Resource and Crop Management Research Monograph No. 22

Macrocharacterization of Agricultural Systems in Central Africa: An Overview

V.M. Manyong, J. Smith, G.K. Weber, S.S. Jagtap, and B. Oyewole

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Preface

The Resource and Crop Management Research Monograph series is designed for the wide dissemination of results of research about the resource and crop management problems of smallholder farmers in sub-Saharan Africa, including socioeconomic and policy-related issues. The range of subject matter is intended to contribute to existing knowledge on improved agricultural principles and policies and the effect they have on the sustainability of small-scale food production systems. These monographs summarize results of studies by IITA researchers and their collaborators in the IITA Resource and Crop Management Division (RCMD). They are generally more substantial in content than journal articles.

The monographs are aimed at scientists and researchers within the national agricultural research systems of Africa, the international research community, policy makers, donors, and international development agencies. Prepublication review and editing of each manuscript are conducted within RCMD.

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Abbreviations

CFA franc	monetary unit of *Communauté financière africaine*
CRI	Crops Research Institute
CS	coastal savanna
DS	derived savanna
FAO	Food and Agriculture Organization of the United Nations
GIS	georeference information system
HF	humid forest
I	Intensification phase
IDESSA	*Institut des savanes*
IER	*Institut d'économie rurale*
INERA	*Institut national de la recherche*
INRAB	*Institut national de la recherche agricole au Bénin*
IRAG	*Institut de recherche agronomique de Guinée*
LGP	length of growing period
MAS	midaltitude savanna
MD	market-driven system
MDE	market-driven expansion system
MDI	market-driven intensification system
MDI (E)	market-driven early intensification system
MDI (L)	market-driven late intensification system
NGS	northern Guinea savanna
NRCRI	National Root Crops Research Institute
PD	population-driven system
PDE	population-driven expansion system
PDI	population-driven intensification system
PDI (E)	population-driven early intensification system
PDI (L)	population-driven late intensification system
PMKT	potential market-driven system
PSMKT	pseudo-market-driven system
R	Ruthenberg index
RIS	resource information system
RRS	Rice Research Station
SGS	southern Guinea savanna

I

Introduction

Problem statement

It is well recognized that farming practices for smallholder farmers are complex because of differences in the scope of expectations from ~~family~~ members in the endowment of resources, in the management of the system, and in the type of outputs (and externalities) generated (Chambers et al. 1989). Such complex systems at microlevel develop wide heterogeneous environments at macrolevel when a larger geographic area becomes the focus of the analysis. Additional factors that are common to smallholders, such as climate, vegetation, infrastructures, and policy reinforce the heterogeneity of environments and make it more difficult to develop technologies that can accommodate the specific conditions of each farming system.

It is also important to recall that all farming practices are subject to adjustment, change, and evolution (Tripp 1991). Historical studies have shown evidence that peasant farmers are not bound by tradition to follow an unchanging set of practices over time. Farmers respond to changing economic conditions (Boserup 1965; Askari and Cummings 1976; Janvry and Dethier 1985), to the availability of new technology (Smith et al. 1994), to pressure from biotic constraints (Weber et al. in press) and changing physical conditions such as drought (Prudencio 1986). As a result of that dynamic process, heterogeneity over time is added to heterogeneity over space. The challenge for the technology developers is to achieve a high rate of return on research in heterogeneous environments.

It is now well accepted that differences in adoption rates can often be explained by the natural and socioeconomic conditions of particular farming systems rather than by the psychological traits of individual farmers and that more emphasis should be placed on identifying appropriate client groups for research before the research program is under way (Shaner 1984). Another challenge faced by technology developers is to maximize the impact of the on-the shelf technologies for problem solving. Here the task is to target existing prototype technologies to appropriate areas for site-specific adaptation and extension purposes.

Research objectives

This study aims to identify and describe on a broad basis the principal agricultural systems of the lowland humid and subhumid parts of the Central African zone. Characterization is done by combining natural and dynamic socioeconomic factors that are responsible for systems' evolution. By characterizing the current situation and the inherent dynamics of systems, the study is expected to capture heterogeneity over space and time. The results can then be used to provide feedback for strategic development and technology targeting, and also for site selection for on-farm testing.

Limitations of the study

This study is an overview of the dynamics of agricultural systems conducted at the regional level. Information analyzed is of a more qualitative than quantitative nature and the result was not planned to provide insights into input/output coefficients which occur during the process of agricultural production. The macrolevel or country-level study is the first in a process of characterization that is planned in three phases (figure 1). It is expected that the next two phases which are at meso- /village-level and micro-/ detailed on-farm level studies will provide more detailed and quantitative information.

The main sources of data were literature reviews and interviews with national scientists. Consequently, the accuracy of the results will depend upon the quality and scope of these data. However, any inaccuracy in the information at the macrolevel of characterization is expected to be gradually reduced by the subsequent levels.

