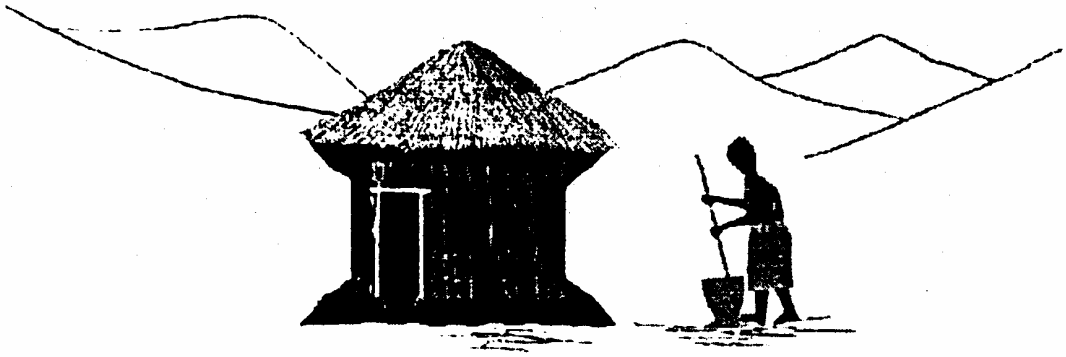
Rwanda Society-Environment Project
Working Paper 2
April 1994

Farming Systems of Rwanda:
Echoes of Historic Divisions Reflected in
Current Land Use

by

Jennifer M. Olson



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PREFACE

The Rwanda Society-Environment Project has its origins in the work of the MSU Center for Advanced Study of International Development (CASID) Environment and Development Project. This project was begun in 1989 and was funded initially by the MSU Foundation.

The Project has developed into a collaborative effort involving Michigan State University, the United Nations Environment Programme, Global Resources Information Database, and in Rwanda the Ministries of Agriculture and Environment and Tourism, and the National University. The objective of the Project is to assist in the improvement of analysis and policy making for natural resources management (NRM) in Africa through a pilot study in Rwanda to identify optimum and minimum data sets for NRM.

The **Working Papers** are intended to serve as a forum for the research team to publish the initial research findings for discussion purposes. **Working paper, 1** in this series presents an overview of the project's objectives and activities.

Funding for the research project at Michigan State University (MSU) is provided by MSU, and the Consortium for International Earth Science Information Network (CIESIN), the SEDAC for NASA, under contract CSN #415-93. The International Development Research Centre (IDRC), Ottawa provided seed money for the Rwandan team. UNEP-GRID has donated the costs of its activities on the project. The support of these institutions is gratefully acknowledged. The individual authors remain responsible for the contents of the **Working Papers** which should not be interpreted as necessarily reflecting the views of the Government of Rwanda, UNEP, IDRC, CIESIN, NASA, or MSU.

This study was conducted before the recent events in Rwanda beginning in April 1994. The events have completely altered the situation of farmers in Rwanda. Nevertheless it is hoped that the lessons learned from the research will still be of use to other countries of Africa, and that they may help in the rebuilding of Rwanda in the future.

This study is dedicated to the people of Rwanda, with greatest sympathy.

I. INTRODUCTION AND SUMMARY[1]

LAND USE REPRESENTS THE SPATIAL IMPRESSION OF THE INTERACTION BETWEEN SOCIO-economic systems and the natural environment. Changes in land use indicate that the patterns of interaction are being altered. In Rwanda major changes in land use have occurred in the past 30 years as a predominantly rural subsistence agriculture society has adapted to a variety of social, economic, political and environmental processes.

For planners concerned with rural development in Rwanda, understanding the agricultural systems of the country are of great importance. In 1975 Delepierre identified regions based upon agricultural potential (elevation, rainfall and soils) which have served as a base for agricultural policy planning since.

The purpose of this paper is to asses the degree to which actual regional distribution of crops and livestock, which reflects the reality of rural Rwanda life, coincides with the agricultural potential regions. The actual regions, Farming System Regions, are based upon a statistical analysis of agricultural production data collected by the Rwandan Ministry of Agriculture in 1987.

The findings of the study demonstrate similarities and important differences between agricultural potential and farming system regions. The similarities reveal the influence of the natural environment on crop choice while the differences reflect long- standing cultural characteristics and also more recent influences of political decisions, economic development and alterations of the physical environment.

The comparison serves to emphasize the importance of understanding the complex patterns of interaction between social and environmental systems over time. Some patterns and processes are durable while others represent responses of farmers to changes in the economic and political contexts of agricultural production.

The study concludes that agricultural policy-making would be improved by consideration of both the natural potential of the land and of the social system affecting how people manage their resource base within the constraints of social/cultural, political and economic processes. In the formation of policies to increase agricultural production while sustaining the productive capacity of natural systems, the interaction between the human and natural systems, and how the policies may influence this interaction, need to be considered.

[1]This paper is based on Olson and Campbell 1993.

II. PAST REGIONALIZATIONS OF RWANDA

REGIONALIZATIONS ARE NOTHING NEW TO RWANDA. AUTHORS HAVE PERIODICALLY classified the Rwandan landscape. The first published maps recorded the traditional, customary divisions of the country by the Rwandans. The European cartographers labeled these as "natural regions" since they assumed the regions were based on variations in topography, geology, climate, and the flora and fauna of the area (Everaerts 1939). The regions, however, reflected a long history of cultural distinctiveness between areas and old political boundaries including kingdoms. The continuing imprint of these regions will be discussed in Section IV of this paper.

Only in 1975 did an agronomist, G. Delepierre, delineate a new regionalization based on the current knowledge of soils, climate and elevation (Delepierre 1975). The new agro-climatic regionalization differed significantly from the old divisions, and it quickly became the basis for agronomic research and governmental planning for the introduction of new crops. Recently, the Minister of Agriculture in 1992-1993, Mr. James Gasana, created another agro-climatic regionalization similar to that of Delepierre but with a finer resolution. The latest agro-climatic regionalization was created by the Projet Carte Pedologique du Rwanda in 1992 based on soil survey results, elevation and climatic data. It, too, strongly resembles the original Delepierre map with a north-south zonation paralleling elevation belts. These regionalizations all attempt to describe the physical landscape of the country, especially in terms of their agronomic potential to produce different crops.

An attempt to create a different sort of regionalization based on Ministry of Agriculture 1980 data of estimated area under food crops was published by Charlery de la Masselière et al in 1986. A factor analysis helped to group crops grown in the same area and a cluster analysis grouped communes into regions. The resultant "food crop regions" (la répartition régionale des cultures vivrières) differed for each season and for annual composite. The boundaries of a few homogenous regions persisted from one period to another but the boundaries of other less homogenous regions changed. Nevertheless the authors delimited 14 regions based on the annual figures, and then compared them with the agro-climatic regions of Delepierre. Certain food crop regions were similar to those of the agro-climatic map but others were significantly different. The authors explain little of the reasons behind this difference. Their regionalisation is similar to that presented in this paper in that they are both based on Ministry of Agriculture commune-level figures. However the Charlery de la Masselière study used estimates of area under crops, a estimate by Ministry staff not based on air photo interpretation, field reports or other information. The study presented in this paper used crop and livestock production estimates which are based on monthly field reports by the commune agronomists. None of the estimates is infallible and they reflect the opinions of Ministry staff (including Mr. Delepierre) of the distribution of crops and animals but the production figures seem to be somewhat less of an approximation.

