks incorporating passionfruit. Their success has been extremely limited. This should not discourage Highlands' country planners from trying to develop the production of these crops, their processing and export marketing, but they should avoid being overly sanguine about prospects.

4.129 Triticale, hops and buckwheat may have a future modest place in Highlands' farming systems in the higher-altitude, numbered, zones. If wheat can overcome food-aid competition to enlarge its place in Great Lakes Highlands' farming systems, so, perhaps, can triticale, the wheat-rye cross that is the first grain invented by man and the first addition to man's gamut of food crops for several millenia. Triticale is similar to wheat (and rye), but it is more tolerant of aluminous soils than they are [44]/, a characteristic of great interest in Zone 1 and even, just conceivably and at the margin, in Zone 3, the Bututsi. Varieties are under observation at ISABU Kisozi. The Highlands import hops for the rapidly growing "modern" beer industry. It might be grown locally. Buckwheat, a grain substitute, is grown on research stations and as a soil-restoring fallow by USAID at its Kajonde seed-production farm in Burundi. Like peas in the traditional "numbered"-zone rotations, buckwheat restores soil fertility while producing a modest output. However, the crop is not known locally and it is unlikely that there would be much demand. Nevertheless, these three crops deserve some research attention just because the ground has to be laid today for future diversification of farming systems.

44/ But new, highly-aluminium-tolerant wheats have been identified by CIMMYT. These segregating lines are being tested, inter alia, at ISABU Kisozi. If successful, they would remove the principal reason for substituting triticale for wheat.

4.130 Expand marsh cultivation. The process of "empirical" reclamation of marshes, principally in Zone A, has already been described in Chapter 3 and in Paras. 4.15-16 and 4.98-101. Seemingly, it is occurring quite rapidly and naturally and needs no public intervention to promote it. Presumably, when conditions are appropriate, the same development will accelerate in Zone B. It was reported to the mission frequently that land-rights' disputes hinder reclamation and development of marshes, but the mission was unable to verify this and was unable to see that such disputes had interfered with development in any macro sense. Nevertheless, if such allegations are based in fact, then public action to clarify usufruct rights in marshes might accelerate development.

Changes in Livestock System

4.131 Replace cattle with goats. As farming density rises and pastures shrink and disappear, Highland farmers are changing their herd composition in this way. The shift occurs despite the high prestige attached to cattle ownership. Other societies where large cattle numbers coexist with high farming density either have highly skewed patterns of land ownership (parts of Latin America) or use cattle for tillage (South Asia). The Great Lakes Highlands' densely-farmed zones have neither of these characteristics [45/]. So the replacement of cattle by goats is taking place quite naturally, in the teeth of tradition, and without public encouragement. There is no apparent need either to resist or to abet this process.

4.132 Stall-feed animals. Publicly-encouraged adjustments to cope with animal husbandry under higher farming densities focus on stall-feeding. This is part of the "fermette" concept that is the center of extension themes in some IDA-financed projects. The animals, whether cattle, goats or sheep, would be kept in stalls and fed plant or household wastes, and fodder that had been gathered or raised. In this connection, it is worth recalling Dressler & Neumann's finding that cultivating hay is not profitable (para. 4.18) [46/]. If true, and the mission believes that it is, that would limit profitable stall-feeding to what could be sustained on by-products and gathered fodder. But little gathered fodder would be available in the densest farming regions where stall-feeding would be expected to catch on.

45/ The Masisi in Zairian Zone 2 does not have high farming density but, based on its resource endowment, probably ought to. In that sense, the Masisi ranches are a product of tenure patterns that are skewed in the same sense as the large-scale ranches of certain Columbian valleys that are on high-farming-potential land. (See also Paras. 2.45 & 3.13).

46/ The observation applies whether the end use is for mulch, as in the context of Para. 4.18, or for fodder, as here.

4.133 The mission observed farmers practicing stall-feeding more or less spontaneously and not under the intimate cajoling of an extension worker in two locations: Ruvabu and lower-Rwerere communes in the outskirts of Gisenyi, and around Nyabisindu. In both instances, the practice (as "spontaneously" practiced) was confined to goats, was carried on with fodder that had been gathered rather than cultivated, and was limited to areas of very high farming density, with average farm size less than 0.7 or 0.6 ha [47/]. In short, farmer behavior suggests that stall-feeding is an intensification that makes sense to farmers only under these conditions.

4.134 Improving animal health. Veterinary services are minimal in the Highlands, especially in the Zairian parts not served by the FAO Livestock Project in Goma and serving principally the Masisi. While the mission knows of no studies on the subject in the Highlands, both the FAO Project experience and experience in other countries suggest that, at the level of animal husbandry in the Highlands, improved veterinary services can be a cost-effective way of increasing animal production. Although this is rarely the case, it should be possible to organize the recovery of veterinary costs from livestock-owning beneficiaries [48/].

4.135 Improving animal breeds has generally proved more difficult than improving animal health where animals live under difficult conditions. Pure breeds from developed countries normally cannot tolerate such conditions, though cross-breeds often can. In the Great Lakes Highlands, most cattle and goats live under poor husbandry conditions. Those cattle that get superior care and a good diet, e.g. the large private herds of the Masisi and Lubero Zones and the herds of government dairy farms in Burundi and Rwanda, are already pure-breds, usually Jerseys. But this experience has little relevance to the pastoralist raising his cattle by transhumance between the Bututsi and the Imbo or Mosso, or in the Semliki Plain. The mission knows of no proven improved breeds for their conditions.

4.136 At Ngozi in Burundi, German technicians are conducting breed-improvement trials with goats that may have wide implications for the majority of Highlands' farmers. Alpine goats have been imported and are being crossed with local stock. The project is also conducting experiments with a number of fodder crops (inspired by work at Nyabisindu) and with feeding. While it is too early for results to be considered definitive, tentative conclusions are: a) that local goats, when fed enough of a diet

---

47/ The mission is indebted to Dr. Wolf-Dieter Kruger of the Nyabisindu Agropastoral Project for recognition of these factors.

48/ Control of East Coast Fever, a major cattle disease in the area, is evolving rapidly with the results of research from the International Laboratory for Research in Animal Diseases in Nairobi. What control measures are optimal is moot, and, probably, changing. The mission did not presume to resolve this controversy.

containing adequate protein, put on weight about as well and convert feed about as efficiently as the best European breed, and b) that local goats' milk-giving capacity is far below that of European breeds, whatever the diet. Consumption of goats' milk seems to be limited by a number of taboos and goats have traditionally not been selected for their milk-giving capacity. However, a market for milk seems to be emerging (see Para. 4.138 below).

4.137 These observations suggest that goat-breed improvement will be attractive to farmers only to the extent that there is a market for milk. However, and perhaps more importantly, they suggest that there is considerable scope for extension to improve farmers' knowledge of how to feed their goats with the limited means at their disposal.

4.138 <u>Meat or milk</u>. Authorities in Rwanda and Burundi often express the wish to shift the production goal of the livestock sector from its present orientation, which is almost exclusively to meat production, towards a mixed meat-milk objective. The German Ngozi goat project fits in with this orientation. And, the large-scale cattle ranchers of Kivu are, in many cases, building herds of mixed-purpose animals. Does such a shift make sense for small farmers? Does it from the national point of view?

4.139 The mission cannot, of course, pretend to have a definitive answer to these questions. Some observations are possible, though, and they suggest that the answer may not be the same to both questions. Firstly, milk protein, as compared to bean or grain protein, is expensive in terms of land and labor use. If fighting protein undernutrition is the goal, then bean breeding is probably a better strategy than promoting milk production. But, from the farmers' point of view, revenue and taste are more important than nutrition.

4.140 In an area as poor as the Great Lakes Highlands and where the non-small-farmer class is so tiny, one would not expect to find much of a market for the relatively expensive protein and fat of milk, which is otherwise water. Moreover, milk is not a part of the traditional diet. Nevertheless, experience around the government dairies at Luvyrondza (Burundi) and Nyabisindu and Kinigi (Rwanda) suggests that there is a not-insignificant demand for milk from the relatively priviledged rural class of teachers and petty bureaucrats who, after all, are quite numerous. Consequently, it is not out of the question for small farmers to augment their cash income by producing milk for sale to relatively affluent neighbors. This requires different breeds of goats or cattle and a different approach to animal feeding than Great Lakes Highlanders now have.

4.141 <u>Fix, individualize grazing-land tenure</u>. Where livestock feed themselves by grazing instead of being stall fed, and this will constitute the Highlands' overwhelmingly dominant mode of production for a long time, the quality of pasture and stocking rate are of critical importance. A viable agrostologic formula for pasture improvement exists for pastures above 1800 m. and on reasonably rich soils; for other areas, what to grow to optimize pasture is not so obvious, but it is obvious that overgrazing it decreases production and degrades the pasture (See paras 4.53-56). In other words, there are better techniques for animal production from pastures than those now being practiced, except for a small number of large-scale operations, mostly cattle ranches in Masisi and Lubero Zones.