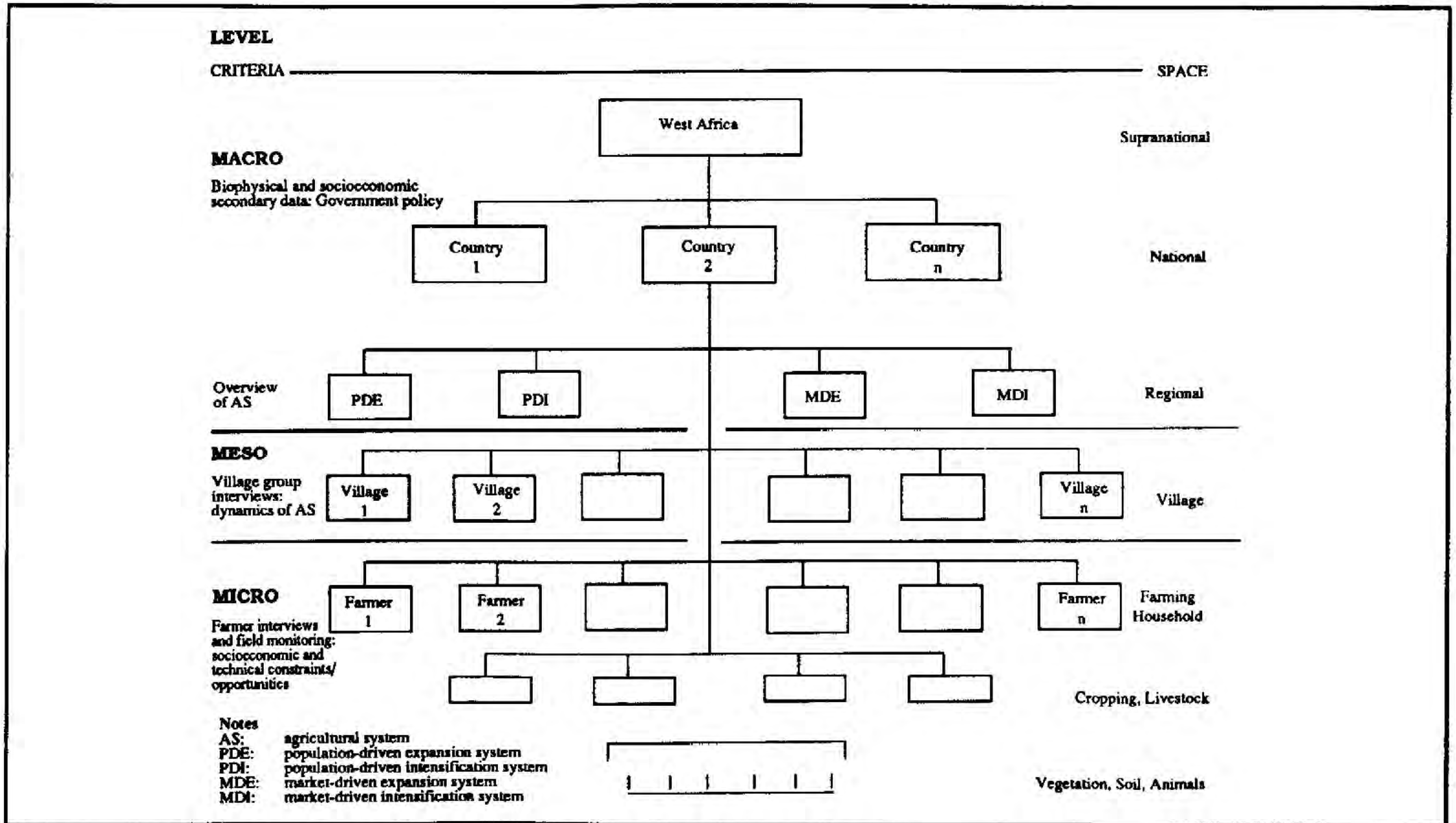


Figure 1. Characterization of agricultural systems: hierarchy of the research

II

Methodology

Study area

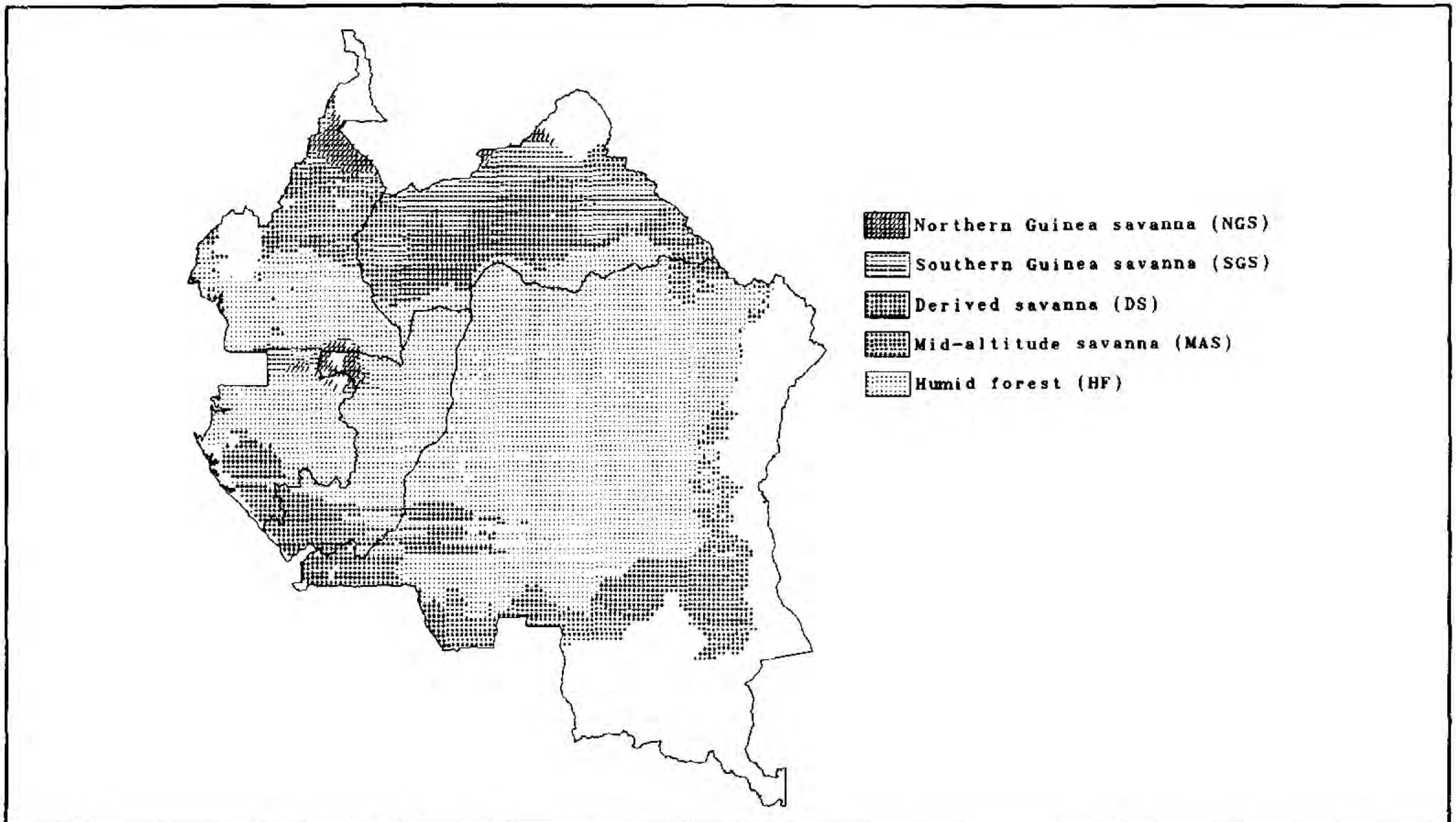
Subhumid and humid parts of five countries in Central Africa constitute the study area (map 1). These include areas <1200 m above sea level and with a precipitation equivalent to or above 150 days of the length of growing period. The five countries covered are Cameroon, Central African Republic, Congo, Gabon, and Zaire. Similar areas of Angola, Chad, and Sudan were not considered because of civil strife at the period of the study. Rwanda and Burundi, also Central Africa countries, were not included because the areas of interest cover less than 10% of these countries.

Data collection

Data were collected both from literature reviews and interviews with key informants from national institutions. Only recent studies published within the five-year period before 1992 were considered from literature reviews. Otherwise (where data were old or nonexistent) national key informants were sought to provide up-to-date information. Policy-decision makers in agriculture, agricultural research scientists, extension officers, leaders of agricultural development projects including nongovernmental organizations were interviewed to provide information on components of the farming systems. Information was also provided on the socioeconomic conditions of farming and on the general environment of agriculture (physical factors, policy, infrastructures). An ad hoc checklist was developed on to which collected information was recorded. National key informants were requested to draw on a local map the boundaries of the farming systems based on the predominant rural activities. Map data were drawn for other variables such as population density, vegetation, soils, ethnic groups, and so on. These data were jointly collected with the national coordinator nominated by the national research institution for each participating country. The duration of data collection varied from two to four weeks depending on the size and constraints specific to each country. Often the national coordinator continued data collection beyond the two-to-four week period to fill the gap where information was still missing.

Data analysis

The collected data and the maps were then entered into a geographical information system (GIS) for analysis. Complementary GIS packages such as Idrisi and Atlas draw were used to create more data files from digitized maps. Resource Information System (RIS) was the main GIS package for analysis. It was used to run spatial analysis by overlaying single variable or multiple variable maps to create new image files. The typical output from such an analysis is the delineation of areas with similar characteristics and the calculation of the proportion covered by each delineated area. This allows priorities to be set across areas identified as similar.



Map 1. Agroecological zones of the study area

III

Characterization of Agricultural Systems

Attributes of agricultural systems

Biophysical resource base

Main characteristics of the resource base in the Central African zone are the dominance of wooded area (either forested or in transition), wet and bimodal seasons, and abundant virgin land (table 1). These results are supported by findings from the World Bank (1994) which estimated that natural forest covers 242 million ha or 60% of the study area. Guinea savannas are virtually nonexistent except for a few small areas located in the northern parts of both Cameroon and the Central African Republic. Rainfall pattern is bimodal and the two rainy seasons alternate at opposite sides of the equator. Rains are intense and reach a peak as high as 4,000 mm/year in the coastal area of the Guinea gulf. However, dry areas also exist in the upper north of the Guinea savannas where the rainfall pattern is monomodal.

Table 1. Characterization of the resource base of the farming systems in Central Africa

AEZ	Total area		Areas with good soil fertility		Areas with available uncultivated arable land	
	m ha	%	m ha	%	m ha	%
NGS	5.2	1.6	2.3	3.1	3.7	1.2
%	100		44.2		71.2	
SGS	20.9	6.5	2.6	3.5	19.3	6.1
%	100		12.4		92.3	
DS	67.8	20.9	15.1	20.2	67.5	21.2
%	100		22.3		99.6	
MAS	30.2	9.3	12.2	16.3	28.5	8.9
%	100		40.4		94.4	
HF	200	61.7	42.5	56.9	199.0	62.6
%	100		21.3		99.5	
Total	324.1	100	74.7	100	318.0	100
%	100		23.1		98.1	

Notes

Consider both column and row percentages, but only column percentages add up to 100%

AEZ = agroecological zone
NGS = northern Guinea savanna
SGS = southern Guinea savanna
DS = derived savanna
MAS = midaltitude savanna
HF = humid forest
m ha = million ha

Major soil groups in the study area are as follows: Ferralsols (62%), Nitosols (12%), Gleysols (5%), Cambisols (3%), Acrisols (2%), and Luvisols (2%) following the FAO classification system (FAO 1978). Map 2 shows the location of the major soil groups in Central Africa. Relative soil fertility for crops is low: only 23.1% of the study area is of good fertility (i.e., soil suitable for the crop that demands least soil nutrient, in this case cassava), but differences have been noticed among agroecological zones (table 1). Uncultivated arable land is abundant (98% of the study area) as a result of the low population density, approximately 14 persons/km^2 (World Bank 1994).

The level of agricultural production and its constraints depend entirely (or almost entirely) on the biophysical resource base. But the severity of generated constraints and, therefore, the required technologies to alleviate these constraints are determined by socioeconomic factors.

Driving forces for agricultural intensification

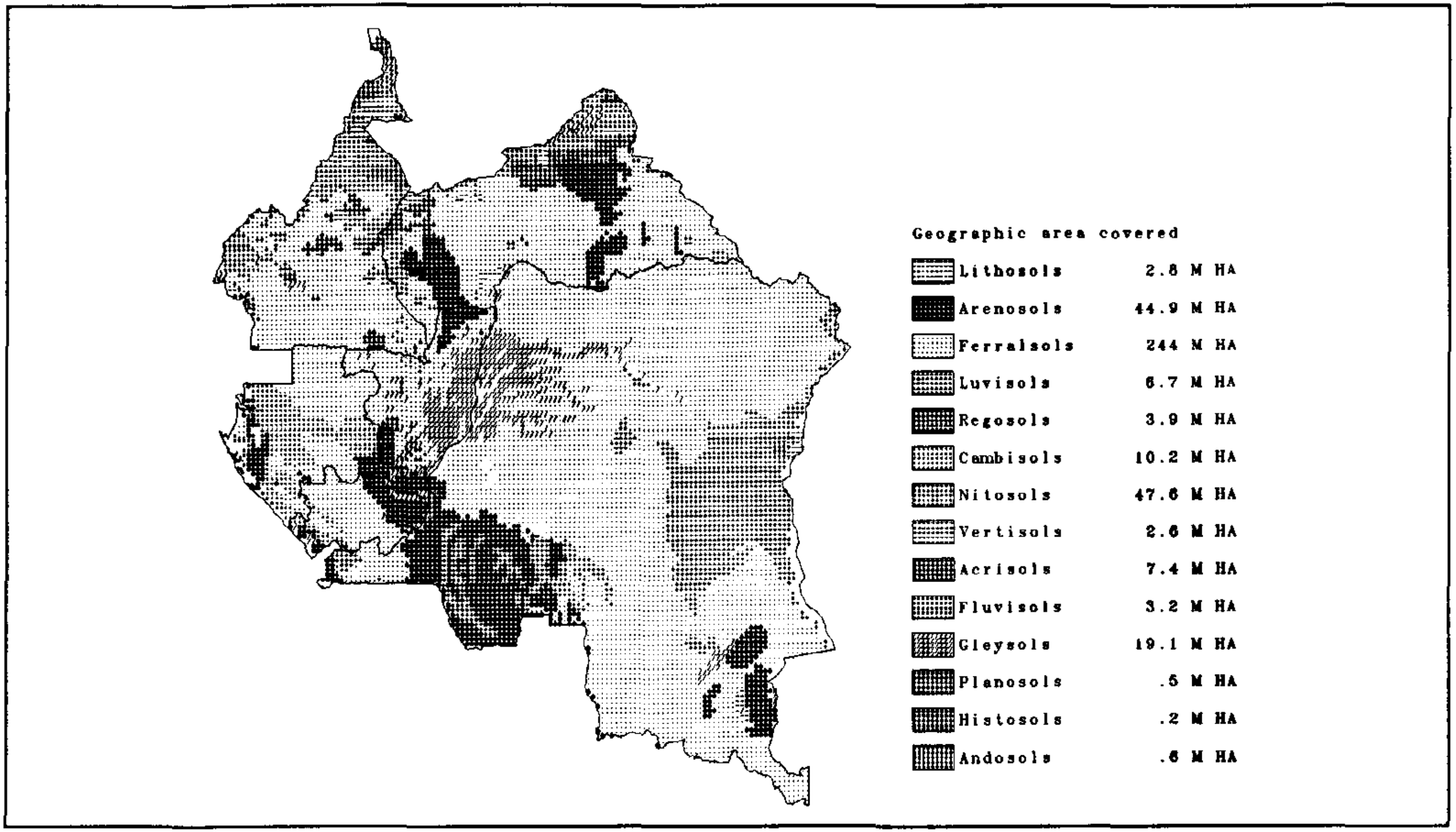
Smallholder farmers generally increase their production for the purposes of feeding the family, ever-expanding in size, or to respond to market incentives, or for both reasons. These two main objectives have led social scientists to hypothesize that there are two main driving forces for agricultural intensification: the increase in population density (Boserup 1965) and the improvement in market opportunities (Binswanger and McIntire 1987). Smith (1992) added that the agricultural intensification induced by the two driving forces leads to different types of resource use and degradation and that different technologies are needed to alleviate related constraints. This present study applies the last hypothesis of Smith (1992) to characterize the dynamics of evolving production systems.