A second food crop production regionalization was created by Clay and Dejaegher (1987) after they had analyzed agricultural production data from household surveys. They found that the Delepierre agro-climatic zones did not reflect apparent cultural differences between the north and the south in farmer crop choices. They therefore drew a line between the north and the south in the Western Highlands to create a combination agro-climatic/cultural regionalization consisting of five large blocks.

The regionalization presented in this paper differs by being based not on historical cultural units, or agro-climatic limitations to crop production, but on analysis of crop production and livestock statistics at a relatively fine spatial scale. This paper thus presents actual farming system regions in which each region is composed of a unique combination of crop and livestock production. These farming system regions are then compared to areas of potential agricultural production, the agro-climatic regions.

III. METHOD OF FARMING SYSTEM REGIONALIZATION

THE FARMING SYSTEM REGIONS WERE DERIVED AFTER A PROCESS OF EXPLORING THE relationships between the spatial distribution of various crops and animals and then applying these insights with statistical techniques to derive a classification of communes.

The crop and animal production data used in this regionalization is from Production Agricole en 1987: Bilan d'Autosuffisance Alimentaire par Commune et par Habitant (MINAGRI 1989). This source was chosen because it contains the most reliable data available at a fine scale of resolution, the commune. Although agricultural production estimates are gathered monthly at the commune level, the methodology is not standardized and varies from area to area. The authors of this book chose 1987 as a "typical" climatic and agricultural year and then adjusted the field estimates with household survey measurements of DSA/MINAGRI available at the prefecture level.

Initially, simple correlation analysis was conducted to examine the statistical relationships between crops and animals. This was to discover what crops and animals were produced together within the country. Certain patterns emerged which were then further explored with principal components analysis (PCA). The Statistical Package for the Social Sciences (SPSS/PC+ version 5.0) was used for the analyses.

PCA was conducted using crop and animal production statistics for all available crops and animals. Distinct groupings of crops were found and these factors were then mapped (Figure 1). Certain crops and animals emerged as key in defining the factors due to the methodology of PCA. These were of course the crops and animals which are distinctive in that they 1) have a similar distribution pattern to one or more of the other crops or animals, and 2) are not dispersed evenly across communes but have a skewed distributional pattern.

Crop groupings emerged concentrated in distinct parts of the country. For example, a factor in which millet and wheat were the defining variables was concentrated in 8 contiguous communes in the south-center. Another factor with taro, soybeans and yams as the defining variables scored high in the south- and center-west of the country. These areas highlighted by the PCA are exceptional in terms of physical or societal features. For example, two small extremely high altitude zones emerged as two of the five factors. Factors describing the majority of the country, however, did not emerge in the PCA. Indeed the factors were defined with crops that are minor even in the areas in which they are grown (e.g. millet, taro, wheat, peanuts). The most important subsistence and commercial crops, such as sweet potatoes and beans, are ubiquitous throughout the country and did

not clearly emerge in the PCA analysis process. In sum, the PCA identified exceptional zones instead of common regions. Similarly, cluster analysis conducted with all crop and animal variables created small clusters of communes whose similarity was their specialization in minor, unusual crops, and one or two other clusters grouping together the vast majority of communes.

Since the objective of the study was to identify homogenous regions whose farming systems are based on the same staple crops and animals, it was decided to classify the communes on the basis of their *major* crops and animals. The large livestock of cattle, sheep, goats and pigs, were all included in the classification. The determination of major crops was accomplished by determining which crops had relatively high production in those communes in which the crops were produced.

To determine which crops were to be considered major and included in the analysis, production was measured in kilocalories, not kilograms, since it provided a better comparison of the relative importance of each crop. The kilogram production of potatoes, for example, may be much larger than that of beans, but when measured in kilocalories their relative importance is comparable. To determine major crops, all communes in which a crop's production was at least 500 calories annually were first selected, and then the mean production of that crop was calculated for those communes. If the mean production was at least 10,000 calories, the crop was considered a major crop. The crops thus considered major and included in the regionalization were bananas, beans, sorghum, sweet potatoes, white potatoes and cassava. These crops are not only produced in large quantities, but most are grown fairly widely across the country if with varying degrees of importance. The minor crops excluded are peas, peanuts, soybeans, maize, millet, rice, taro and yams. These minor crops had frequently defined factors in PCA since they are only grown in particular sections of the country.

In order to compare the relative importance of production between communes, the kilograms produced in each commune were standardized to reduce the effect of commune size. Production *per capita* was chosen as the standard since 1) the MINAGRI area under crop estimates are less reliable than the production estimates, and 2) production per capita would, in the case of Rwanda where nearly all of the rural population is farmers, give a good indication of household-level decision making of what crops and animals are produced. Since the crop and animal production data was based on 1987 statistics, an estimate of the 1987 population was used for the standardized statistic. The 1987 population was estimated by interpolating between the censuses of 1978 and 1991 (MINIPLAN 1982; MINIPLAN 1992).

Urban communes were then excluded from the analysis since their agricultural production per apita is, of course, much lower than in the rest of the country and this would skew the analyses. The urban communes were defined on the basis of their population concentrations, existence of urban-related functions (hospitals, universities, airports etc) and minimal agricultural activity (sources of data: Ben Chaabane et al 1991, MINIPLAN 1992). Cluster analysis identified five communes as particularly urban, namely those of Kigali (Nyarugenge commune), Butare (Ngoma), Cyangugu (Kamembe), Gisenyi (Rubavu), and Ruhengeri (Kigombe).