4.142 The explanation for this collectively sub-optimal behavior stems from the common ownership of most grazing lands. What everyone owns, it pays no one to improve. It pays everyone to use up common goods before someone else does, and that is just what is happening to the common-ownership pastures of the Great Lakes Highlands, which are overgrazed and unimproved. Judging by what one sees in the Highlands now, the only solution is to individualize ownership, so that owners have an interest in improvements and in optimizing the animal numbers the pasture or range carries. This is being carried out by the IDA-financed Ituri Project to the north of the Great Lakes Highlands but in an ecologically similar zone. The Belgian-financed Mugamba Sud Project may offer a solution intermediate to complete privatization in the hands of large-scale operators. Ownership of the rectangular paddocks created by the project resides with a sufficiently small group of relatives that they exercise some rational restraint, at least, over the stocking rate.

* * * * * * * *

4.143 This list of possible system changes is not complete. Such a list never could be. But its length and complexity gives an idea of the choices facing Great Lakes Highlands farmers -- some choices, in the opinion of the mission, much more attractive than others.

V. Elements of a Strategy

5.01 From the foregoing, it should be obvious that, while we have very little precise knowledge about the workings of Great Lakes Highlands farms, we do possess a great deal of information. In other words, there have been no serious and reasonably complete farm-management studies in the region that would enable us to construct reliable farm models; however, based on casual empiricism of the highest quality and on the assumption that the Highland's farmers are really quite clever and have good reasons for adjusting their systems in the ways that they are, it is possible to isolate a number of system modifications that clearly benefit farmers in certain subregions and that it is appropriate to encourage now.

5.02 Below we summarize from Chapter IV the 15 beneficial practices which we are most optimistic about encouraging now, with little or no further study, and then give some opinions about how to encourage them. Then, reflecting the fact that we believe that most of the systems changes being suggested <u>cannot</u> be certified as in the best interests of Highlands' farmers given our present knowledge, we try to identify a research agenda for getting that knowledge. Finally, we suggest what we think IDA's role in this process ought to be.

Practices to Encourage Now

5.03 Here are 15 cultural practices whose attractiveness to farmers we regard as demonstrated, at least within the zones or under the conditions indicated.

1) <u>Thin banana groves and intercrop</u> with, for instance, beans (see para. 4.103). Applicable throughout Zones A-E wherever there are dense banana groves. Happening by itself but extension might accelerate.

2) <u>Use improved potato varieties</u> (see para. 4.95). Applicable for Zones 1 and 2, also 4 and 5. Since proven varieties are available, continued production and expanded marketing of cuttings are needed to speed adoption.

3) <u>Prune coffee</u> (see para. 4.86). Zones A-E. More (and better) pruning seems to give high returns for little labor, even where market context keeps prices low (notably Zaire). Extension has to work in that context.

4) <u>Plant trees on contour-strip field boundaries</u> (see paras. 4.29-32). Appropriate for highest population zones (A, C, 2) where fuelwood is most lacking. Promotion would require nurseries to provide seedlings of appropriate species and, initially, some extension.

5) Fertilize tea (see para. 4.73, 4.79). Zones 1,2,4,5. Since importance of this practice is well known and tea sector is highly organized, failure to fertilize adequately stems from dysfunctional market context (no fertilizer available) and/or from dysfunctional tea parastatals.

6) Use improved maize varieties (see para. 4.93). Mainly Zones 1, 2, 4, and 5, but probably Zones A-E also. Since much better varieties are in use under identical conditions in nearby countries, varietal screening, possibly multiplication, and marketing are needed to promote. If a seed industry were built, it would promote itself and little extension would be needed.

7) Fix and individualize grazing-land tenure (see para. 4.141-4.142). Especially applicable in Zones 1, 3-5, B, D, E. Natural process can be accelerated by conducive legal context (Zaire) or promoted by a project (Zone 3).

8) Establish Kikuyu grass and clover as permanent pasture (see para. 4.56), Applicable at altitudes over 1800 m where there is room for permanent pasture (Zairian part of Zone 2 and Zone 5). Spread depends on individualization of tenure and probably fencing (see 7 above) but extension and availability of seed should speed adoption.

9) Expand marsh cultivation (see para. 4.130). Zone A and soon Zone B. No public intervention needed, except perhaps to clarify tenure, since this development is taking place rapidly by itself and "empirical" techniques seem to be the best available.

10) Replace cattle with goats (see para. 4.131). Densely-settled zones (A, C, 2, and, increasingly 1 and 4). No public intervention needed to stimulate transition, but local community action important to have goats kept tied up.

11) Mulch coffee with farm by-products (see paras. 4.12-24). Zones A-E. Probably little extension needed, but extension recommendations should be conformed to lessons of economics: that cultivation of plants for mulching and transporting mulch for long distances does not pay.

12) Stall-feed cattle (see paras. 4.132-4.133). Most densely settled parts of Zones A, C, and 2. Nyabisindu experience suggests this well-known, land-saving but labor-using practice interests farmers only where land opportunity cost is very high. Promotion through extension.

13) Intercrop coffee with bananas, other crops (paras. 4.112) Appropriate where producer coffee price is low and purchased inputs unavailable (Zones C (in Zaire), D), but possibly in other coffee zones too (A, B). Where fertility is low and mulching/weeding do not pay, bean cover is better than grass cover; reduced coffee yields in spaced banana groves are better than none. Little extension needed since practice is spreading already where permitted (Zaire). Further research needed to determine whether practices justified in Rwanda and Burundi where presently outlawed.

14) Improve cover of pure-stand coffee (paras. 4.88). Notably Zones A and C (East of Rift). Given diminishing availability of mulch, extension should encourage that new plantings be of dwarfs with closer spacing.

15) Use better-covering varieties of sweet potato (paras. 4.50, 4.90). Principally Zones A and C (east of Rift). Sweet potato's place in rotation grows with increasing population density in lettered zones. Its role as soil cover is important. As with coffee, varieties exist that cover better and have other properties equal to varieties now used. Extension could promote them.

5.04 The shortness of the list above, compared to the many cultural practices discussed in Chapter 4, shows that, in the mission's opinion, a great many uncertainties remain as to what changes would be good for Highlands' farmers. It is not, by any means, clear that all of the modifications in cultural practices discussed in Chapter 4 and not included in the list of fifteen above are not in the interest of Highlands' farmers. Some, certainly, are not in their interest. But for most, the verdict is not yet in. More study is needed before a valid judgement can be made.

5.05 That is, incidentally, also the case for some of the practices we feel confident to encourage now. For instance, where, exactly, is the practice of stall feeding an interesting and profitable one for farmers? We do not know with any kind of precision how much incremental labor is involved in building and maintaining stalls, in growing or collecting fodder and bringing it to stall-fed animals, in removing manure, composting it, carrying and spreading it (nor do we know farmers' assessment of the unpleasantness of this labor). And we cannot quantify the fertility effects of animal-waste soil amendments from stall-feeding as vs. those from grazing, nor the differences in the technical parameters of animal growth. Consequently, we are left with and limited to the observation that Highlands' farmers shun the extra work of stall-feeding until they are pretty desperate -- until they are very short of land, have serious soil-fertility problems, and have little else to spend their time on (that is, a low reservation price of farm-family labor). How acute these factors have to be before stall-feeding pays we do not know. Of course, as always, farmers are the best judges of their circumstances. Therefore, the best approach is likely to be to have the extension service display stall-feeding in its cafeteria line of available cultural practices and to let farmers choose. Nevertheless, it would be nice if the "experts" had a bit more expertise, at least to the point of knowing more precisely where to encourage stall-feeding --- or dozens of other practices possibly suitable for certain groups of Highlands' farmers.

A Research Agenda

5.06 In the opinion of the mission, it is important not to set overly ambitious goals for farm-management research. It is important to avoid gathering information for its own sake or to satisfy intellectual curiosity. In a cafeteria approach, as suggested above, governments will not prescribe what farmers will grow or impose their crop rotations; farmers would choose; governments would facilitate. In that context, farming-systems research should recognize that each farm is different and should be so because each farmer faces different circumstances of soil, water, temperature, family size and composition, proximity to markets, land endowment and other wealth, access to credit, and non-farm jobs, and personal values; and that all models, perforce, distort. Therefore, the objective of the research should be to improve understanding of the choices now being made by Great Lakes Highlands' farmers, and to elucidate the choices implied in the proposed changes discussed in Chapter 4 above, and more.

5.07 To do that, two kinds of research program are indicated. Firstly, improve understanding of choices farmers are making now, classical farm-management research needs to be conducted. On a small sample of farms in each zone, operations have to be closely monitored in order to identify the inputs and outputs to/from the farming operation, both in physical and value units, and the timing of those inputs and outputs. Our principal point of ignorance is labor inputs: both the physical quantities and the value farm families put on their own labor for different tasks and at different times of year. No insuperable methodological tasks are involved. The complexity of rotations, with non-uniform crop mixes, and relaying and staggering of planting and harvesting, make it difficult to allocate land and labor inputs by crop, but it would be extremely instructive if that could be done, even on a very small number of farms. As for sampling, this study proposes one division of the Highlands into zones for modelling purposes that would be acceptable, but it is not the only conceivable one. Rwanda, in particular, has a set of ten ecological regions of the Highlands that represent subdivisions of the five into which this study divided the Highlands of that country. Any coherent system that is not too complicated would do.