Intensification driven by population density alone gives way to population-driven systems which rely mainly on internal natural resources to stop resource degradation and to improve soil fertility. Intensification driven by market opportunities develops market-driven systems which have more technological options, based both on internal and external resources, to sustain the production system. Within population-driven and market-driven categories an expansion and an intensification phase are distinguished, given the intensity of land use (Manyong et al. in press). Three criteria are used to distinguish population-driven from market-driven systems and their associated phase of intensification: access to wholesale markets, the presence of a major cash crop for sustained production, and the land-use intensity.

Access to wholesale markets

If transport infrastructure (roads, railways, navigable rivers) for all or many villages within an identified farming system area is usable throughout the year, the rural area is considered to have good access to markets. A road density of 30 km/100 km^2 suggested by Fresco (1988) as a criterion for an area with good access to markets was not applicable because details about lengths of roads, railways, and navigable rivers were not available at the village level.

Good access to markets is a precondition for a market-driven system because it reduces the marketing margins, thus increasing the output/input price ratio and the profitability of the system as well. Results of the analysis indicate that only about 27% of the study area was assessed as having good access to wholesale markets.



Map 2. Major soil types (FAO/UNESCO classification system in 1974)

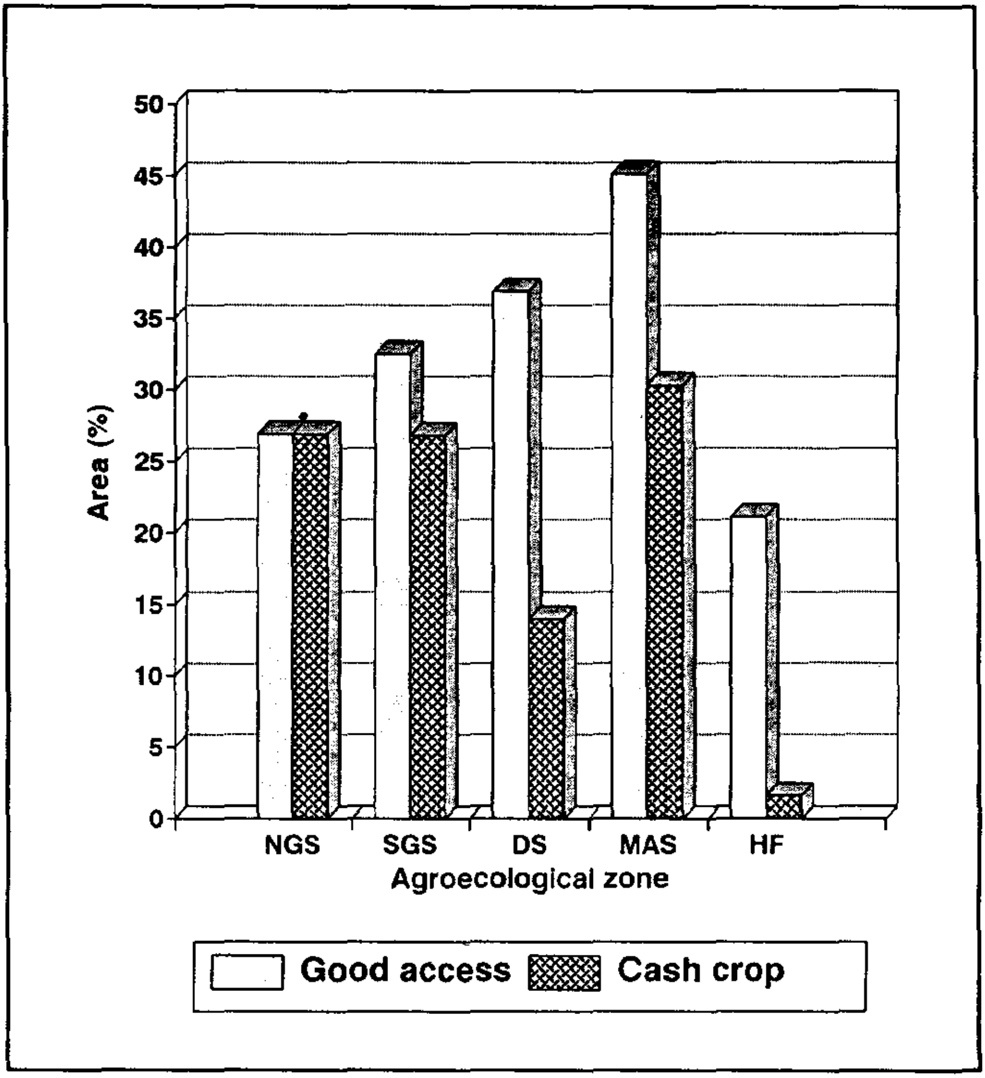
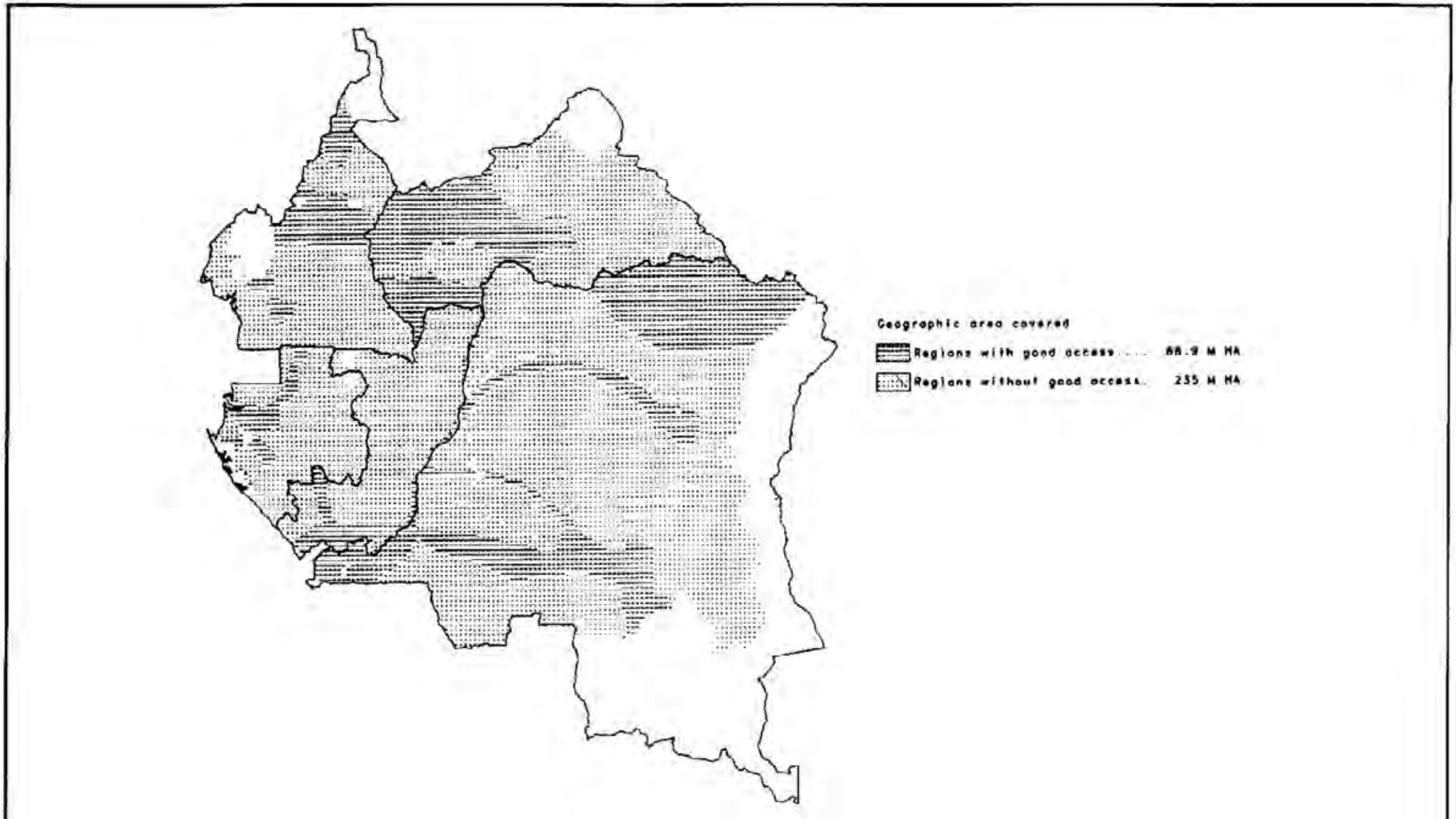


Figure 2a. Agricultural driving forces in Central Africa: access and cash crop

Rural areas were more accessible in subhumid than in humid areas (figure 2a). These results are different from those of the west African zone where areas with good access to markets constitute as much as 60.4% of the study area and where the access was better in the humid zone than in the subhumid (Manyong et al. in press). The quality of road infrastructure is a major constraint in the Central African zone: paved roads represent only 170 km/million people or 0.2 km/km^2 (calculated from World Bank 1994) while the paved road density in Nigeria was 8.3 km/km^2 in 1985 (Gaviria et al. 1989). It should be noted that part of the midaltitude savannas was assessed as having good access because road infrastructure is not a major constraint to cattle rearing, the predominant rural activity of the area. Map 3 shows the distribution of the study area according to this factor in Central Africa.