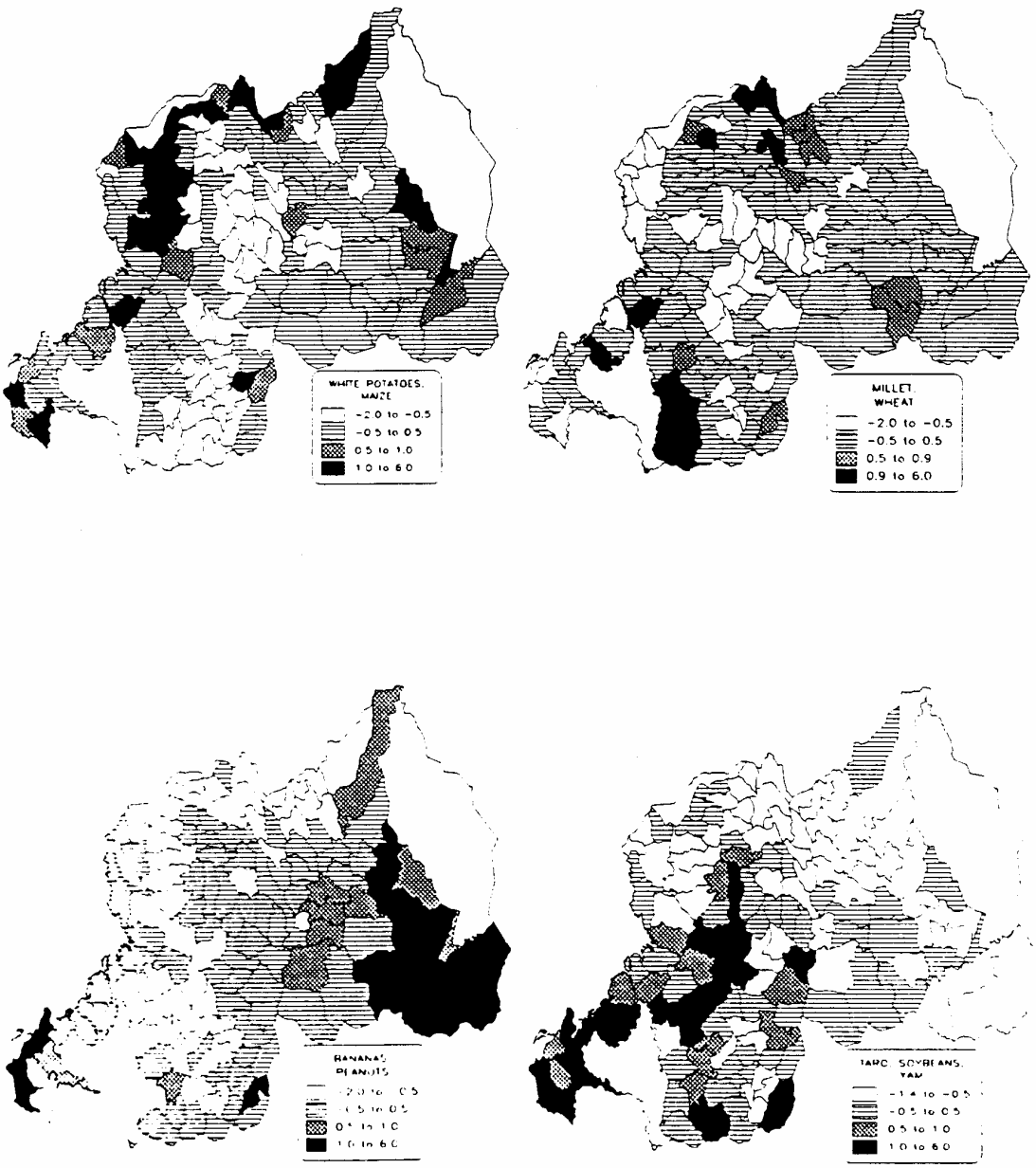

Figure 1 Mapped Factor Scores

Finally, with the major crop and animal production variables standardized as per capita production and normalized as Z scores, and urban communes excluded, cluster analysis was performed (Table 1). The Ward method was used to group communes with similar crop and animal production patterns. The resultant clusters were mapped in the MAPVIEW program and it was found that most communes in each cluster were spatially contiguous— there did seem to be a distinctive spatial pattern of farming systems. Some of the exceptional zones which had emerged from the PCA analysis (the eastern edge of Nyungwe Forest, Bugesera, the southwest and southeast corners) appeared integrated into larger farming systems. The communes along the Parc des Volcans in the Northwest remained as a separate entity. The rest of the country had been divided into clearly distinct regions with similar farming patterns.

A determination of the most meaningful and interpretable number of regions was made as eight. A few outlier communes which had not been classified with a spatially contiguous region were placed within the spatially-contiguous region they most resembled (as determined by which they joined when the number of clusters was reduced). Similarly, the five urban communes were assigned to the spatially-contiguous region they most resembled.

Once the regionalization was completed, statistical analysis was performed to describe and contrast the regions. Tables of agricultural production, as well as elevation, rainfall and population density, help to characterize the regions (Tables 2 to 4). The statistical difference in per capita crop and livestock production between regions was tested with multiple comparison testing .[2] The production of some livestock, that of sheep and pigs, is very concentrated with Gikongoro producing more pigs and the Volcanic Highlands producing more sheep than any other region. Production of sheep is less important but still significantly higher in the Burberuka Foothills, the Burberuka Highlands and Norther Ridge, and Gikongoro than in the other regions. On the other hand, cattle and goat production is less concentrated but the Eastern Lowlands does produce more cattle than the northern regions and Kibungo, and Kibungo does produce significantly more goats than most other regions.

Similarly, some crops appear very concentrated in one or two regions, especially minor crops which had not been used in the regionalization procedure. The crops produced in significantly higher quantities in one region compared to *all* other regions include peanuts and bananas in Kibungo, millet (eleusine) in Gikongoro, rice and sorghum in the Eastern Lowlands, and maize and white potatoes in the Volcanic Highlands. Some of these crops are found in other regions as well in significantly higher quantities than the rest of the country, for example peanuts are also concentrated in the Eastern Lowlands, and maize and white potatoes in the Buberuka Highlands/ Northern Ridge. Some crops are less concentrated than those but still grown in higher quantities in only two or three regions compared to the rest of the country, such as peas in the Buberuka Highlands/Northern Ridge and the Volcanic Highlands, wheat in the Volcanic Highlands, Buberuka Highlands/Northern Ridge and in Gikongoro, and cassava in the Eastern Lowlands and the Central Plateau. Other crops are widely grown and only distinguished by where they are *not* grown, including beans (everywhere but in the Volcanic Highlands and Gikongoro) and sweet potatoes (again not in the Volcanic Highlands).

The concentration of some livestock and particularly of minor crops illustrates the uniqueness

[2] A one-way analysis of variance was conducted with Duncan range, harmonic means and .05 level of significance.