5.08 Secondly, to elucidate the choices implied in proposed system changes involves a further step. On-farm trials are needed to show the impact of the proposed changes on farmers' returns to their labor, to their land, and to their "capital" -- that is to say their collective wisdom and knowledge about farming. If research-station researchers deeply understood farmers' present systems and the constraints under which they operate, they would automatically orient their research to what might prove attractive to farmers and less to what is agronomically optimal. This close link between researchers, extension services, and farmers is so often advocated (and not just in the Highlands), and so rarely achieved. One way to achieve it might be to oblige researchers to work with farmers on their fields, for the use of which they need to get farmers' permission. But even if there never is total success in infusing research as a whole with this desirable spirit of close identification with farmer conditions and with extension, nevertheless research organizations can be assigned specific tasks in evaluating proposed system changes that require work with the system.

5.09 The mission has proposed a non-exhaustive list, many items on which, it believes, merit this kind of research (see Chapter 4). The mission appreciates that this is not the only possible list of proposed system changes that merit investigation. It is proposed as a basis for discussion, and in the hope that such discussions will take place, and that research on a number of systems' changes will begin, and soon.

5.10 To what extent is this research agenda already being carried out (cf. 3.23 to 3.29)? USAID and the Rwandan Ministry of Agriculture have instituted a farm census by sampling that should generate important information on existing farming systems in all of Rwanda's farming zones. Another USAID project will begin in Rwanda in 1984 in three communes in Ruhengeri Prefecture (Zone 2). While this project will be "prepared" (in the Bank sense of that term) by the university that will carry it out only in early 1984, it is intended that it will both conduct classical farm-management studies to deepen the understanding of existing systems, and investigate the choices implied in proposed system changes. This effort will cover only a part of Rwandan Zone 2. In Burundi, ISABU and USAID are planning to initiate farming-systems research. In Rwanda, the National Agricultural Research Project, now being prepared by IDA for implementation by ISAR, is likely to contain more farming-system research than ISAR has carried on heretofore. In the cases of ISABU and ISAR, the scope and content of the farming-systems research are not yet known.

5.11 Throughout the Highlands, a number of projects are carrying on specific research on specific innovations, usually, however, not in a farming-systems context that will, upon completion, provide answers to questions about how the proposed system changes fit into the existing farming systems and how adopting the changes would change farmers' returns to labor, land, and know-how. The informative but incomplete studies undertaken by the Nyabisindu Agropastoral Project are an example. Similar partial research is being carried out by INERA under USAID auspices on legumes at Mulungu, by MIDEMA (Matadi Mills) on wheat at Ndihira, by the Lakeshore Coffee and Foodcrops Project with IDA and Swiss support at Kibuye on cover crops and trees, by ISAR/PNAP with CIP and Belgian support at Ruhengeri on potatoes, by BGM with IDA support in Zone B of Rwanda, by the Mugamba Sud Project with Belgian support in Luvyrondza on pastures, by GTZ in Ngozi on goats, and more.

5.12 A logical first step would be to assess and coordinate the research on farming systems already going on in the Great Lakes Highlands, and to promote exchange of information between researchers. This task is modest in scale but of great importance. The IRAZ (Agronomic and Zootechnic Research Institute), in Gitega, a Great Lakes' States Economic Community (CEPGL) institution, would seem to be well suited for this task.

The Role of IDA

5.13 As regards obtaining answers to unanswered questions about farming systems, IDA has a direct role to play through its lending to support research and in its more general technical assistance to ministries of agricuture and planning. Since all recent agricultural sector work has emphasized the importance of a farming-systems approach, there is no disagreement in principle. The mission hopes that this study will help to give content and definition to the idea of a farming-systems approach. It also hopes that this content and definition will inform IDA's indirect role, which may well be more important than its direct one: emphasizing the importance of getting a better understanding of existing farming systems and of the impact on them of proposed system changes in the context of IDA's sector dialogue with Great Lakes Highlands' governments and with other donors.

5.14 As regards the specific farming-systems changes that IDA fosters through its own lending, the mission hopes that this lending will, in future, be informed by the many considerations discussed above. So doing might help to avoid promoting systems changes that are, in the final analysis, not in farmers' interest, and may encourage the designers and preparers of future projects to broaden their ideas of what farming systems' changes are possible and desirable.

ANNEX

Conservation and Improvement of Soil Fertility

Improvement of soil fertility is the overriding problem to increase agricultural production in the Highlands. Unless this problem is solved first, it is unlikely that other technological advances such as the introduction of improved varities, the use of fertilizers, will give satisfactory results. Fortunately most Highlands soils have a high potential to recuperate soil fertility. This is due to favorable temperature and good rainfall distribution which allows year round growth of the vegetative cover, at least for deep-rooted plants.

The following three components should be considered for conservation and improvement of soil fertilizing:

- Recycling of plant nutrients

- Prevention of run-off

- Soil cover

Recycling of Plant Nutrients

The natural vegetation of the Highlands was and is still in part afro-alpine forest and its transition to the humid tropical forest. The only exception is Zone B, the Kagera Piedmont which is covered with tree savannah. All these forest lands had originally, before they were cultivated, rich top soils, regardless of the quality of the mother.rock. This is not only due to the protection which trees provide against rain, sun and run-off, but also due to the fact that forest trees in the Highlands are deep rooted and mobilize and recycle plant nutrients from the deeper soil layers to the top soil. Roots take up nutrients from the decomposed mother rock or which have been leached deeper from the top to soil layers, and deposit them on the top soil in the form of dead leaves.

Once the forest is removed for crop production or pasture, deterioration of the fertility of the top soil begins through leaching of nutrients to deeper soil layers, run-off and direct insolation. Because most annnual food crops and pasture grasses are shallow rooted, the leached nutrients are not accessible to the crops and the top soil is not replenished with nutrients from the deeper soil layers. The nutrients available to the crops decreases through removal of the harvest.

The speed of soil nutrient losses depends on, amongst other factors, on the inherent soil fertility deriving from the quality of the mother rock. It is fast on soils derived from granite, kneis and shists (zone 1 and 3) and much slower on volcanic ashes (zone 2).

It is clear that this type of soil fertility deterioration can best be countered by applying agro-forestry farming systems, an association of annual crops with trees. In the past practically nothing has been done in the Highlands to control soil fertility deterioration through agro-forestry methods. However, research done in this field mainly at Nyabisindu 1/ has led to the development of agro-forestry systems, which could be applied throughout the highlands areas, at elevations from 1400 to 2200m. Appropriate species (Grevilea robusta, Sesbanea sesban, Cefrela sp. Leucaena leucocephala) for interplanning in farmers fields have been determined; and also those species which should not be interplanted with crops. Also adequate spacing has been established (10% of the number of trees in classical afforestation) which will not impair crop yields. This agroforestry method is valid for large scale extention throughout the Highlands below 2200m. Prevention of run-off (Erosion Control).

During colonial times all the efforts to conserve soil fertility were concentrated on erosion control. The universally applied method, throughout the Highland area, and irrespective of local conditions, consisted in planting contour grass hedges (Setaria spp. or Pennisetum purpureum) and digging below the grass lines blind ditches for water -- retention. Farmers were requested and often forced to practice this method on all their fields.

A tremendous effort was made to introduce this method. By 1960, about 1 million km of antierosive hedges had been established in Burundi, Rwanda and Kivu protecting about 1.2 million ha of land. This method gave satisfactory results provided the structures were maintained, but it was never voluntarily accepted by the farmers. After independence these erosion control measures were discontinued. Most of the terraces which resulted naturally from the planting of hedges and downhill cultivation, still exist, but without hedges nor ditches and have greatly diminished erosion control effect.

In retrospect, it can be said that this run-off control method had the following disadvantages and therefore rendered it unpopular to farmers:

1/ Zeuner T.H. and Neumann J. Contribution à la Réunion du Groupe Forestier National, Projet Agropastoral Nyabisindu, 1981.

- Grasses are reproduced vegetatively (cuttings). Production of cuttings is done in special nurseries occupying valuable land and have to be carried over long distances.

- Grasses which have a shallow root system and are cut for mulch or fodder exhaust the soil and compete with adjacent crops, thus reducing the area of useful crop land.

- The opening and regular cleaning of blind ditches requires much labor and also reduces the area of cultivable land.

- Through regular downhill cultivation, the cultivated land between two hedges flattens and a vertical wall develops below the grass hedge. The farmers hoe gradually nearer and nearer to the grass hedge and eventually below it until the hedge collapses.

- Depending on the physical properties and steepness of the land, the blind ditches may induce land slides due to excessive water infiltration. All these disadvantages of this erosion control method are well known.

All these disadvantages of this erosion control method are well known to the farmers and they resist applying it.

There exists no uniform method of runoff control which can be applied throughout the Highlands. Therefore, new methods should be developed for each region taking into account the quantity of soil loss through run-off and the adaptability of the method to the farms under present land use.