Map 3. Access to markets

Major profitable cash crop for sustained production

Data collection was limited to the assessment of the five most important rural activities (crops or livestock or fishing). In this study, a major profitable cash crop refers to any of the most important rural activities and was defined in a stepwise analytical approach using the following characteristics:

1. It should be one of the two crops ranked by key informants as "top crops" of the farming system.
2. The crop should have a comparative advantage in the area among other feasible options (suitable ecology, availability of improved technology). FAO (1978) has provided suitability maps for most of the crops grown in Central Africa.
3. The crop should be marketed with substantial returns to the farmers (not only to the middlemen or the consumers).
4. The proceeds should be reinvested in agriculture (not in trade, for instance) to maintain or improve the long-term productivity of the system. External inputs such as hired labor and the application of recommended doses of fertilizer (or veterinary requirements in the case of livestock) were considered to be a reinvestment in agriculture.

Results from the analysis indicate that about 9% of the study area was assessed as having a major profitable cash crop for sustained production. The percentage is slightly higher in the savannas because of cattle rearing and cotton growing but almost nil in the humid forest (figure 2a). Cash crop production in the forest has been declining in the Central African subregion during the last two decades. For instance, in Zaire, production indices for major cash crops (coffee, rubber, oil palm) showed a continuous declining trend between 1970 and 1990. In small areas where a positive trend was observed, poor road infrastructure increased the marketing margins that wiped out the little amount gained by farmers. However, a continuous growth was noticed in food crop production such as cassava, maize, rice because of the increases in population density (République du Zaire 1991). Map 4 shows the area having one major cash crop for sustained production.

Land-use intensity

This factor is used to distinguish the expansion and intensification phases and stages within the intensification phase of the agricultural systems. An expansion phase corresponds to low land-use intensity and the intensification phase corresponds to either a moderate or a high land-use intensity in farming. For this study, the formula of Ruthenberg (1980) was used to calculate the land-use intensity for annual and semiperennial crops. The following thresholds were defined taking soil quality into account, since in poor soil land degradation starts at lower levels of land-use intensity than in good soils:

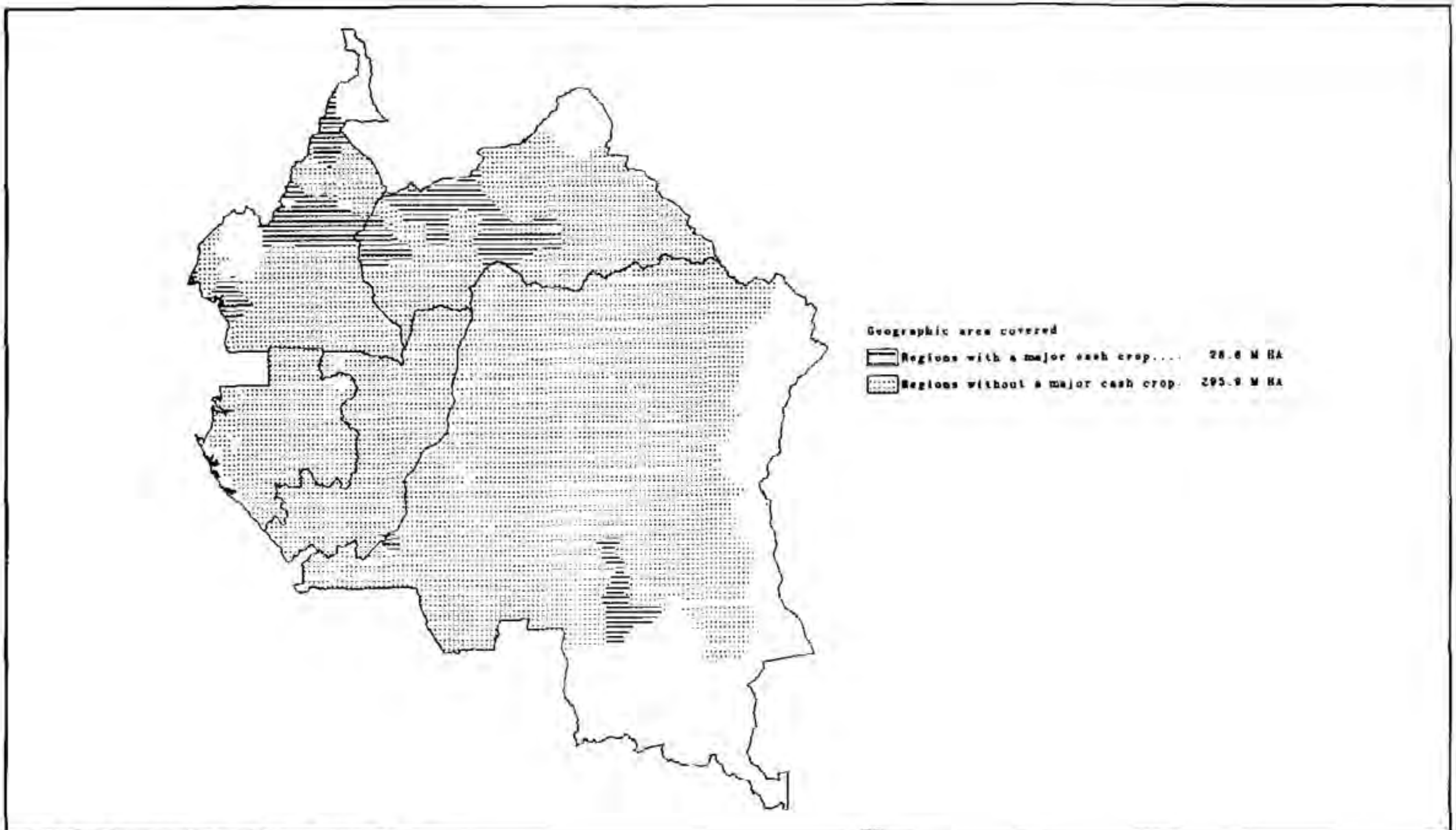
Land-use intensity

	Low	Moderate	High
Good soil	R < = 33	R = 34 to 66	R > 66
Poor soil	R < 20	R = 20 to 50	R > 50
Phase	expansion	intensification	
		early stage	late stage

Notes

R = a/(a + b)*100 where R = Ruthenberg index in %

a = Years of cultivation, and b = Years of fallowing



Map 4. Presence of a major cash crop

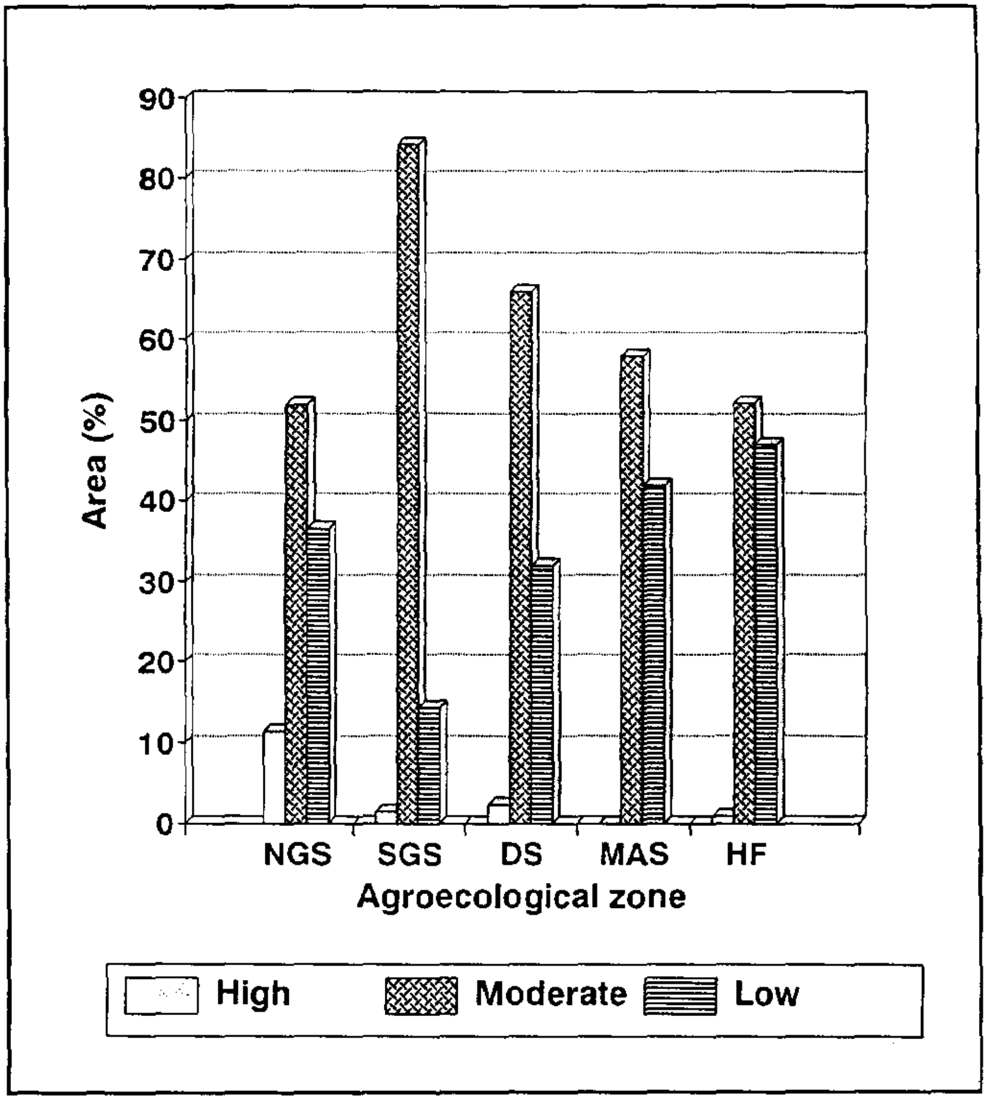


Figure 2b. Agricultural driving forces in Central Africa: land-use intensity

Results indicated that 59.9% of the study area was in an intensification phase, while 40.1% was in an expansion phase. The breakdown showed moderate land use to be predominant in all the agroecological zones (figure 2b). While low land-use intensity was expected, the high percentage of areas with moderate and high intensity of land use in a land-abundant area was somewhat surprising. The reason, key informants explained, for this unexpected situation was both the high cost of clearing the thickly wooded land and the scarcity of labor in the forests of the Central African zone. The latter is caused by both low population density and outmigration of young manpower from rural areas to urban centers. In a country such as Gabon where policy-decision makers are very concerned about the outmigration of youths from rural areas, the average age of household heads was as high as 55 years in 1990 (République Gabonaise 1990). Restricted access to land can also induce intensive use of land in land-abundant areas. Kembola and Manyong (1989) reported that the appropriation of large areas by big companies and the presence of a protected game reserve in the low-populated Mayumbe forest of Western Zaire were responsible for the intensification of land use and related degradation of natural resources by small-scale farming. Map 5 shows areas of different land-use intensity for the Central African zone.