Table 1 Production by Farming System Region (Z scores of mean annual per capita production)

	FARMING SYSTEM REGION								TOTAL RURAL COMMUNES
	Volcanic Highlands	Buberuka & No. Ridge	Buberuka Foothills	Gikongoro	Lake Kivu Shore	Central Plateau	Eastern Lowlands	Kibungo	
INCLUDED IN CLUSTER ANALYSIS:									
Banana (Z)	-1.202	-.936	-.034	-.917	.079	.093	.190	2.397	.000
Bean (Z)	-1.416	-.168	.222	-.949	-.664	.209	.755	.603	.000
Cassava (Z)	-1.159	-1.016	-.776	-.318	-.351	.797	.844	-.287	.000
White potato (Z)	4.559	.856	-.194	.033	-.014	-.415	-.401	-.428	.000
Sorghum (Z)	-.730	-.444	.111	-.210	-.896	-.185	1.244	.429	.000
Sweet potato (Z)	-1.983	-.857	.796	.779	-.351	.557	-.358	-.810	.000
Cattle (Z)	-.560	-.479	-.309	.118	-.179	.102	.681	-.351	.000
Goats (Z)	-.416	-.549	.066	-.158	.304	-.546	.610	.929	.000
Pigs (Z)	-.609	-.523	-.308	2.175	-.050	-.079	-.421	-.337	.000
Sheep (Z)	1.828	.845	1.227	.579	-.405	-.504	-.648	-.916	.000
NOT INCLUDED IN CLUSTER ANALYSIS:									
Coffee (Z)	-1.035	-.889	-.409	-.036	.646	.287	.214	-.220	.000
Eleusine millet (Z)	-.261	.070	-.205	1.239	.105	-.259	-.238	-.261	.000
Maize (Z)	2.633	1.015	.272	-.348	.414	-.444	-.491	-.612	.000
Pea (Z)	1.027	1.488	.135	.298	.179	-.531	-.534	-.574	.000
Peanut (Z)	-.492	-.492	-.451	-.485	-.367	-.307	.769	2.324	.000
Rice (Z)	-.283	-.283	-.160	-.283	-.283	-.061	.718	.258	.000
Soybean (Z)	-.586	-.580	-.370	.185	.424	.430	-.212	-.305	.000
Taro tuber (Z)	-.788	-.725	-.094	.784	.640	.078	-.186	-.647	.000
Wheat (Z)	1.276	.904	.076	.746	-.345	-.352	-.371	-.372	.000
Yam (Z)	-.638	-.638	-.509	.477	.256	.251	.186	-.426	.000

mentioned as having a concentration of a particular crop or animal still have a unique combination of different crops and animals.

IV. COMPARING FARMING SYSTEMS WITH OTHER REGIONALIZATIONS

THE SPATIAL PATTERN OF THE FARMING SYSTEM REGIONS WAS EXPECTED TO FOLLOW THE physical environmental factors which affect crop growth. Rwanda is characterized by dramatic contrasts in temperature and rainfall as the elevation changes from the lowland savanna areas of the East to the mountain chains of the West. An agronomist, Delepierre (1975), used elevation, rainfall and soils information to demarcate agro-climatic regions which depict zones within which different crops would best grow (Figure 2). Most of his regions flow north to south in wide elevation belts. They are regions of potential crop distributions. He wrote that other criteria such as natural vegetation and even human population density were directly related to these principal physical factors. His regions and others similar to his have become the standard used by the government for agricultural planning, research and policy. For example, the government has initiated import-substitution wheat production programs in the Terres de Laves, the Hautes Terres du Buberuka and the Crête Congo-Nil based on their climate and soil characteristics.

The farming system regions (Figure 3), appear to be somewhat similar to Delepierre's regions. There is a distinct north/south belt separating the East from the West and another separating the Central Plateau from Lake Kivu Shore. Similarly the descent in the Northwest from the Volcanoes to the Burberuka Highlands and then the Burberuka Foothills is reflected in the ringed farming system regions as the staple crops change with elevation.

However, the north/south belts also reflect societal factors which affect what crops and animals are growth today. The 1500 meter division between the Eastern and Western farming system regions is an historical political divide. The mid-latitude foothills of the Western Highlands were densely settled with a system of intense cultivation by the 18th century. The unusual concentration of farmers was probably attracted by the high agricultural potential and lack of diseases (Gourou 1953), but a highly organized political system also provided the necessary structure for coexistence. The population grew in the 19th and 20th centuries with the adoption of crops from the New World and elsewhere (Schijns 1987, Chretien 1984), and slowly the area under cultivation expanded. The new settlements were, however, restricted from cultivating the Eastern savanna since that area was reserved as pasture for the King's cattle (Newberry 1988). Only at independence in 1962 was the East opened for in-migration, and the resultant wave of migrants developed separate farming systems from whence they had come.

Other historical legacies continue to affect crop and animal production patterns which overlay the physical environmental variables and have led to regional blocks dividing the north/south belts. Indeed, the farming system regions presented here, created with recent crop production data, unexpectedly resemble the old "regions naturelles," or *cultural regions* (Figure 3).