For instance in Zone 2, the soils have a large water absorption capacity and since farmers there cultivate on ridges following contour lines, no additional run-off control appears necessary. On the other highland regions except Zone B, it appears that run-off is important as a soil degrading factor and that physical measures should be taken to control it.

For a refinement of erosion control measures, this assumption should be confirmed by run-off measurement in the different areas. The Faculty of Geography of the National University of Rwanda has such studies under way and results can be expected soon.

Until the above mentioned question find an answer for further refinement of erosion control, the following general recommendations can be made for run-off control which are known to improve soil fertility and are likely to be voluntarily accepted by the farmers.

- The natural slope of the land should not be disturbed by ditches, steep walls etc.

- The hedge plants should not compete with adjacent crops but rather enhance soil fertility.

- Contour hedges should be established with plants propagated by seed, preferably deep rooted legumes which improve soil fertility (for instance pigeon peas (Cajanus cajan), Leucena leucocephala, and Calyandra eulothyrus). These bushes, sown densely,improve the tilth on the soil, which facilitates water infiltration, thus acting in part as a ditch for water retention.

- Use of plants for hedges, which are more attractive to farmers than grasses, providing food, fodder and or firewood. Simultaneously or at a later stage when soil fertility has improved, interplanting in the hedges crops most valued by the farmers. Over most of the Highlands area below 2000m, banana and coffee could be interplanted. This would assure that the farmers would take good care of the hedges.

Trials in the above mentioned sense are being carried out by the Kirimiro Project in Burundi and the Coffee Development and Food Crops Project in Rwanda. The technical validity of these proposals has been, tested 2/ and what remains to be ascertained is the acceptability to farmers.

Any long term program to improve agricultural production in the Highlands will have to be based on systematic conservation and improvement of the soil fertility. Since the end of colonial times practically nothing has been done in the Highlands in this field and most of the crop yield data indicate that soil fertility has decreased over the last 20 years.

To start a new regionwide soil fertility improvement program the existing hundreds of thousands km2 of terraced land should be considered as a huge sunken capital left over from colonial times. The terraces without hedge rows and crumbling walls are inefficient to stem run-off, but with little effort they could be rehabilitated and their efficiency improved. The main problem is to stabilize the terrace walls. This could be achieved by sowing the above mentioned deep rooted legumes on the terrace hedges or even into the crumbling walls. The stabilization of these terraces would be a first step for future introduction of agro-forestry farming system and changes in land use.

2/ Nair, P.K.R. Some Promising Agroforestry Technologies for Hilly and Semi-arid Regions of Rwanda. Nairobi: International Center for Research in Agro-forestry (ICRAF), 1983.

Soil Cover

Permanent cover by live or dead plant material is, in the context of most highland soils, the most efficient soil protection. This was recognized early by the colonial administration and led to the introduction and even compulsion of mulching coffee, the most valuable export crop. Due to demographic pressure, mulching material is becoming scarce and a substitute to mulching coffee by the use of cover crops is being actively investigated.

The problem of providing year round soil cover on fields planted to annual crops is much more difficult to solve than for perennials (coffee). The solution would be to have a cover crop during the dry season and especially at the beginning of the rainy season when the main crop does not yet cover the soil sufficiently. This might be possible by the use of xerophylic (deep rooting) varieties of grain legumes such as cowpeas (Vigna unguiculata), mung beans (Phaseolus aureus), urd (Vigna mungo). If this proves possible, it would require drastic changes in the farming system to introduce these crops. No valid techniques to solve this problem of soil cover are yet available for the Highlands.

The above mentioned 3 components for improvement of soil fertility are considered, for the purpose of this report, as "permanent" measures in the sense that once adopted they continue to function without major intervention. In contrast to these methods there are "renewable" measures to increase soil fertility which have to be implemented periodically. For the Highlands, the following three components are valid:

- Fallow
- Composting and integration of crop and livestock production
- Use of fertilizers

Fallow

To fallow land is the traditional method for rebuilding soil fertility in the Highlands. Due to demgraphic pressure fallow length has decreased or fallows has almost completely disappeared in the zones A, C, 2. In the other areas, natural fallow is still practiced, the length of the fallow period depending on the availability of land.

The natural fallow (it is the spontaneous vegetation cover) has the disadvantage that it is time-consuming because, during the first years, mostly shallow rooted graminea populate the fallows. The Agro-Pastoral Project at Nyabusindu has developed a so called "intensive fallow" consisting in planting deep rooted legumes (of the following species:

Dolichos, Indigofera, Thephrosia, Crotalaria, etc). The soil fertility improvement achieved within one year with this type of fallow is remarkable. This fallow system is not yet widely used and it is unlikely to be adopted in areas which have still natural fallows because of the tradition of using natural fallow land for pasture. However, the intensive fallow may become an asset to improve soil fertility where there is little or no fallow land left, if it can be integrated into the farming system.

Composting and Integration of Crop and Animal Production

Most farms in Zone A and C and in certain restricted areas around Butembo (Zone 4) and Bukavu are so small that they no longer have or soon no longer will have fallow land to rebuild soil fertility on specific parts of their land. The only means left to them to renew soil fertility through on-farm produce is composting crop and household refuses.

The whole problem of the most rational use of crop and household wastes to improve soil fertility should be reviewed.

The question should be answered whether composting has an advantage over direct burying of fresh organic material into the soil. Due to climatic conditions, decomposition of organic material in the soil is fast and possibly the compost stage is not necessary for a fast mobilisation of plant nutrients from fresh organic material.

The system of direct burying of weeds and crop refuses is practised in Zone 2 by burying the crop wastes when ridges are prepared for a new-crop. The feasibility of applying the same land preparation method in the other Highland areas should be investigated. This would not only solve the problem of rational use of crop wastes instead of burning them as is done at present, but the adoption of contour ditches would greatly improve run-off control.

On farms where animals (cattle, goats, sheeps) are fully or partly stall-fed, composting crop and household refutes together with manure, is an excellent practice which is gradually being adopted by the farmers. The problem in this case is the fodder base for the stall-fed animals. Skillful selection of the hedge plants for erosion control as proposed, may provide the necessary fodder and induce more farmers to stall-feed their animals.

Use of Fertilizers

Very little fertilizer is used throughout the Highland areas. The fertilizer trails carried out so far show very irregular response. In

Burundi good response is reported from the use of fertilizers on beans. In Rwanda response to fertilizer use varies a great deal. When it comes to the value/cost consideration of fertilizer use, the use of fertilizers may not be a paying proposition in the Highland because of the high cost of fertilizers and the relatively low price of agricultural products.

A consistant finding, recurring in many trials, is that fertilizers applied together with compost or manure give much better response than the application of fertilizers only. ISAR goes so far as to recommend the mixing of fertilizers to compost before it is spread on the field. This seems to be an indication on the general state of degradation of the soils and their lack of organic material. Therefore it can be concluded that unless the general quality of the soils is improved through soil fertility improvement methods, large scale use of fertilizers might be a waste of money.

Two factors may lead in the near future to increased use of fertilizers: a) local production of fertilizers which would bring down fertilizer prices and b) that the countries of the highland may become net food importers.

The outlook for local production of fertilizers in the region is not bad. Phosphate deposits are known to exist in Burundi and Kivu and there are plans to produce, in the near future, nitrogen fertilizers based on methane from Lake Kivu.

If and when Rwanda and possibly also Burundi become net food importers, which may occur in the near future if agricultural production is not substantially increased, it would probably be more economic to import fertilizers than food paid at world market prices.

These considerations highlight the urgency of implementing soil fertility improvement programs throughout the Great Lakes Highlands.

World Bank Publications of Related Interest

Adoption of Agricultural Innovations in Developing Countries: A Survey
Gershon Feder, Richard Just, and David Silberman

Staff Working Paper No. 542. 1982. 65 pages.

ISBN 0-8213-0103-9. Stock No. WP 0542. $3.

Agrarian Reform as Unfinished Business—the Selected Papers of Wolf Ladejinsky
Louis J. Walinsky, editor

Studies in agrarian policy and land reform spanning four decades, grouped chronologically according to Ladejinsky's years in Washington, Tokyo, and Vietnam and while at the Ford Foundation and the World Bank. Oxford University Press, 1977. 614 pages (including appendixes, index).

LC 77-24254. ISBN 0-19-920095-5, Stock No. OX 920095, $32.50 hardcover; ISBN 0-19-920098-X, Stock No. OX 920098, $14.95 paperback.

Agrarian Reforms in Developing Rural Economies Characterized by Interlinked Credit and Tenancy Markets
Avishay Braverman and T.N. Srinivasan

Staff Working Paper No. 433. 1980. 32 pages (including references).

Stock No. WP-0433. $3.

Agricultural Credit
Outlines agricultural credit practices and problems, programs, and policies in developing countries and discusses their implications for World Bank operations.

A World Bank Paper. 1975. 85 pages (including 14 annex tables).

Stock No. BK 9039 (English), BK 9052 (French), BK 9053 (Spanish). $5 paperback.

The Agricultural Development Experience of Algeria, Morocco, and Tunisia: A Comparison of Strategies for Growth
Kevin M. Cleaver

Compares agricultural experience of Algeria, Morocco, and Tunisia. Provides insights into the importance of food and agriculture for development, and determinants of agricultural growth.