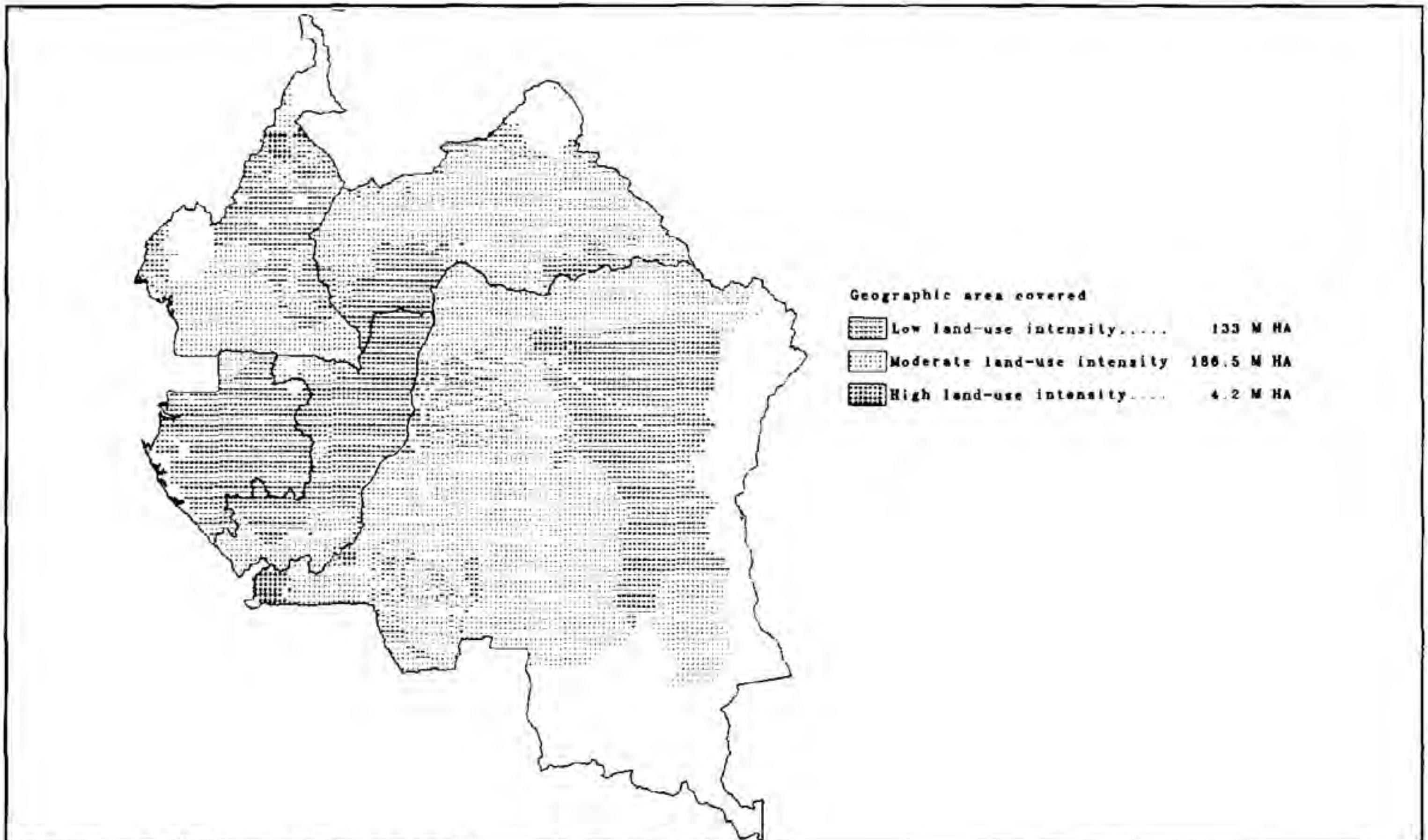
Implications for research

1. Characterization of the biophysical resource base has indicated that the Central African zone has great biodiversity and therefore potential for conservation. Given the facts that about 70% of the population live in rural areas, the average population density is 14 persons/km^2, the average household size is 6, and a household cultivates on average 1.5 ha/year, only about 2.5% of the study area is being cultivated. This leaves most of the forest zone free for the development and implementation of conservation projects.

2. Infrastructure of poor quality constitutes a major constraint to the expansion of cultivated land and to the adoption of improved technologies from research centers (national or international). Even in areas with good access to markets, adoption has not been substantial: only 32% of the potential offered by good access to market was valued as a profitable economic activity for sustainable agriculture (table 2). The percentage was highest in the northern Guinea savanna (100%) and lowest in the humid forest (8%). Farmers' activities which have contributed to achieving these potentials are growing cotton (Guinea savannas); rearing cattle; growing vegetables and cassava (derived savannas); rearing cattle (midaltitude savannas), and growing coffee and cassava (humid forest).

Research priority is on post-harvest technologies for cassava, the main crop of the subregion. Improved cassava germplasm, adapted to socioeconomic conditions of the farmers, also needs to be introduced into the area. Plantain and banana are well adapted to the forest zone. However, lines are required that are resistant to diseases such as black sigatoka, prevalent in the Central African zone (IITA 1993).

3. Intensification of land use in a fragile environment (heavy rains, poor soils) leads to resource degradation once the natural climax vegetation is not allowed to re-establish. This degradation is likely to happen in the fields close to the homestead and in those along accessible roads. The development of sustainable home-garden systems in the forest margins should be a priority in a forested zone.



Map 5. Land-use Intensity in Central Africa

Table 2. Use of production potential offered by good infrastructure

AEZ (1)	Areas with good access % (2)[a]	Areas with major cash crop % (3)[a]	Achieved potential % (4 = 3:2)
NGS	26.9	26.9	100
SGS	32.5	26.8	82.5
DS	36.9	14.0	37.9
MAS	45.1	30.3	67.2
HF	21.1	1.6	7.6
Total	27.4	8.7	31.8

Notes
NGS, SGS, DS, MAS, HF: see table 1
a : percentage of (1)

Agricultural systems

Types
An agricultural system, as defined in this monograph, is a collection of farming systems in which changes in production processes are determined by the interactions of different degrees of the three criteria already mentioned, namely access to markets, presence of a major cash crop, and intensity of land use. As a result of an evolutionary process caused by the dynamics of the interactive factors, systems move along a continuum, but for analytical purposes, two basic types of agricultural systems and two phases for each type are distinguished: market-driven and population-driven types and the expansion and intensification phases. The Central African region is a typical population-driven region with about 92% of the total land area represented as a population-driven agricultural system and 8% as a market-driven agricultural system (figure 3). Analysis by phase indicates that the population-driven intensification phase ranks first (53.3% of total land area), population-driven expansion phase ranks second (39%); the market-driven intensification phase ranks third (5.5%); and the market-driven expansion phase comes fourth and last with 2.2% of the total land area (figure 4).

Ranking by agroecological zones (table 3) shows almost all the zones to be in population-driven intensification and population-driven expansion phases. Only the southern Guinea savanna has market-driven intensification as an important phase. Such an intensification phase at the farmer level in a low-populated environment has been explained by the shortage of labor to effect continual clearing of new areas of densely wooded forest for farming purposes. The farmers would rather choose to cultivate the same fields continuously until the opportunity cost of labor for farming the fields becomes higher than the opportunity cost of labor in opening up new land. The market-driven

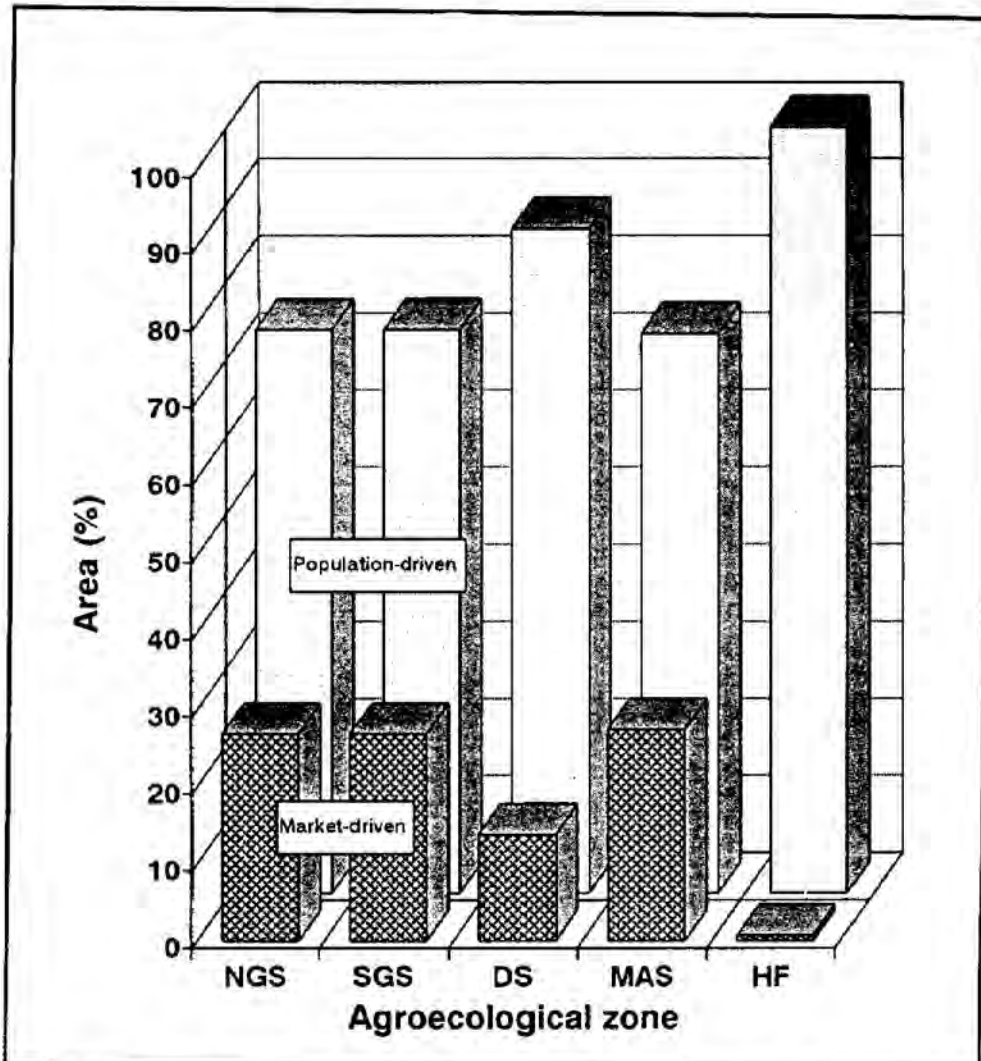


Figure 3. Agricultural systems in Central Africa

systems in Central Africa are more equally distributed between the southern Guinea savanna, the derived savanna, and the midaltitude savanna. The expansion phase in the market-driven path occupies very small areas for all the agroecological zones just as it did in the west African zone (Manyong et al. in press). Therefore, very low levels of land-use intensity are an unusual management practice for market-driven systems. Map 6 shows areas under different paths of intensification.