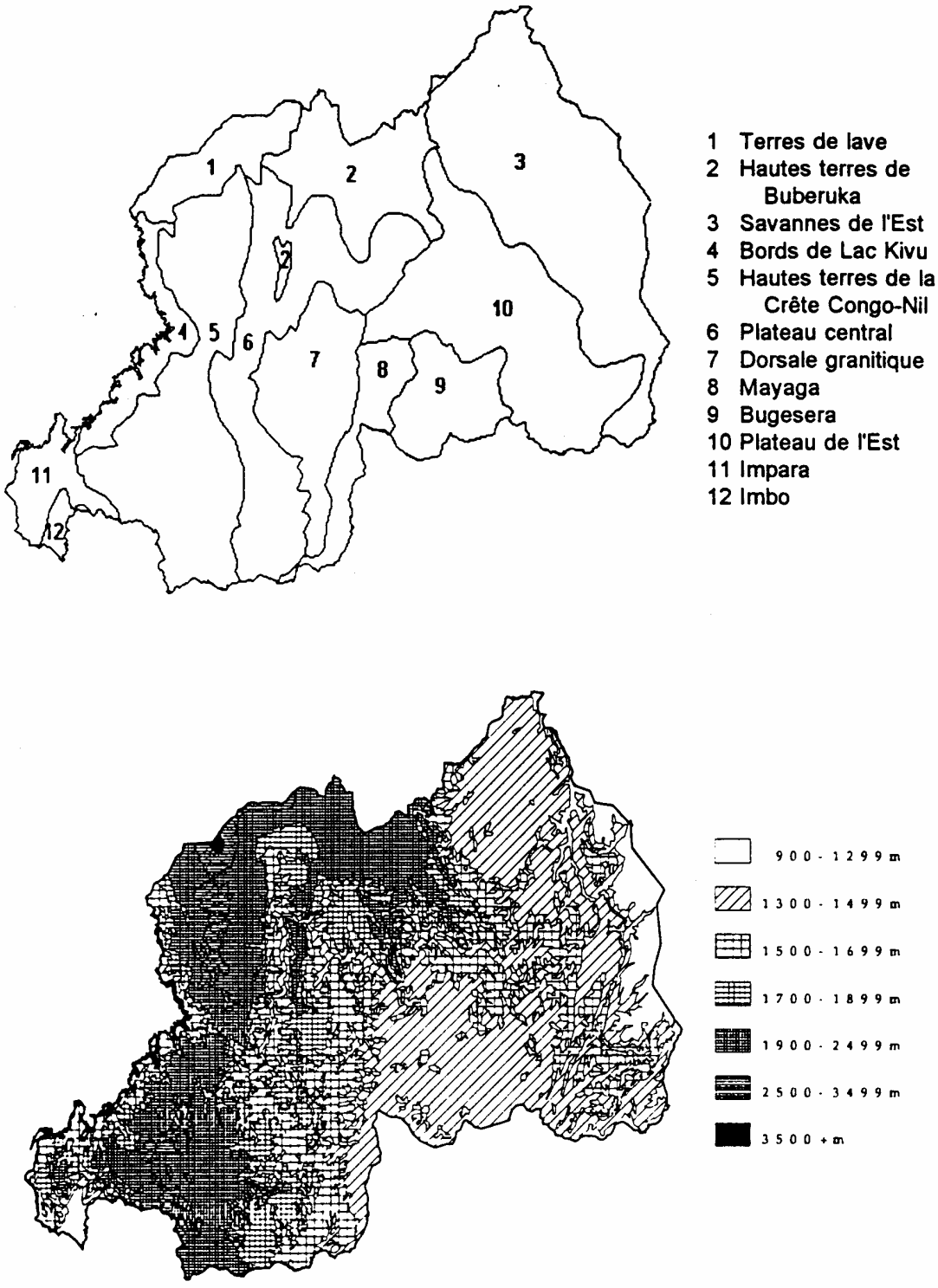

Figure 2 Agro-Climatic Regions (from Delepierre 1975), Elevation (from Prioul and Sirven 1984)

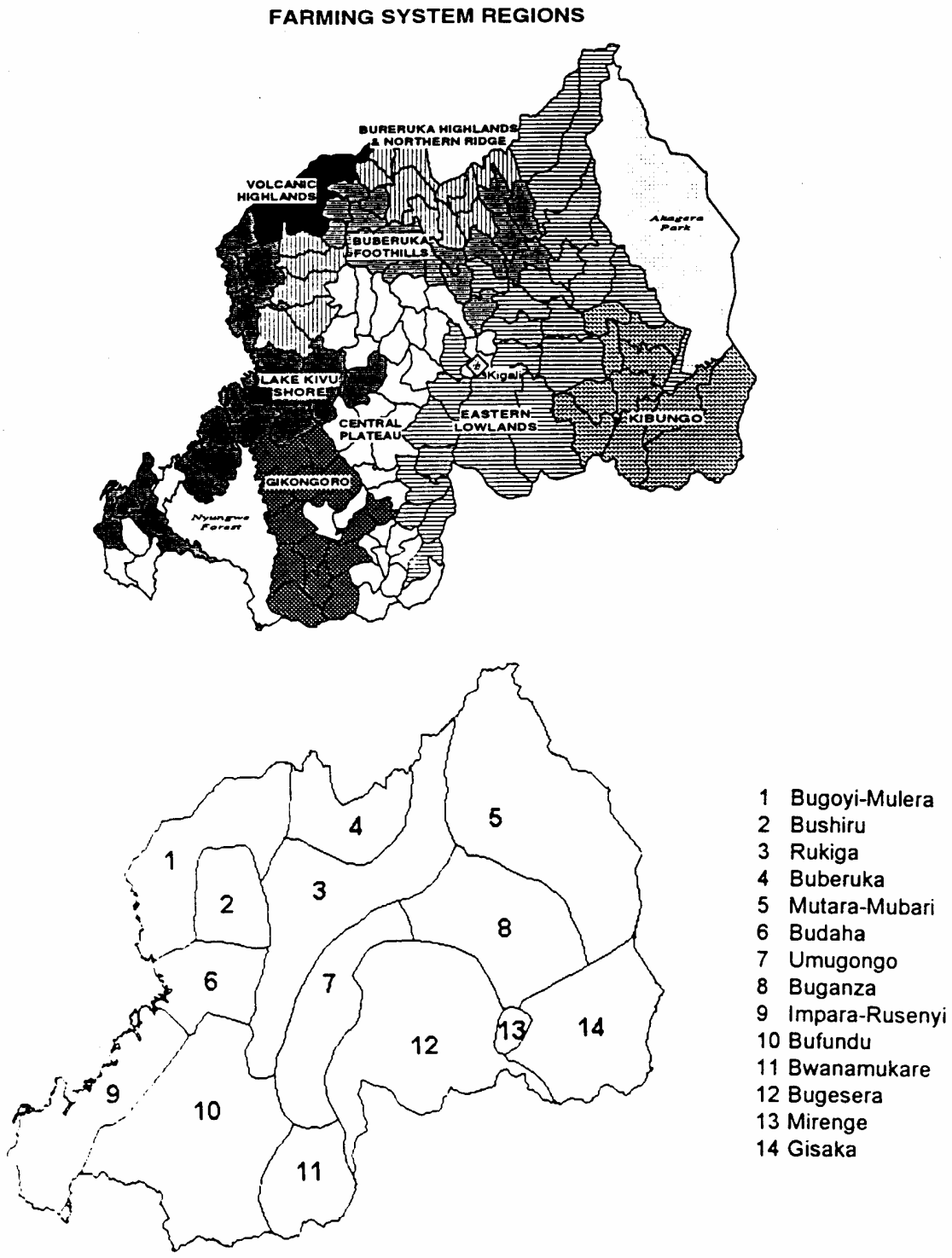

Figure 3 Farming System Regions (upper); Cultural Regions (lower: from Nzisabira 1989, after Min des Colonies 1950)

Table 2 Characteristics of Farming System Regions

Farming System Region	Elevation[1] m (mean)	Rainfall[2] mm (mean)	Soils[3]	Crops and Animals "Defining" Cluster	Principal Crops (important minor crops)	Comparable Cultural Regions
Volcanic Highlands	2200-2400 (2200)	1300-1500 (1300)	andepts, andosols (recent volcanics)	white potato, sheep	white potato, maize (maize, wheat, pea)	Bugoyi-Mulera
Buberuka Highlands & Northern Ridge	1900-2000 (1900)	1200-1600 (1300)	humic ferrisols (on schist)	white potato, sheep, beans	beans, sweet potato, white potato, maize, sorghum (pea, maize, wheat)	Buberuka
Buberuka Foothills	1500-1900 (1700)	1100-1360 (1300)	humic ferrisols (on schist)	sheep, sweet potato	sweet potato, beans, bananas, sorghum	Rukiga
Gikongoro	1500-2100 (1800)	1200-1500 (1300)	high elev.: umbrepts (highly acidic); mid-elev.: ferrisols on granite	pigs, sweet potato, sheep	sweet potato, sorghum, beans, cassava (millet, taro, wheat)	Bufundu
Lake Kivu Shore	1400-2000 (1700)	1200-1500 (1300)	shore: ferrisols on schists mid-elev.: umbrepts	low/average production of variety of crops	bananas, sweet potato, beans, cassava (taro)	Impara, Budaha, Bugoyi
Central Plateau & Imbo	1100-1800 (1600)	1000-1500 (1200)	north: ferrisols on granite; south: ferrisols on quartzite crests, histosols in valleys	cassava, sweet potato	sweet potato, bananas, beans, cassava, sorghum	Rukiga, Umugongo, Bwanamukare, Imbo
Eastern Lowlands	1200-1600 (1400)	700-1200 (1000)	xero-ferralsols on slopes, vertisols in valleys; near Kigali: ferralsols	sorghum, cassava, beans, cattle, goats	sorghum, beans, bananas, cassava, sweet potato (peanuts, rice)	Mayaga, Bugesera, Buganza, Mutara-Mubari
Kibungo	1200-1400 (1300)	800-1000 (900)	humic ferralsols with lateritic sites	bananas, goats, beans	bananas, beans, sorghum, sweet potato, cassava (peanuts)	Gisaka

[1] Source: Prioul and Sirven 1981. Mean derived from analysis in IDRISI.