Staff Working Paper No. 552. 1983. 55 pages.

ISBN 0-8213-0120-9. Stock No. WP 0552. $3.

The Agricultural Economy of Northeast Brazil
Gary P. Kutcher and Pasquale L. Scandizzo

This study, based on an agricultural survey of 8,000 farms, assesses the extent and root causes of pervasive rural poverty in northeast Brazil. The authors review a number of policy and project options; they conclude that courageous land reform is the only effective means of dealing with the problem.

The Johns Hopkins University Press, 1982. 288 pages.

LC 81-47615. ISBN 0-8018-2581-4, Stock No. JH 2581. $25.00 hardcover.

NEW

Agricultural Extension by Training and Visit: The Asian Experience
Edited by Michael M. Cernea, John K. Coulter, and John F.A. Russell

Captures nearly ten years of experience with the Training and Visit Extension System. Addresses five issues: farmer participation, the research-extension linkage, training, system management, and monitoring and evaluation. Within this framework, extension system managers and evaluators from six Asian countries and six discussants present their experience and analyses. Notes the World Bank's strong commitment to agricultural development in its member countries and to helping least advantaged farmers to improve their productivity. Valuable to policymakers, project designers, rural sociologists, extension workers, and other agricultural researchers.

1984. 176 pages.

ISBN 0-8213-0301-5. Stock No. BK 0301. $13.50.

NEW

Agricultural Extension: The Training and Visit System
Daniel Benor, James Q. Harrison, and Michael Baxter

Contains guidelines for reform of agricultural extension services along the lines of the training and visit system. The central objective—making the most efficient use of resources available to governments and farmers—is achieved through encouraging and facilitating feedback from farmers to research workers through extension personnel who visit and advise farmers on a regular, fixed schedule, thus helping research to solve actual production constraints faced by the farmer.

Explains the complex relationships in training and visit extension and draws attention to the range of considerations that are important to implementing the system.

1984. 95 pages.

ISBN 0-8213-0140-3. Stock No. BK 0140. $5.

Agricultural Land Settlement
Theodore J. Goering, coordinating author

Examines selected issues related to the World Bank's lending for land settlement and gives estimates of the global rate of settlement andthe world's ultimate potentially arable land.

A World Bank Issues Paper. 1978. 73 pages (including 4 annexes). English, French, and Spanish.

Stock Nos. BK 9054 (English), BK 9055 (French), BK 9056 (Spanish). $5 paperback.

Agricultural Price Management in Egypt
William Cuddihy

Staff Working Paper No. 388. 1980. 174 pages (including annex, bibliography).

Stock No. WP-0388. $5.

Agricultural Price Policies and the Developing Countries
George Tolley, Vinod Thomas, and Chung Ming Wong

This book first considers price policies in Korea, Bangladesh, Thailand, and Venezuela, bringing out the consequences for government cost and revenue, farm income, and producer and consumer welfare. Other effects, including those on agricultural diversification, inflation, economic growth, and the balance of payments are also discussed. The second part of the book provides a methodology for estimating these effects in any country. Operational tools for measuring the effects on producers, consumers, and government are developed and applied.

The Johns Hopkins University Press. 1982. 256 pages.

LC 81-15585. ISBN 0-8018-2704-3, Stock No. JH 2704, $25 hardcover; NEW: ISBN 0-8018-3124-5, Stock No. JH 3124, $9.95 paperback.

NEW

Agricultural Prices in China
Nicholas R. Lardy

Analyzes recent adjustments to China's agricultural pricing systems and its effects on urban consumers and overall production patterns. Defines price ratios from key inputs and outputs and examines price/cost relations in view of the institutional setting for price policy.

Staff Working Paper No. 606.1983. 84 pages.

ISBN 0-8213-0216-7. Stock No. WP 0606. $3.

Agricultural Research

Points out that developing countries must invest more in agricultural research if they are to meet the needs of their growing populations. Notes that studies in Brazil, India,Japan, Mexico, and the United States show that agricultural research yields a rate of return that is more than two to three times greater than returns from most alternative investments and cites some of the successes of the high-yielding varieties of rice and wheat that were developed in the mid-1960s. Discusses the World Bank's plans to expand its lending for agricultural research and extension, particularly for the production of food and other commodities that are of importance to low-income consumers, small farmers, and resource poor areas.

Sector Policy Paper. 1981. 110 pages (including annexes). English, French, and Spanish.

Stock Nos. BK 9074 (English),BK 0160 (French), BK 0161 (Spanish). $5 paperback.

Agroindustrial Project Analysis
James E. Austin

Provides and illustrates a framework for analyzing and designing agro-industrial projects.

EDI Series in Economic Development. The Johns Hopkins University Press, 1981.2nd printing, 1983. 224 pages (including appendixes, bibliography, and index).

LC 80-550. ISBN 0-8018-2412-5,Stock No. JH 2412, $16.50 hardcover; ISBN 0-8018-2413-3, Stock No. JH 2413, $7.50 paperback.

French: L'Analyse des projets agroindustriels. Economica, 1982. ISBN 1-7178-0480-3, Stock No. IB 0537. $7.50 paperback.

Spanish: Analisis de proyectos agroindustriales. Editorial Tecnos, 1981. ISBN 84-309-0882-X, Stock No. IB 0520, $7.50 paperback.

NEW

Alternative Agricultural Pricing Policies in the Republic of Korea: Their Implications for Government Deficits, Income Distribution, and Balance of Payments
Avishay Braverman, Choong Yong Ahn, Jeffrey S. Hammer

Develops a two-sector multimarket model to evaluate agricultural pricing policies, replacing insufficient standard operational methods. Measures the impact of alternative pricing policies on production and consumption of rice and barley, real income distribution, import levels of rice, self-sufficiency in rice, and public budget. Provides a valuable synthesis of the work that has been done to date on agricultural household models. Helps economists evaluate the impact of alternative pricing policies aimed at reducing deficits. Based on the experience of the Grain Management Fund and the Fertilizer Fund in Korea.

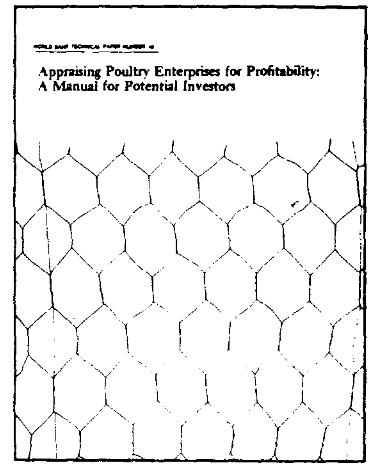
Staff Working Paper No. 621. 1983. 174 pages.

ISBN 0-8213-0275-2.Stock No. WP 0621. $5.

Argentina: Country Case Study of Agricultural Prices, Taxes, and Subsidies
Lucio G. Reca

Staff Working Paper No.386. 1980. 72 pages (including 3 annexes).
Stock No. WP-0386. $3.

NEW



Appraising Poultry Enterprises for Profitability: A Manual for Potential Investors
International Finance Corp.

Decisionmaking tool for entrepreneurs and project managers considering investments in integrated poultry projects. Use this guide to conduct on-site investigation of proposed project. Figure production costs and determine fixed asset and working capital for broiler operations. Analyze market and accurately forecast market prices. This comprehensive guide tells how to manage integrated broiler operations, gives specifications for broiler and breeder houses and summarizes production costs.

Technical Paper No. 10. 1983. 110 pages.

ISBN 0-8213-0165-9.Stock No. BK 0165. $5.

The Book of CHAC: Programming Studies for Mexican Agricultural Policy
Edited by Roger D. Norton andLeopoldo Solis M.

The principal tool of analysis is the sector model CHAC, named after the Mayan rain god. This model can be used throughout the sector to cover short-cycle crops, their inputs, and their markets. It can also be broken down into submodels for particular localities if more detailed analysis is required. The model helps planners weigh the costs among policy goals, which can vary from region to region. This volume reports the experience of using the CHAC model and also presents purely methodological material.

The Johns Hopkins University Press, 1983. 624 pages (including maps, bibliographies, index).

LC 80-29366. ISBN 0-8018-2585-7, Stock No. JH 2585. $35 hardcover.

Building National Capacity to Develop Water Users' Associations: Experience from the Philippines
Frances F. Korten

Staff Working Paper No. 528. 1982. v + 69 pages (including references).

ISBN 0-8213-0051-2. Stock No. WP 0528. $3.

Bureaucratic Politics and Incentives in the Management of Rural Development
Richard Heaver

Analyzes management problems in implementing rural development from a bureaucratic political standpoint. Emphasizes the need to take account of informal interests in managing programs. Suggests possible methods for assessing incentives.

Staff Working Paper No. 537. 1983. 74 pages.

ISBN 0-8213-0084-9. Stock No. WP 0537. $3.