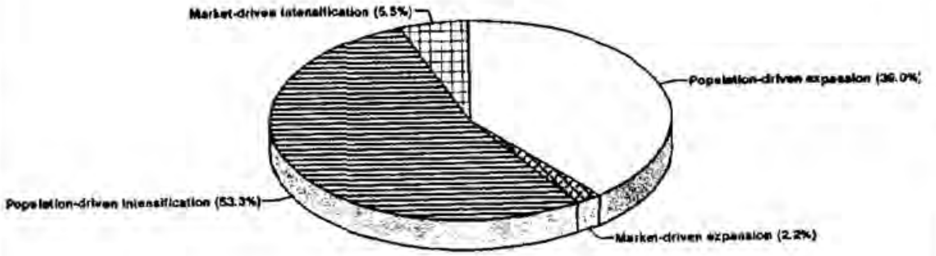


Figure 4. Phases of agricultural systems in Central Africa

Agricultural systems and land availability

New arable land is still available in 98% (316 million ha) of this region (total area 324 million ha) (table 4). Of these 316 million ha, 296.6 million ha (91.5% of the region) are in population-driven systems representing 99% of the total population-driven areas. On the other hand, the remainder of the 316 million ha (6.1% of the region) is in the market-driven systems. This percentage (6.1%) represents 19.7 million ha or 78% of the total market-driven areas. The fact that the proportion is lower in market-driven areas than in population-driven areas is an indication that land frontiers, i.e., when no more virgin land is available, are reached much more quickly in market-driven systems. This is likely to increase the opportunity cost of land that could justify the development of both private ownership of land and a land market common in market-driven areas. However, when the same proportional analysis was run for the land-use intensity aspect by combining land-use intensity (figure 2b) with land availability (table 4), it shows that new arable land is still available in all areas where the land-use intensity is low, in 97% of areas where it is moderate, and in 65% where it is high. This indicates among other things, that land-use intensity is not always dependent on land availability even in land-abundant regions such as the Central African subzone.

Agricultural systems and soil fertility

The soils of the African continent are generally acidic and poor. In Central Africa good soils were found only in about 23% of the total land area (table 1). The bulk of market-driven areas (18.9 million ha or 75%) is concentrated in areas of poor soils while areas with population-driven systems on good soils cover 67.5 million ha or 21% of the total land area. These results buttress the fact that soil fertility is not a determinant but rather a modifier in the evolutionary pathway of intensification.

Table 3. Ranking of agricultural systems phases in Central Africa

Rank	NGS		SGS		DS		MAS		HF	
	AS	%	AS	%	AS	%	AS	%	AS	%
1	PDI(E)	36.5	PDI(E)	61.4	PDI(E)	54.7	PDI(E)	48.0	PDI(E)	51.8
2	PDE	36.5	MDI(E)	23.7	PDE	29.7	PDE	24.9	PDE	47.0
3	MDI(E)	15.4	PDE	12.0	MDI(E)	11.1	MDE	18.5	PDI(L)	0.6
4	MDI(L)	11.5	MDE	1.9	MDE	2.2	MDI(E)	8.5	MDI(E)	0.5
5	PDI(L)	0	MDI(L)	1.0	PDI(L)	1.9	PDI(L)	0	MDI(L)	0.1
6	MDE	0	PDI(L)	0	MDI(L)	0.3	MDI(L)	0	MDE	0

Notes
Consider only column percentage and for each agroecological zone, ranks 1 to 6 add up to 100%
PDE : population-driven expansion system
PDI(E) : population-driven early intensification system
PDI(L) : population-driven late intensification system
MDE : market-driven expansion system
MDI (E) : market-driven early intensification system
MDI (L) : market-driven late intensification system
AS : agricultural system
NGS, SGS, DS, MAS, and HF: see table 1

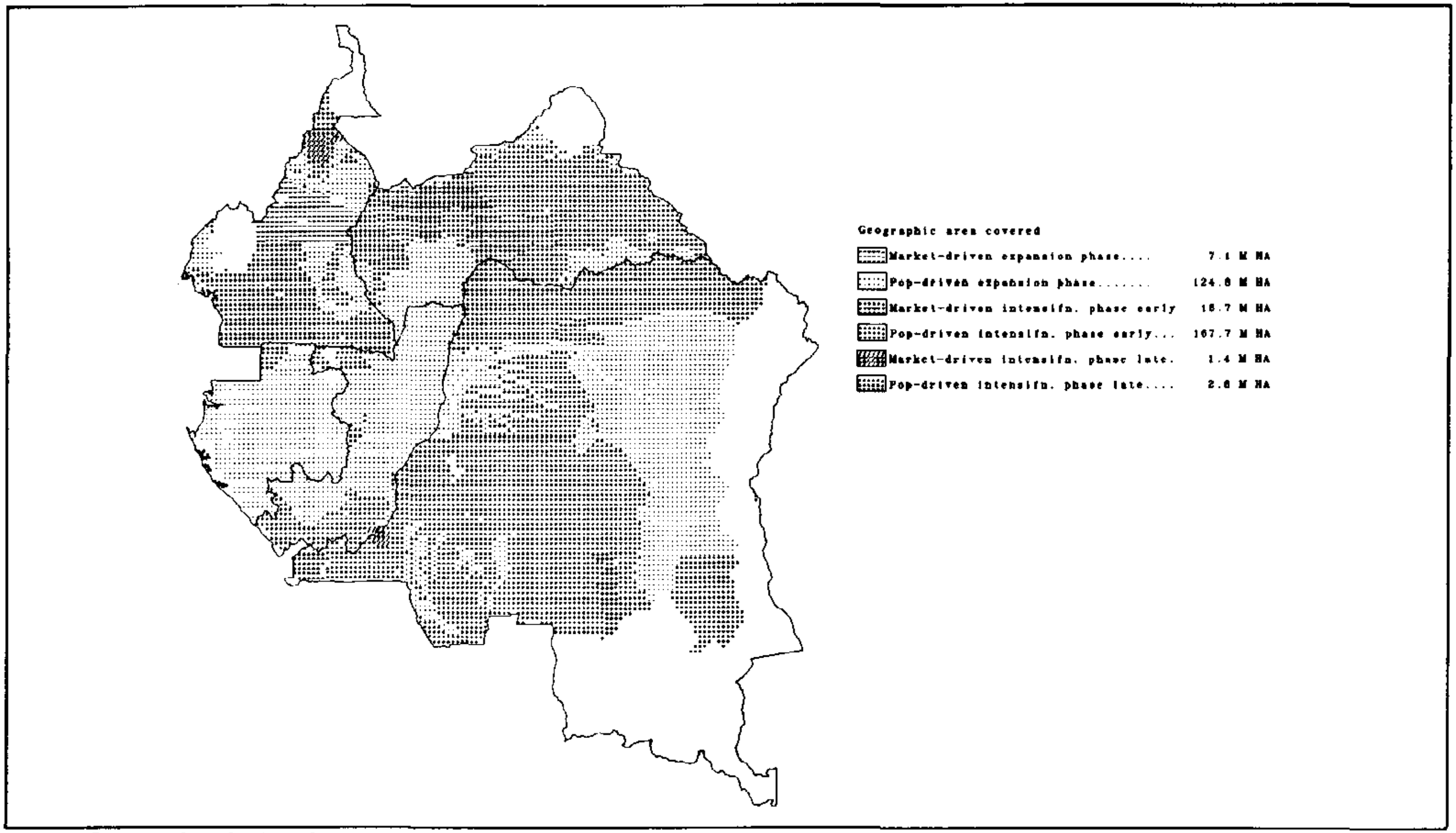
Table 4. Virgin land availability by land-use intensity of agricultural systems in Central Africa (% of area)

Areas with	Land-use intensity			Total land
	Low (1)	Moderate (2)	High (3)	(4)[a]
MD	2.2	3.9	0	6.1
PD	38.8	51.9	0.8	91.5
Total	41.0	55.8	0.8	97.6

Notes
a (4) = (1+2+3) (Central Africa = 100%) PD: population-driven system
MD: market-driven system

Distribution of agricultural systems per country

Results of an analysis of the distribution of agricultural systems by country show that in the market-driven areas of Central Africa, the Central African Republic occupies 54%, Cameroon 34%, and Zaire 12%. Agricultural intensification is mainly driven by population forces in Congo and Gabon (table 5). The results further show Zaire has 56% of the population-driven area, the Central African Republic has 15%, Congo has 11%, Cameroon has 10%, and Gabon has 8%. The market-driven versus population-driven efficiency ratio for each country is calculated by relating the percentage of market-driven and population-driven systems to the relative area of the country in the region. This ratio measures the relative importance of each country within a given pathway of intensification.