[2] Source: MINITRAP 1992. Mean derived from analysis in IDRISI.

[3] Source: from Prioul and Siven 1981

Table 3 Mean Annual Per Capita Production (kg) by Farming System Region

	FARMING SYSTEM REGION								TOTAL RURAL COMMUNES
	Volcanic Highlands	Buberuka & No Ridge	Buberuka Foothills	Gikongoro	Lake Kivu Shore	Central Plateau	Eastern Lowlands	Kibungo	
Banana (kg/cap)	1.9	9.3	34.4	9.8	37.5	37.9	40.6	102.1	35.3
Bean (kg/cap)	14.4	39.8	47.7	23.9	29.7	47.4	58.5	55.4	43.2
Pea (kg/cap)	7.5	9.4	3.9	4.6	4.1	1.2	1.2	1.1	3.4
Maize (per cap)	40.0	24.4	17.3	11.3	18.7	10.4	10.0	8.8	14.7
Sorghum (kg/cap)	14.5	20.7	32.7	25.8	10.9	26.3	57.2	39.6	30.3
Cassava (kg/cap)	0.0	9.9	26.6	58.4	56.1	135.8	139.1	60.6	80.5
White potato (kg/cap)	474.5	125.4	26.4	47.8	43.3	5.5	6.9	4.3	44.7
Sweet potato (kg/cap)	3.2	87.2	210.5	209.2	124.9	192.6	124.4	90.7	151.1
Coffee (per cap)	0.0	0.9	4.0	6.4	10.7	8.4	7.9	5.2	6.6
Cattle (per cap)	.041	.050	.070	.119	.085	.117	.139	.065	.098
Sheep (per cap)	.153	.104	.123	.090	.041	.036	.029	.016	.062
Goats (per cap)	.133	.123	.167	.151	.184	.123	.206	.229	.162
Pigs (per cap)	.000	.003	.010	.088	.018	.017	.006	.009	.019
Percent caloric need met by production	71.20	68.08	96.21	80.25	77.26	103.42	115.25	121.94	95.03
1991 pop density/km2	472	404	403	293	426	397	269	235	359

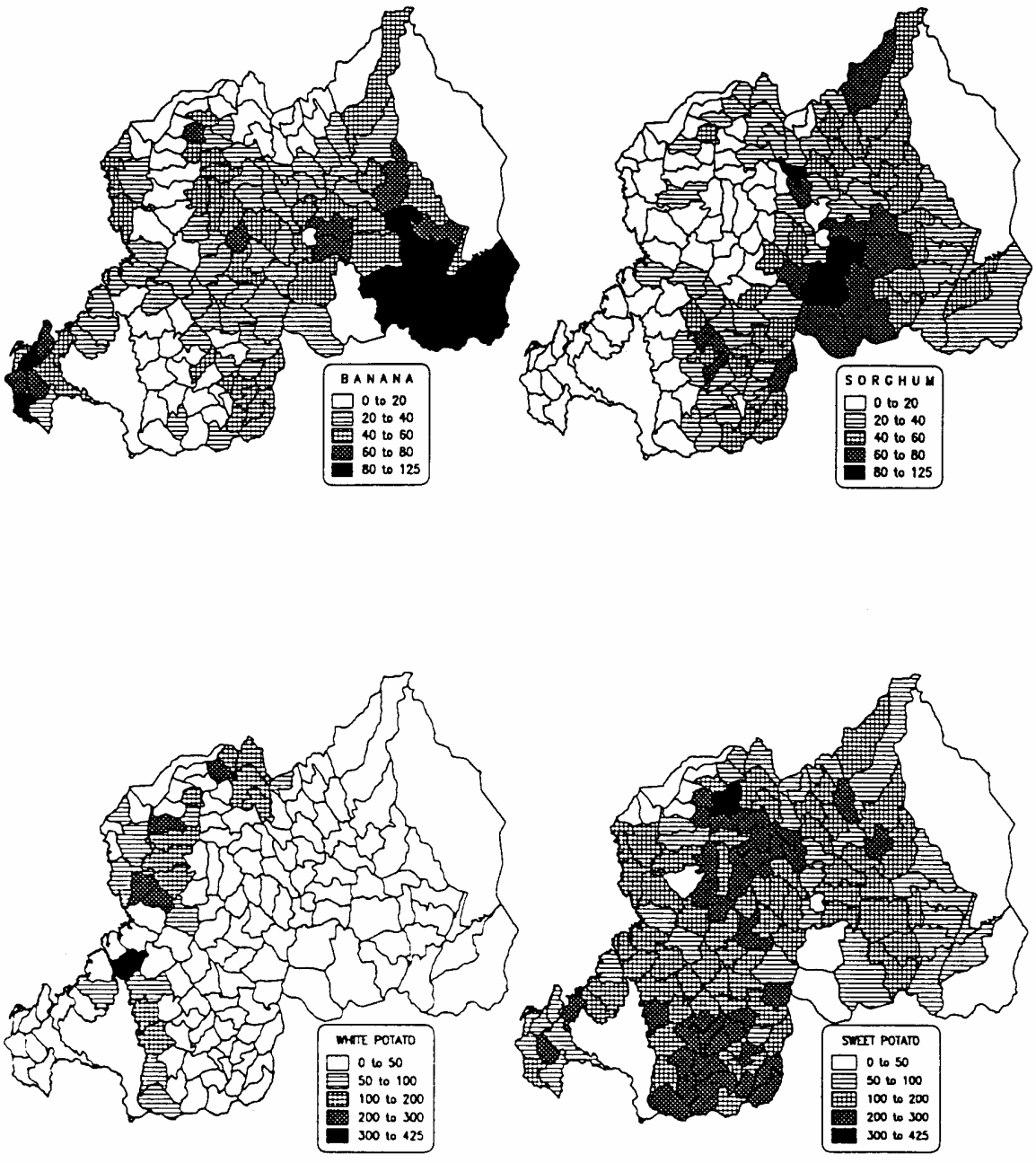

Figure 4 Spatial Distribution of Bananas, Sorghum, White Potato and Sweet Potato (kg/cap)