NEW

The Common Agricultural Policy of the European Community: A Blessing or a Curse for Developing Countries?
Ulrich Koester and Malcolm D. Bale

Examines the importance of the European Community (EC) in global agricultural trade. Points out that the EC is the leading importer of agricultural goods and is the dominant exporter of a number of agricultural products. Emphasizes that policymakers in developing countries must understand the implications of the EC's common Agricultural Policy. Spells out how this policy operates and categorizes important commodities.

Staff Working Paper No. 630. 1984. 64 pages.

Stock No. WP 0630. $3.

The Design of Organizations for Rural Development Projects: A Progress Report
William E. Smith, Francis J. Lethem, and Ben A. Thoolen

Staff Working Paper No. 375. 1980. 48 pages. English and French.

Stock Nos. WP 0375 (English), BK 9241 (French). $3.

Prices subject to change without notice and may vary by country.

The Design of Rural Development: Lessons from Africa
Uma Lele

Analyzes new ways of designing rural development projects to reach large numbers of low-income subsistence populations. The third paperback printing contains a new chapter by the author updating her findings.

The Johns Hopkins University Press, 1975; 3rd printing, 1979. 260 pages (including glossary, appendix, maps,bibliography, index).

ISBN 0-8018-1769-2, Stock No. JH 1769, $9.95 paperback.

French: Le developpement rural: l'experience Africaine.Economica, 1977. ISBN 2-7178-0006-9, Stock No. IB 0545, $9.95 paperback.

Economic Analysis of Agricultural Projects
Second edition, completely revised and expanded

J. Price Gittinger

Sets out a careful and practical methodology for analyzing agricultural development projects and for using these analyses to compare proposed investments. It covers what constitutes a "project," what must be considered to identify possible agricultural projects, the life cycle of a project, the strengths and pitfalls of project analysis, and the calculations required to obtain financial and economic project accounts.

The methodology reflects the best of contemporary practice in government agencies and international development institutions concerned with investing in agriculture and is accessible to a broad readership of agricultural planners, engineers, and analysts.

This revision adds a wealth of recent project data; expanded treatment of farm budgets and the efficiency prices to be used to calculate the effects of an investment on national income; a glossary of technical terms; expanded appendixes on preparing an agricultural project report and using discounting tables; and an expanded, completely annotated bibliography.

EDI Series in Economic Development.

The Johns Hopkins University press. July 1982. 2nd printing, March 1984. 528 pages (including appendixes and glossary/index).

LC 82-15262. ISBN 0-8018-2912-7, Stock No. JH 2912, $37.50 hardcover; ISBN 0-8018-2913-5, Stock No. JH 2913, $13.50 paperback.

Spanish: Analisis economico de proyectos agricolas. Editorial Tecnos, S.A. ISBN 84-309-0991-5. $13.50.

Economic Aspects and Policy Issues in Groundwater Development
Ian Carruthers and Roy Stoner

Staff Working Paper No. 496. 1981. 110 pages (including annex, bibliography).

Stock No. WP-0496. $5.

Economic Return to Investment in Irrigation in India
Leslie A. Abbie, James Q. Harrison, and John W. Wall

Staff Working Paper No. 536. 1982. 52 pages.

ISBN 0-8213-0083-0. Stock No. WP 0536. $3.

Farm Budgets: From Farm Income Analysis to Agricultural Project Analysis
Maxwell L. Brown

Clarifies the relation between simple farm income analysis and the broader field of agricultural project analysis and emphasizes the more practical aspects of project preparation. Gives guidance to those responsible for planning in agriculture.

EDI Series in Economic Development. The Johns Hopkins University Press, 1980. 154 pages.

LC 79-3704. ISBN 0-8018-2386-2,Stock No. JH 2386, $15 hardcover; ISBN 0-8018-2387-0, Stock No. JH 2387, $6.50 paperback.

Spanish: Presupuestos de fincas. Editorial Tecnos, 1982. ISBN 84-309-0886-2, Stock No. IB 0522, $6.50 paperback.

Fishery
Highlights the importance of fisheries to the economies of developing countries and recommends that the World Bank provide assistance to those countries that have the fishery resources and are willing to develop them further.

Sector Policy Paper,1982.

ISBN 0-8213-0138-1. Stock No. BK 0138, $5 paperback.

Forestry
Graham Donaldson, coordinating author

Examines the significance of forests in economic development and concludes that the World Bank should greatly increase its role in forestry development, both as a lender and adviser to governments.

Sector Policy Paper. 1978. 63 pages (including 7 annexes). English, French, and Spanish.

Stock Nos. BK 9063 (English), BK 9064 (French), BKL 9065 (Spanish). $5 paperback.

NEW

Forestry Terms—Terminologie forestiere

English—French; Francais—Anglais.

Presents terminology related to forestry development and erosion control in arid and semiarid lands. Since fuelwood problems and desertification have become serious, particularly in Western Africa, the World Bank has become increasingly involved in wood-based energy and erosion-control and in forest-management projects. Assists translators and researchers who work in this field.

A World Bank Glossary—Glossaire de la Banque mondiale

1984. 48 pages.

ISBN 0-8213-0175-6. Stock No. BK 0175. $5.

Improving Irrigated Agriculture: Institutional Reform and the Small Farmer

Daniel W. Bromley

Staff Working Paper No. 531. 1982. 96 pages.

ISBN 0-8213-0064-4.Stock No. WP 0531. $3.

India: Demand and Supply Prospects for Agriculture

James Q. Harrison, Jon A. Hitchings, and John W. Wall

Staff Working Paper No. 500. 1981. 133 pages (including 5 appendixes, references, annex).

Stock No. WP-0500. $5.

Irrigation Management in China: A Review of the Literature

James E. Nickum

Analyzes irrigation management in the People's Republic of China. Major topics covered are the institutional environment, the organizational structure, water fees and funding, and water allocation. The report is based on Chinese-language materials published in China and now available in the United States.

Staff Working Paper No. 545. 1983. 106 pages.

ISBN 0-8213-0110-1. Stock No. WP 0545. $5.

Land Reform

Examines the characteristics of land reform, its implications for the economies of developing counties, and the major policy options open to the World Bank in this field.

A World Bank Paper. 1975. 73 pages (including 2 annexes).

Stock No. BK 9042. $5 paperback.

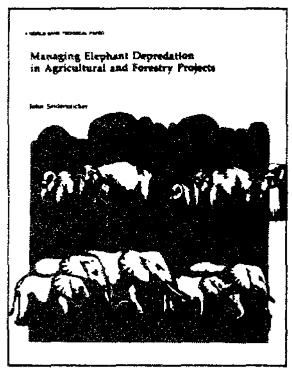
Land Tenure Systems and Social Implications of Forestry Development Programs

Michael M. Cernea

Staff Working Paper No. 452. 1981. 35 pages (including references, bibliography).

Stock No. WP-0452. $3.

NEW



Managing Elephant Depredation in Agricultural and Forestry Projects

John Seidensticker

Outlines procedures for managing elephants in and around project areas as part of the project design. Helps project designers plan activities that will protect wildlife and prevent financial loss from damage by animals. Illustrates methods used to investigate elephant behavior and ecology. Notes that careful scheduling of project activities is required to ensure that elephants are not isolated in production areas.

Technical Paper No. 16. 1984.50 pages.

ISBN 0-8213-0297-3.

Stock No. BK 0297. $3.

Managing Information for Rural Development: Lessons from Eastern Africa

Guido Deboeck and Bill Kinsey

Staff Working Paper No. 379. 1980. vii + 70 pages (including 5 annexes, index).

Stock No. WP-0379. $3.

Measuring Project Impact: Monitoring and Evaluation in the PIDER Rural Development Project—Mexico

Michael M. Cernea

Staff Working Paper No. 332. 1979. 137 pages (including 3 annexes, appendix, map).

Stock No. WP-0332. $5.

Monitoring and Evaluation of Agriculture and Rural Development Projects

Dennis J. Casley and Denis A. Lury

This book provides a how-to tool for the design and implementation of monitoring and evaluation systems in rural development projects. Because rural development projects are complex, they seek to benefit large numbers of people in remote rural areas, and they involve a variety of investments. The need for monitoring and evaluating them during implementation has been accepted in principle, but effective systems have not heretofore been formulated. The concepts of monitoring and evaluation are differentiated and issues that need to be considered in designing systems to monitor and evaluate specific projects are outlined, emphasizing the timeliness of the monitoring functions for effective management. Elaborates on such technical issues as selection of indicators, selection of survey methodology data analysis, and presentation. It is directed primarily to those working with specific projects and will be useful to project appraisal teams, to designers of monitoring and evaluation systems, and to project staff who work with these systems.

The Johns Hopkins University Press. 1982. 145 pages.

LC 82-7126. ISBN 0-8018-2910-0, Stock No. JH 2910. $8.50 paperback.

Monitoring Rural Development in East Asia

Guido Deboeck and Ronald Ng

Staff Working Paper No. 439. 1980. 91 pages (including annexes).

Stock No. WP-0439. $3.

NEW

Monitoring Systems and Irrigation Management: An Experience from the Philippines

Agricultural economists, planners, and field workers will find this 1983 case study report a practical guide for designing efficient monitoring and evaluation systems for irriation and similar projects. It illustrates the practical application of the principles covered in the 1982 publication *Monitoring and Evaluation of Agriculture and Rural Development Projects.* Highlights the problems as well as the successes.