Map 6. Status of agricultural systems

Table 5. Agricultural systems by country

Country	Study area %	MD %	PD %	MD ratio %		PD ratio %	
	(1)[a]	(2)[a]	(3)[a]	4=(2):(1)	Rank	(5)=(3):(1)	Rank
CAR	17.7	54.0	14.6	305.0	1	82.5	5
Cameroon	12.0	33.6	10.2	280.0	2	85.0	4
The Congo	10.3	0.0	11.2	0.0	5	108.7	1
Gabon	7.5	0.0	8.1	0.0	4	108.0	2
Zaire	52.5	12.4	55.9	23.6	3	106.5	3
Central Africa	100	100	100	100		100	

Notes
a Consider only column % (Central Africa = 100%)
MD, PD: see table 4

Ranking the efficiency ratings aptly demonstrates how each country will effectively utilize the resources made available by the prevailing conditions. In market-driven area, parts of the Central African Republic, Cameroon, and Zaire will utilize most efficiently any technology oriented towards a market-driven system and based on purchased external inputs. Likewise in population-driven areas, parts of Congo, Gabon, and Zaire will better utilize any technology oriented towards a population-driven system, i.e., low external input technology (figure 5). This information is vital for priority setting in research planning and management for effectively channelling resources to areas where the greatest advantage will be derived. However, since no condition is permanent or static, changes in the status of the driving forces or the prevailing conditions could change a population-driven system to a market-driven and vice versa.

Trends in agricultural systems

Potential market-driven systems

Some areas that are population-driven could be transformed into market-driven environments if the existing conditions for population-driven areas were to change. We define them as potential market-driven systems. The following are some of the factors that have the potential to convert population-driven into market-driven systems in Central Africa (table 6).

1. **Good access, but no major cash crop (PMKT1).** The introduction of a cash crop or any technology that gives the environment a comparative advantage readily transforms the environment from a population-driven into a market-driven pathway. This category is represented by about 19% of the total area of Central Africa. The breakdown by agroecological zone shows that the southern Guinea savanna has 5.7%, midaltitude savanna 11.6%, humid forest 20.6%, and derived savanna 23.1%. Research should focus on these areas, as on described on page 23.

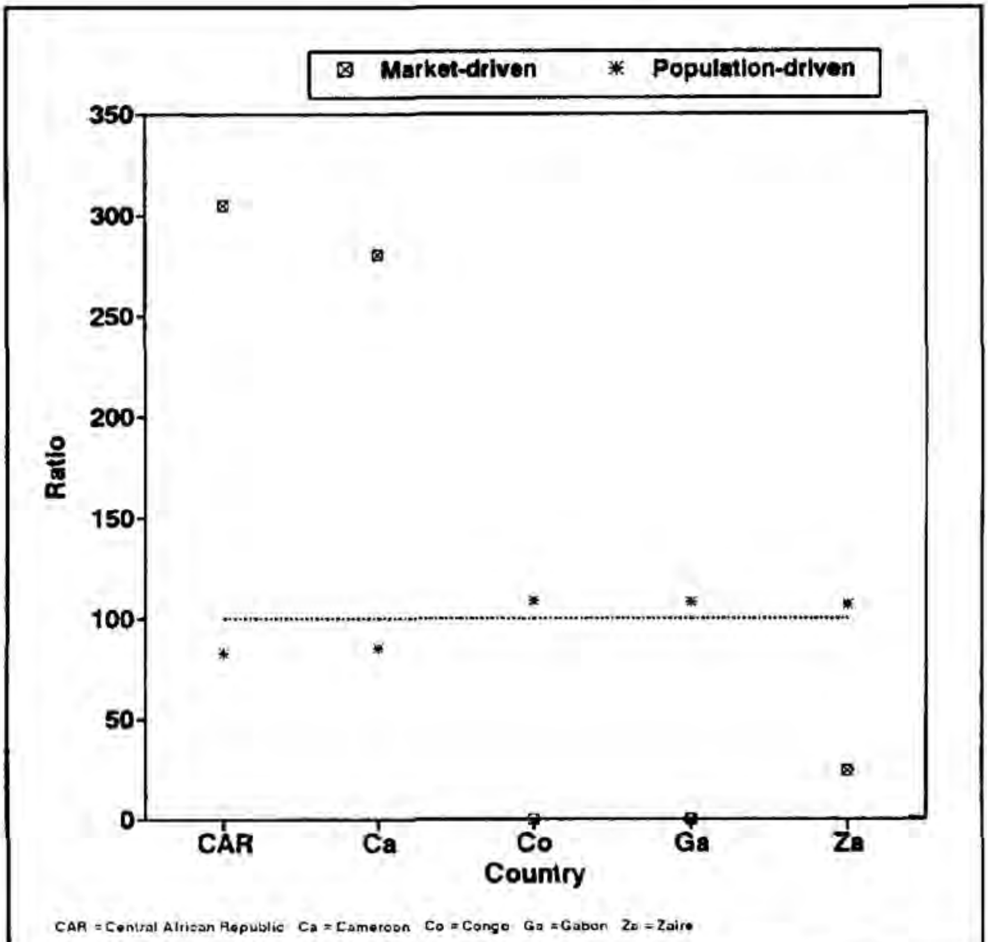


Figure 5. Market vs population driven ratio (%) by country in Central Africa

Table 6. Trends in the agricultural systems of Central Africa (% of agroecological zone)

	NGS	SGS	DS	MAS	HF	Total
PMKT1	0	5.7	23.1	11.6	20.6	19.0
PMKT2	1.9	0	0.1	1.7	1.0	0.8
PMKT3	0	1.9	21.4	8.3	14.3	14.2
PSMKT	26.9	21.1	8.9	1.0	0.2	3.9

Notes
PMKT means Potential market-driven system
PSMKT means Pseudo market-driven system
NGS, SGS, DS, MAS, and HF: see table 1

• in the southern Guinea savanna: maize — improved open-pollinated varieties will be suitable for this zone.
• in the midaltitude savanna: maize — improved varieties should be introduced with better nitrogen-use efficiency; preferably an open-pollinated variety conditioned to midaltitude environments.
• in the humid forest: cassava — high-yielding varieties (TMS 30572 etc.) should be introduced; post-harvest technologies on processing and storage should be improved; plantain/banana — high-yielding varieties resistant to black sigatoka should be introduced. Also post-harvest technologies on processing, storage and utilization should be improved.
• in the derived savanna: cassava is the key crop as in the humid forest.

2. **Major cash crop but poor access.** This condition is common in areas growing traditional tree cash crops. In these areas multinationals construct roads just to facilitate the production and marketing of tree crops. In the past ten years, however, the roads have greatly deteriorated but farmers continue to grow the tree cash crops. These systems would shift to a market-driven path if access improved. They represent about 1% of Central Africa with proportions as follows: northern Guinea savanna (1.9%), midaltitude savanna (1.7%), and humid forest (1%).

3. **High off-farm cash in population-driven systems.** These are population-driven systems where larger proportions of income come from nonfarming activities (trading, nonfarm salaries, traditional diamond or gold mining, etc.) The systems are population-driven because cash is not reinvested in agriculture because of low profitability. If a good technology were available, farmers would be willing to reinvest in agriculture. In Central Africa about 46 million ha or 14% of the total land area falls into this category. Derived savannas have the greatest share (21%), followed by the humid forest (14%), midaltitude (2.5%), and southern Guinea savanna (1.9%).

Pseudo-market-driven systems

All market-driven systems are potentially population-driven. If the conditions predisposing them to be market-driven should disappear, they would simply turn to population-driven systems. However, a pseudo-market-driven system in this monograph is defined as a system in which government policies act as a modifier in creating and sustaining the system. The cotton-based systems of parts of Zaire and the Central African Republic are examples of such a policy-induced market system. Another example is the cassava/vegetable-based system in the Central African Republic where heavy support from French nongovernmental organizations provide farmers with subsidies to produce vegetables and assist them in selling agricultural products. This situation has resulted into a dual system at farmers' level: vegetables are grown with practices typical of market-driven systems while other food crops, including cassava, are grown with practices typical of population-driven systems.

The areas mostly affected are the Guinea savannas of Central Africa (northern Guinea savanna 27% and southern Guinea savanna 21%).

IV

Characterization of IITA Mandate Crops

Distribution of the mandate crops

The farming systems in Central Africa are made up of several crop combinations common to the whole of Africa. Among other reasons this practice is to reduce the risk of crop failures. Many authors (Steiner 1982; Okigbo 1986; Makinde and Manyong 1994) have recognized the diversity and complexity of crop enterprises in African farming systems. But while farmers grow so many crop combinations, only a few could be predominant (or considered a major crop). For instance, Makinde and Manyong (1994) showed that 19 types of crops were grown in the northern Guinea savanna of Nigeria, but only four crops covered about 81% of the cultivated area. That is the reason why, in the macrolevel study, the assessment was limited to the top five crops grown by smallholder farmers. The first two of the five crops are regarded as major while the last three are minor. IITA's mandate crops in Central Africa are distributed across the region in varying proportions and combinations (table 7). Cassava is cultivated as one of the top five crops of the farming systems in 307.6 million ha or 95% of the study area, followed by maize (245.4 million ha or 76%), plantain/banana (142 million ha or 44%), yam (58.3 million ha or 18%), and cowpea (13.1 million ha or 4%). Soybean is not yet established as an important crop in the region according to the above definition though present at a lower level in savanna areas. There are also differences in the distribution of crops across the agroecological zones. Cassava is important in all the agroecological zones but more is grown in the derived savanna and humid forest. Plantain and banana are dominant in the humid forest, and maize in the midaltitude and derived savannas. Cowpea is mainly grown in the northern Guinea savanna and yam is mainly in the humid zone. While cassava and plantain/banana were assessed in this study as major crops, maize, yam, and cowpea were seen to be grown mainly as minor crops according to our definition (figure 6). Table 8 shows the importance of the mandate activities of other International Research Centers within IITA's mandate area. Cattle (ILRI's main research activity) are important mainly in the savannas especially the midaltitude savannas; sorghum (ICRISAT's main activity) is important only in northern and southern Guinea savannas, while rice (WARDA's main activity) is predominant in the humid forest, midaltitude, and derived savannas. The geographic location of IITA's mandate crops appears in maps 7 to 11.