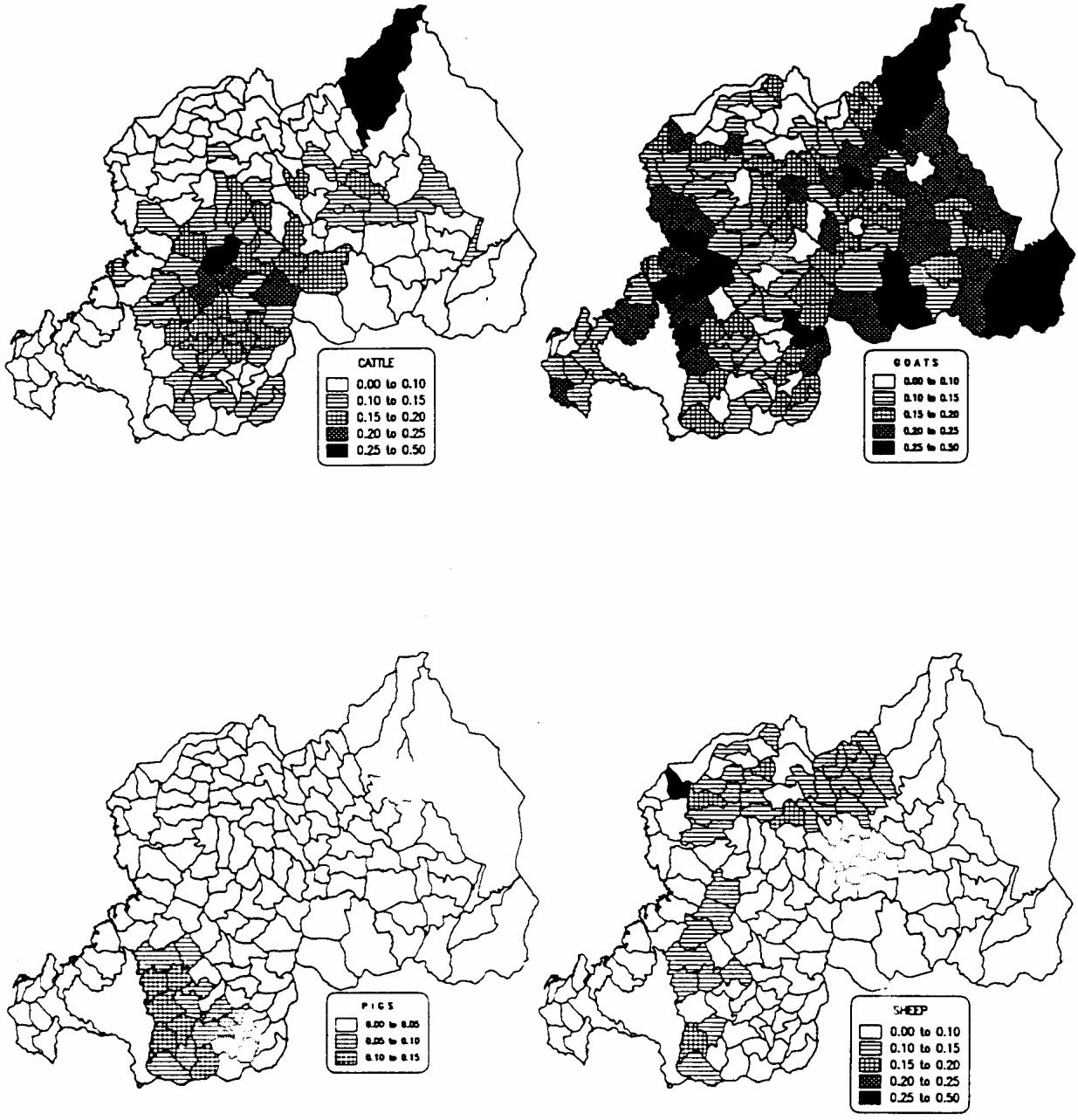

Figure 5 Spatial Distribution of Cattle, Goats, Pigs and Sheep (per capita)

These cultural regions were accepted as the standard regionalization of the country until recently, and indeed their names are still in common use by Rwandans. The first atlas of the country, published in 1974, introduced them as simply "the regions" in a section contrasting areas of the country (Sirven et al 1974). The origins of the cultural regions are unclear. An older article states that their demarkation was based more on instinct than natural science since they cut across and combine physical environmental zones (Rép.Rwandaise 1970). The origin of some, including Gisaka, Bugesera, Mubari and Rusenyi, can be traced to eighteenth century kingdoms (BCRU 1960). No matter what their origin, however, they seem to reflect persistent cultural, economic and political processes which continue to affect farmers' choice of crops and animals.

Cultural regions reflected in the farming system regions but not in the agro-climatic regions include Gisaka (Kibungo), Bufundu (Gikongoro), Bushiru (North Ridge) and Rukiga (Buberuka Foothills). Smaller cultural or agro-climatic regions such as Mayaga, Bugesera and Impara were merged into larger farming system regions on the basis of major crops but they still form unique units when minor crops are considered.

Contrasting farming systems have formed in areas with similar altitudes, rainfall and soils. Long-term societal factors have affected regional specialization in certain crops and animals. A few of the regions with similar physical variables but separate farming systems will be briefly contrasted below. Table 2 provides a more systematic characterization of each region.

The Kibungo Region, for example, has a similar climate and elevation to that of the Eastern Lowlands. Kibungo, however, has become highly specialized in banana production whereas the farming system of the Eastern Lowlands is diversified and produces sorghum, cassava and beans (Table 3). This difference between the two regions has resulted from the development of a highly organized commercial network which transports the high-value bananas and banana beer from Kibungo to the capital city, Kigali. Kibungo was able to develop this profitable commercial base for its farming system since it has only recently been intensely settled (1976-1985) and still has relatively large farms suitable for large-scale commercial production. Kibungo farmers employ circular migrants from the Northwest to perform the low-wage agricultural labor necessary for banana production (Clay et al 1989). The Kibungo Region was identified as a separate old cultural region, Gisaka, known for its production of peanuts (Anonymous 1955). Today, peanut growing is still concentrated in Kibungo but large-scale banana production now defines the region.

The Eastern Lowlands Region was also a region of in-migration but from an earlier period (1962-1976), and farms there are already significantly smaller than in Kibungo (Olson 1990). Instead of a single-crop, commercially-based farming system, the Eastern Lowlands depend upon a variety of commercial and subsistence crops. Due to the higher population density, the proportion of land devoted to subsistence crops such as cassava and sweet potato is larger than in Kibungo. Nevertheless, the Eastern Lowlands, particularly Bugesera, does commercialize large quantities of the high-value sorghum and beans which are sold in the capital city Kigali. Sorghum and bean production requires a higher labor input than do bananas, so the Eastern Lowlands with its higher population density is at a relative advantage compared to Kibungo (Figure 4). A parastatal ranch in the Northeast accounts for the large numbers of cattle found there (Figure 5).