1983. 162 pages.

ISBN 0-8213-0059-8. Stock No. BK 0059. $5.

NEW

Opportunities for Biological Control of Agricultural Pests in Developing Countries
D. J. Greathead and J. K. Waage

Describes how to use living organisms as pest control agents, either alone or as one component of pest management. Biological control offers hope of long-term—permanent—results, causes no pollution, poses no risk to human health and is often cheaper than chemical controls. Gives methods and costs. Specifies controls for specific crops found in developing countries.

Technical Paper No. 11. 1983. 55 pages.

ISBN 0-8213-0164-0. Stock No. BK 0164. $3.

Prices, Taxes, and Subsidies in Pakistan Agriculture, 1960-1976
Carl Gotsch and Gilbert Brown

World Bank Staff Working Paper No. 387. 1980. 108 pages.

Stock No. WP-0387. $5.

Project Evaluation in Regional Perspective: A Study of an Irrigation Project in Northwest Malaysia
Clive Bell, Peter Hazell, and Roger Slade

This innovative study develops quantitative methods for measuring the direct and indirect effects of agricultural projects on their surrounding regional and national economies. These methods are then applied to a study of the Muda irrigation project in northwest Malaysia. A linear programming model is used to analyze how a project changes the farm economy, and a social accounting matrix of the regional economy is then estimated. This provides the basis for a semi-input-output model, which is used to estimate the indirect effects of the project on its region. Thereafter, a similar methodology is used to estimate the project's effects on key national variables, thus permitting a full social cost-benefit analysis of the project.

The Johns Hopkins University Press. 1982. 336 pages (including maps and index).

LC 81-48173. ISBN 0-8018-2802-3, Stock No. JH 2802, $30 hardcover.

Rethinking Artisanal Fisheries Development: Western Concepts, Asian Experiences

Staff Working Paper No. 423. 1980. 107 pages (including references).

Stock No. WP-0423. $5.

Rural Development

Discusses strategy designed to extend the benefits of development to the rural poor and outlines the World Bank's plans for increasing its assistance in this sector.

Sector Policy Paper, 1975, 89 pages (including 14 annexes).

Stock No. BK 9036. $5 paperback.

NEW

Rural Financial Markets in Developing Countries
J. D. Von Pischke, Dale W. Adams, and Gordon Donald

Selected readings highlight facets of rural financial markets often neglected in discussions of agricultural credit in developing countries. Considers the performance of rural financial markets and ways to improve the quality and range of financial services for low-income farmers. Also reflects new thinking on the design, administration, evaluation, and policy framework of rural finance and credit programs in developing countries.

The Johns Hopkins University Press. 1983. 430 pages.

ISBN 0-8018-3074-5. Stock No. JH 3074. $32.50 hardcover.

Rural Poverty Unperceived: Problems and Remedies
Robert Chambers

Staff Working Paper No. 400. 1980. 51 pages (including references).

Stock No. WP-0400. $3.

Rural Projects through Urban Eyes: An Interpretation of the World Bank's New-Style Rural Development Projects
Judith Tendler

World Bank Staff Working Paper No. 532. 1982. 100 pages.

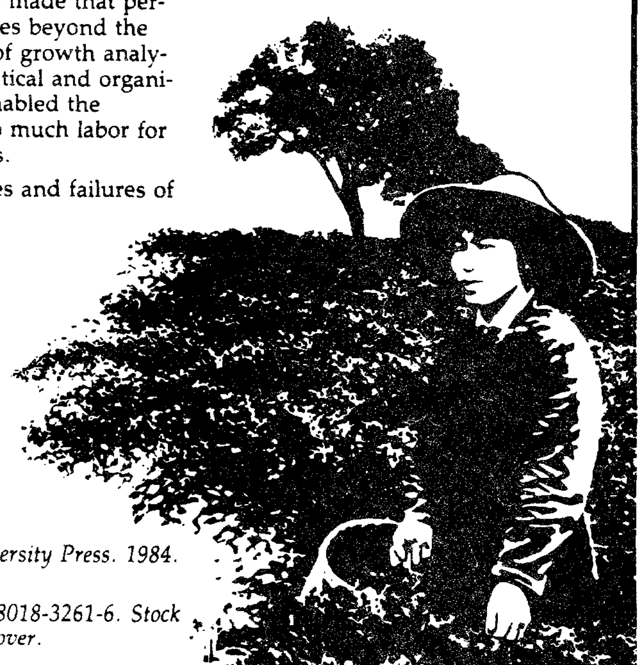
ISBN 0-8213-0028-8. Stock No. WP 0532. $3.

NEW

Rural Development in China
Dwight H. Perkins and Shahid Yusuf

Looks at China's rural development experience as a whole since 1949. Analyzes China's agricultural performance and traces it back to the technology and other sources that made that performance possible. Goes beyond the conventional sources of growth analysis to examine the political and organizational means that enabled the Chinese to mobilize so much labor for development purposes.

Describes the successes and failures of China's rural development policy. Helps clarify both the strengths and weaknesses of a self-reliant strategy of rural development.



The Johns Hopkins University Press. 1984. 232 pages.

LC 83-049366. ISBN 0-8018-3261-6. Stock No. JH 3261. $25 hardcover.

NEW

Sheep and Goats in Developing Countries: Their Present and Potential Role
Winrock International Livestock Research and Training Center

Sheep and goats are viewed as an integral component of complex agricultural systems. This comprehensive analysis leads to recommendations on the need for a balanced production system approach for research, training, and development programs. Assesses the role of sheep and goats in food production systems by examining advantages and disadvantages, aid/donor support, constraints on contributions, and overcoming constraints. Emphasizes the need for a combination of support activities and marketing and pricing policies for small ruminants and their products. Reviews ongoing projects.

Technical Paper No. 15.1983. 109 pages.

ISBN 0-8213-0272-8.

Stock No. BK 0272. $5.

Sociocultural Aspects ofDeveloping Small-Scale Fisheries: Delivering Services to the Poor
Richard B. Pollnac

Staff Working Paper No. 490. 1981. 64 pages (including references).

Stock No. WP-0490. $3.

Some Aspects of Wheat and Rice Price Policy in India
Raj Krishna and G.S. Raychaudhuri

Staff Working Paper No. 381. 1980. 62 pages (including 2 appendixes, 6 tables, bibliography).

Stock No. WP 0381. $3.

NEW

Sub-Saharan Agriculture: Synthesis and Trade Prospects
Shamsher Singh

Agricultural production, the single most important determinant of overall economic growth, has been sluggish in Sub-Saharan African countries during the past two decades. This overview takes a three-pronged approach to understanding the problems of agricultural production in the 47 countries that make up the region. It outlines domestic and global constraints; summarizes price, trade, and consumption forecasts for major agricultural exports; and project trends.

Staff Working Paper No. 608. 1983. 172 pages (including more than 75 tables and charts).

ISBN 0-8213-0221-3.Stock No. WP 0608. $5.

A System of Monitoring and Evaluating Agricultural Extension Projects
Michael M. Cernea and Benjamin J. Tepping

Staff Working Paper No. 272. 1977. 121 pages (including 9 annexes, bibliography).

Stock No. WP-0272. $5.

Thailand: Case Study of Agricultural Input and Output Pricing
Trent Bertrand

Staff Working Paper No. 385. 1980. 143 pages (including 2 appendixes).

Stock No. WP-0385. $5.NEW

Traditional Land Tenure and Land Use Systems in the Design of Agricultural Projects
Raymond Noronha and Francis J. Lethem

The feasibility of agricultural projects and their intended impact are often determined by traditional patterns of tenure and land use. This paper provides agricultural project designers with an analytical basis and rationale for examining systems and suggests how to use such information in designing projects.

Staff Working Paper No. 561. 1983. 54 pages.

ISBN 0-8213-0168-3. Stock No. WP 0561 (English) $3.

ISBN 0-8213-0269-8. Stock No. BK 0269 (French) $3.

NEW

Training and Visit Extension
Daniel Benor and Michael Baxter

Contains a comprehensive explanation of the organization and operation of the training and visit system of agricultural extension. Emphasizes simplicity and decisiveness. Defines organization and mode of operation and allows continuous feedback from farmers to extension and research workers. This method has been adopted in some 40 countries in Asia, Africa, Europe, and Central and South America. Useful to extension staff at all levels, agricultural research personnel, trainers, and staff of agricultural organizations, as well as universities and training institutions involved in agricultural and rural development and public administration.

1984. 214 pages.

ISBN 0-8213-0121-7.Stock no. BK 0121. $15.

Women and the Subsistence Sector: Economic Participation and Household Decisionmaking In Nepal
Meena Acharya and Lynn Bennett

Fascinating analysis of the complex social, demographic,and economic factors that affect women's decisionmaking role in the subsistence sector. Data collected from seven villages show women play a major role in agricultural production, both as laborers and managers. Bringing women into the market economy would make better use of local resources and improve their status and economic security in Nepal.

Staff Working Paper No. 526.1983. 160 pages.

ISBN 0-8213-0024-5. Stock No. WP 0526. $5.

The World Bank Publications Order Form

SEND TO: **YOUR LOCAL DISTRIBUTOR** OR TO **WORLD BANK PUBLICATIONS**
(See the other side of this form.)
P.O. BOX 37525
WASHINGTON, D.C. 20013 U.S.A.

Date ____________________

Name ______________________________

Title ______________________________

Firm ______________________________

Address ______________________________

City __________ State ______ Postal Code __________

Country __________ Telephone (______) __________

Purchaser Reference No. ____________________

Ship to: (Enter if different from purchaser)

Name ______________________________

Title ______________________________

Firm ______________________________

Address ______________________________

City __________ State ______ Postal Code __________

Country __________ Telephone (______) __________

Check your method of payment.
Enclosed is my ☐ Check ☐ International Money Order ☐ Unesco Coupons ☐ International Postal Coupon.
Make payable to World Bank Publications for U.S. dollars unless you are ordering from your local distributor.

Charge my ☐ VISA ☐ MasterCard ☐ American Express ☐ Choice. (Credit cards accepted only for orders addressed to World Bank Publications.)

______________________ Credit Card Account Number ______________ Expiration Date ______________________ Signature

☐ Invoice me and please reference my Purchase Order No. ______________.

Please ship me the items listed below.

Stock Number	Author/ Title	Customer Internal Routing Code	Quantity	Unit Price	Total Amount $

All prices subject to change. Prices may vary by country. Allow 6–8 weeks for delivery.

Subtotal Cost $______

Total copies ______ Air mail surcharge if desired ($2.00 each) $______

Postage and handling for more than two complimentary items ($2.00 each) $______

Total $______

Thank you for your order.

IBRD-0053

Distributors of World Bank Publications

ARGENTINA
Carlos Hirsch, SRL,
Attn: Ms. Monica Bustos
Florida 165 4° piso
Galeria Guemes
Buenos Aires 1307

AUSTRALIA, PAPUA NEW GUINEA, FIJI, SOLOMON ISLANDS, WESTERN SAMOA, AND VANUATU
The Australian Financial Review Information Service (AFRIS)
Attn: Mr. David Jamieson
235-243 Jones Street
Broadway
Sydney, NSW 20001

BELGIUM
Publications des Nations Unies
Attn: Mr. Jean de Lannoy
av. du Roi 202
1060 Brussels

CANADA
Le Diffuseur
Attn: Mrs. Suzanne Vermette
C.P. 85, Boucherville J4B 5E6
Quebec

COSTA RICA
Libreria Trejos
Attn: Mr. Hugo Chamberlain
Calle 11-13, Av. Fernandez Guell
San Jose

DENMARK
Sanfundslitteratur
Attn: Mr. Wilfried Roloff
Rosenderns Alle 11
DK-1970 Copenhagen V.

EGYPT, Arab Republic of
Al Ahram
Attn: Mr. Sayed El-Gabri
Al Galaa Street
Cairo

FINLAND
Akateeminen Kirjakauppa
Attn: Mr. Kari Litmanen
Keskuskatu 1, SF-00100
Helsinki 10

FRANCE
World Bank Publications
66, avenue d'Iéna
75116 Paris

GERMANY, Federal Republic of
UNO-Verlag
Attn: Mr. Joachim Krause
Simrockstrasse 23
D-5300 Bonn 1

HONG KONG, MACAU
Asia 2000 Ltd.
Attn: Ms. Gretchen Wearing Smith
6 Fl., 146 Prince Edward Road
Kowloon

INDIA
UBS Publishers' Distributors Ltd.
Attn: Mr. D.P. Veer
5 Ansari Road, Post Box 7015
New Delhi 110002
(Branch offices in Bombay, Bangalore, Kanpur, Calcutta, and Madras)

INDONESIA
Pt. Indira Limited
Attn: Mr. Bambang Wahyudi
Jl, Dr. Sam Ratulangi No. 37
Jakarta Pusat

IRELAND
TDC Publishers
Attn: Mr. James Booth
12 North Frederick Street
Dublin 1

JAPAN
Eastern Book Service
Attn: Mr. Terumasa Hirano
37-3, Hongo 3-Chome, Bunkyo-ku 113
Tokyo

KENYA
Africa Book Services (E.A.) Ltd.
Attn: Mr. M.B. Dar
P.O. Box 45245
Nairobi

KOREA, REPUBLIC OF
Pan Korea Book Corporation
Attn: Mr. Yoon-Sun Kim
P.O. Box 101, Kwanghwamun
Seoul

MALAYSIA
University of Malaya Cooperative Bookshop Ltd.
Attn: Mr. Mohammed Fahim Htj Yacob
P.O. Box 1127, Jalan Pantai Baru
Kuala Lumpur

MEXICO
INFOTEC
Attn: Mr. Jorge Cepeda
San Lorenzo 153-11, Col. del Valle,
Deleg. Benito Juarez
03100 Mexico, D.F.

NETHERLANDS
MBE BV
Attn: Mr. Gerhard van Bussell
Noorderwal 38,
7241 BL Lochem

NORWAY
Johan Grundt Tanum A.S.
Attn: Ms. Randi Mikkelborg
P.O. Box 1177 Sentrum
Oslo 1

PANAMA
Ediciones Libreria Cultural Panamena
Attn: Mr. Luis Fernandez Fraguela R.
Av. 7, Espana 16
Panama Zone 1

PHILIPPINES
National Book Store
Attn: Mrs. Socorro C. Ramos
701 Rizal Avenue
Manila

SAUDI ARABIA
Jarir Book Store
Attn: Mr. Akram Al-Agil
P.O. Box 3196
Riyadh

SINGAPORE, TAIWAN, BURMA
Information Publications Private, Ltd.
Attn: Ms. Janet David
02-06 1st Floor, Pei-Fu Industrial Building
24 New Industrial Road
Singapore

SPAIN
Mundi-Prensa Libros, S.A.
Attn: Mr. J.M. Hernandez
Castello 37
Madrid

SRI LANKA AND THE MALDIVES
Lake House Bookshop
Attn: Mr. Victor Walatara
41 Wad Ramanayake Mawatha
Colombo 2

SWEDEN
ABCE Fritzes Kungl, Hovbokhandel
Attn: Mr. Eide Segerback
Regeringsgatan 12, Box 16356
S-103 27 Stockholm

SWITZERLAND
Librairie Payot
Attn: Mr. Henri de Perrot
6, rue Grenus
1211 Geneva

TANZANIA
Oxford University Press
Attn: Mr. Anthony Theobold
Maktaba Road, P.O. Box 5299
Dar es Salaam

THAILAND
Central Department Store, Head Office
Attn: Mrs. Ratana
306 Silom Road
Bangkok

Thailand Management Association
Attn: Mrs. Sunan
308 Silom Road
Bangkok

UNITED KINGDOM AND NORTHERN IRELAND
Microinfo Ltd.
Attn: Mr. Roy Selwyn
Newman Lane, P.O. Box 3
Alton, Hampshire GU34 2PG
England

UNITED STATES
The World Bank Book Store
600 19th Street, N.W.
Washington, D.C. 20433
(Postal address: P.O. Box 37525
Washington, D.C. 20013, U.S.A.)

Baker and Taylor Company
501 South Gladiola Avenue
Momence, Illinois, 60954

380 Edison Way
Reno, Nevada, 89564

50 Kirby Avenue
Somerville, New Jersey, 08876

Commerce, Georgia 30599

Bernan Associates
9730-E George Palmer Highway
Lanham, Maryland, 20761

Blackwell North America, Inc.
1001 Fries Mill Road
Blackwood, New Jersey 08012

Sidney Kramer Books
1722 H Street, N.W.
Washington, D.C. 20006

United Nations Bookshop
United Nations Plaza
New York, N.Y. 10017

VENEZUELA
Libreria del Este
Attn. Mr. Juan Pericas
Avda Francisco de Miranda, no. 52
Edificio Galipan, Aptdo. 60.337
Caracas 1060-A

WORLD BANK TECHNICAL PAPERS (continued)

No. 21. Industrial Restructuring: Issues and Experiences in Selected Developed Economies

No. 22. Energy Efficiency in the Steel Industry with Emphasis on Developing Countries

No. 23. The Twinning of Institutions: Its Use as a Technical Assistance Delivery System

No. 24. World Sulphur Survey

No. 25. Industrialization in Sub-Saharan Africa: Strategies and Performance

No. 26. Small Enterprise Development: Economic Issues from African Experience

The World Bank

Headquarters
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

Telephone: (202) 477-1234
Telex: WUI 64146 WORLDBANK
RCA 248423 WORLDBK
Cable Address: INTBAFRAD
WASHINGTONDC

European Office
66, avenue d'Iéna
75116 Paris, France

Telephone: (1) 723-54.21
Telex: 842-620628

Tokyo Office
Kokusai Building
1-1 Marunouchi 3-chome
Chiyoda-ku, Tokyo 100, Japan

Telephone: (03) 214-5001
Telex: 781-26838

Cover design by Bill Fraser

ISSN 0253-7494
ISBN 0-8213-0398-8