In the West of Rwanda, distinct farming systems have formed not only in areas of particular elevation zones, but also in areas of comparable elevation, rainfall and soils. This is especially

apparent in comparing the northern and the southern region in the West; historical and recent cultural, economic and political factors have led to different crop and animal bases of the farming systems.

The Buberuka Foothills, for example, are similar in elevation and rainfall to both the Lake Kivu Shore and Gikongoro regions, and are only slightly higher than the Central Plateau (Table 3). The region also has a comparable population density to that of the Central Plateau and Lake Kivu Shore. However, the Buberuka Foothills farming system is distinctly different from the others. It has a diversified farming system like the others but based on different crop mixes: a high production of sweet potatoes distinguishes it from the Lake Kivu Shore, the importance of bananas, beans and sorghum is greater than in Gikongoro, and production of white potatoes separates it from the Central Plateau (Tables 2 and 3). However, the choice of animals is the most important distinguishing characteristic separating Buberuka Foothills from regions of similar elevation: the relatively large number of sheep that farmers raise there is unique to the Northwest (Figure 5).

The Northwesterners have a preference for sheep raising over other animals. The three northwestern regions of the Volcanic Highlands, the Buberuka Highlands and the Buberuka Foothills contain almost all the sheep in the country other than a few raised in Gikongoro in association with cattle. Sheep are flexible animals in terms of their climatic and dietary requirements and indeed are found in the hottest and driest areas of Africa. Their spatial concentration in Rwanda is due to long-standing cultural preferences of the people in the Northwest for sheep, whereas elsewhere in the country people tend to prefer to raise other animals (Rwamasirabo et al 1991).

Sheep raising and white potato production are important elements which defined the northwestern regions, but a minor crop not used in the cluster analysis reinforces the distinctiveness of the northwest. Maize production is concentrated particularly in the Volcanic Highlands and also grown in the Buberuka Highlands and Foothills. One reason for the concentration of maize in the Northwest is high elevation since it can grow where sorghum does poorly. However, in regions of similar elevation in the South, farmers prefer millet (eleusine) (refer to Figure 1).

Spatial concentration of another animal is also important in defining Gikongoro as a separate farming system region despite the fact that its elevation and rainfall are similar to those in other regions. Pig raising is limited to the Gikongoro region not because of any inherent environmental or food requirements of pigs. Pig raising was first introduced to Rwanda by the Catholic missionaries in Save and has since spread only within the old Bufundu region (Rwamasirabo et al 1991). The spatial distribution of pigs parallels the distribution of other animals and crops whose adoption pre-dates that of pigs, so pig distribution in and of itself only reinforces the old delimitation of Gikongoro as a separate farming system.

Gikongoro depends on sweet potatoes for calories much more so than other highland regions where crops such as beans and sorghum are widely grown. This may be partially due to the poor soils in Gikongoro which are no longer productive of grains and pulses (Olson 1992). Cultural factors affecting Gikongoro's farming system are again, however, illustrated by the

Table 4 Proportion of Calories Produced by Crop and Animal Sources

	FARMING SYSTEM REGION								TOTAL RURAL COMMUNES
	Volcanic Highlands	Buberuka & No Ridge	Buberuka Foothills	Gikongoro	Lake Kivu Shore	Central Plateau	Eastern Lowlands	Kibungo	
BANANAS									
Bananas	1 3	6 8	18.6	5.5	24.4	18.6	17.9	42.9	17.8
PULSES									
Beans	8.1	23.0	20.2	10.8	15.3	18.2	20.3	18.3	17.8
Peas	4.5	5.9	1.5	2.6	2.2	.5	.4	.3	1.8
Peanuts	0 0	0.0	.1	.0	.2	.3	1.8	3.9	.7
GRAINS									
Maize	23.5	15.2	7.6	6.4	9.9	4.3	3.7	3.0	7.3
Sorghum	7.9	12.1	13.3	11.7	5.9	10.1	20.5	13.0	12.3
Wheat	2.3	2.1	.4	1.6	.0	.0	.0	.0	.5
TUBERS									
Cassava	.0	1.8	3.7	9.5	9.0	17.0	16.5	6.7	10.5
White potatoes	50.9	13.1	1.8	5.1	5.7	.4	.5	.2	4.6
Sweet potatoes	.7	18.8	30.5	37.9	22.5	27.0	15.3	10.1	23.1
ANIMAL PRODUCTS									
Beef and milk	.4	.6	.6	1.2	.8	1.0	1.1	.4	.9
Goat meat	.2	.2	.2	.3	.3	.1	.3	.2	.2
Mutton	.3	.2	.1	.1	.0	.0	.0	.0	.1
Pork	.0	.1	.3	3.6	.6	.5	.1	.2	.7
OTHER	.0	.1	1.0	3.7	3.1	2.0	1.7	.7	1.8
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

concentration of certain uncommon crops such as millet, taro and yams in Gikongoro although they are environmentally suited to other regions as well.

V. DISCUSSION AND CONCLUSIONS

WITHIN FARMING SYSTEMS REGIONS, VARIATIONS IN ELEVATION, SOILS AND RAINFALL ARE found. However, these regions are defined by common crop and livestock production mixes. The contrast between the physical environmental factors and the agricultural patterns reveals the influence of cultural, political and economic factors on the choice of crop cultivation and livestock raising. Livestock raising, for example, is not limited by environmental variables to certain zones but sheep and pigs are spatially concentrated due to cultural preferences and historic reasons. White potato production is concentrated in the Northwest due to an early government policy promoting commercialization of white potatoes in that area. Banana production is concentrated in Kibungo due to economic and infrastructural development.

The farming system regions unexpectedly resemble traditional cultural regions more closely than the agro-climatic regions defined by physical environmental variables. The persistence today of the cultural regions as cohesive units despite years of political, economic and social evolution is remarkable. Their cohesion conforms to the concepts of the de la Blache French school of geography in which regions, "pays," were self-contained socio-economic units defined by a common agricultural and cultural base (Hartshorne 1939).

Former political, economic and cultural processes have evolved to remain important in farmer decisions of what crops and animals to produce. Discovering echoes of the cultural regions in the cluster analysis results is all the more unexpected since many of the crops and animals used in the cluster analysis have been only recently adopted— for example the distribution of cassava, white potatoes, bananas and pigs is due to fairly recent economic and political developments. This indicates that Rwanda's farming systems continue to evolve within the bounds of the older cultural, economic and political processes. Although the agro-climatic regions based on physical environmental variables indicates where a crop may potentially grow, the farming system regions incorporate the dimension of societal factors affecting farmers' adoption of new crops and animals.

Research on the potential adoption of a new crop, animal or agricultural technique should, therefore, be done at the farming system region level since adoption is influenced by the societal factors reflected in the regionalization, and adoption would probably diffuse first within a region. Agricultural policy formation would be improved by consideration of both the environmental potential of the land and the social system affecting how people manage their resource base within the opportunities and constraints of social/cultural, political and economic conditions. Existing societal processes mediate the outcome of agricultural policy.

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