Table 7. IITA mandate crops as one of the five main crops in farming systems in Central Africa by agroecological zone

AEZ	IITA area m ha (1)	Cassava % (2)[a]	Plantain/Banana % (3)[a]	Maize % (4)[a]	Yam % (5)[a]	Cowpea % (6)[a]	Soybean % (7)[a]
NGS	5.2	44.2	21.2	61.5	11.5	51.9	0
SGS	20.9	76.1	9.6	71.8	7.8	6.2	0
DS	67.8	95.6	25.8	89.4	11.1	6.1	0
MAS	30.2	89.7	18.9	90.7	5.3	11.6	0
HF	200	98.8	57.8	69.9	23.5	0.8	0
Total	324.1	94.9	43.8	75.7	18.0	4.0	0

Notes
a Consider only column percentages [Col (1) = 100%]. The crops have an equal chance of appearing once in the system, therefore the total row percentage by agroecological zone is more than 100
(2) ... (7) as percentage of (1)
AEZ, NGS, SGS, DS, MAS, and HF and m ha: see table 1

Table 8. Mandate activities for other international agricultural research centers as one of the main enterprises in the farming systems in Central Africa

AEZ	IITA area		Cattle		Sorghum		Rice	
	m ha	%	m ha	%	m ha	%	m ha	%
NGS	5.2	1.6	2.5	6.4	3.1	24.0	0	0
SGS	20.9	6.5	7.4	18.8	5.4	41.9	0	0
DS	67.8	20.9	12.9	32.7	1.6	12.4	1.2	2.3
MAS	30.2	9.3	11.7	29.7	2.8	21.7	4.3	8.2
HF	200	61.7	4.9	12.4	0	0	46.9	89.5
Total	324.1	100	39.4	100	12.9	100	52.4	100

Notes
Column percentages add up to 100% for each activity
AEZ, NGS, SGS, DS, MAS, HF and m ha: see table 1

Mandate crops in agricultural systems

Population-driven systems were found to be predominant in Central Africa because of poor access. An analysis of IITA's mandate crops according to path of intensification is set out in table 9. This shows that 93% of cassava is grown in population-driven areas and 7% in market-driven areas. Within the market-driven areas, cassava is grown mainly in the southern Guinea and midaltitude savannas (31%). Plantain and banana are grown (100%) in population-driven areas. The figures for maize are 91% in population-driven areas and 9% in market-driven areas and confirm the trend whereby maize is gradually taking over the savannas from sorghum. Within the market-driven path, maize is important mainly in northern Guinea savanna (45%), southern Guinea savanna (37%) and midaltitude savanna (21%). Cowpea is important in market-driven areas where it benefits from market infrastructures for cotton growing. The results indicate 35% is grown in market-driven areas and 65% in population-driven areas. The data show that 95% of yam is grown in population-driven areas and only 5% in market-driven areas. Within market-driven areas, yam is important in the midaltitude savanna (100%) and southern Guinea savanna (69%) because of the presence of both a cattle-rearing area and the market-driven cassava/vegetable-based system.

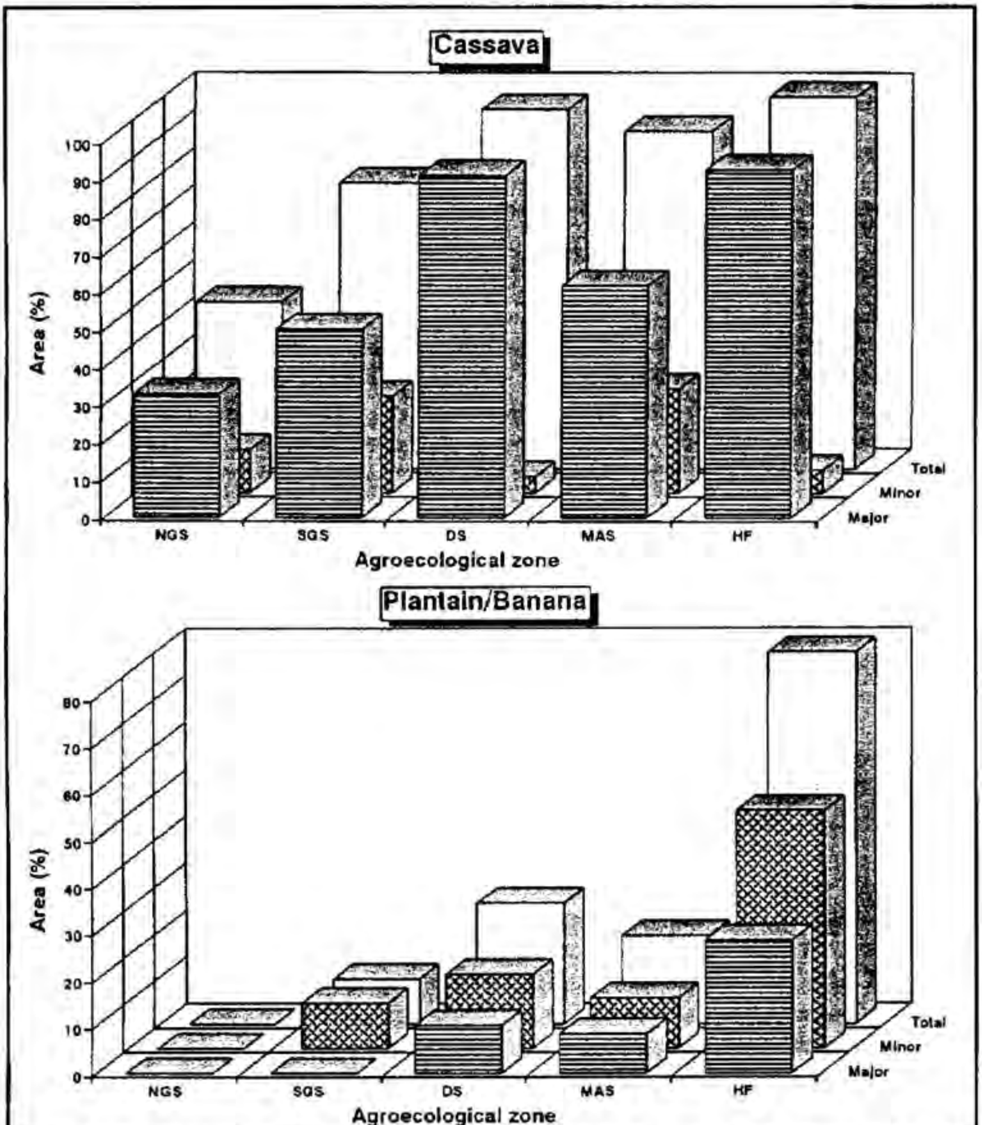


Figure 6a. Importance of cassava and plantain/banana by agroecological zone

These results have implications when research priorities for crops are defined. Crops grown in population-driven areas depend for their sustainability on natural resources (family labor, natural soil fertility, fallows to control pests), therefore research should be directed towards the development of technologies that economize these resources. In market-driven areas, farmers are able to purchase additional external inputs, such as hired labor and fertilizer. Because extra cash is generated, research efforts should be geared towards technologies that make efficient use of these external inputs. There are thus established indications that pressure on natural resources is lower in market-driven areas than population-driven areas.

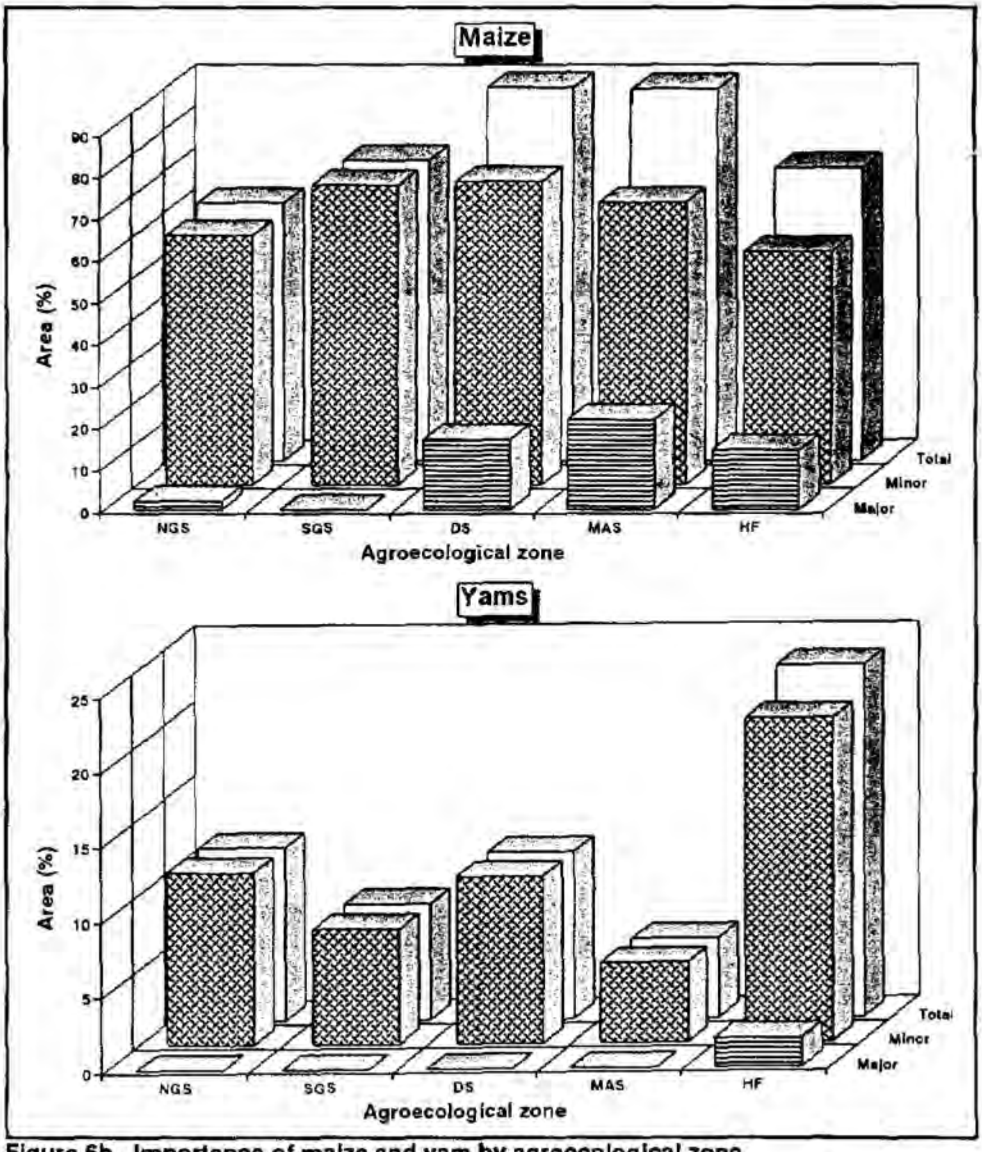
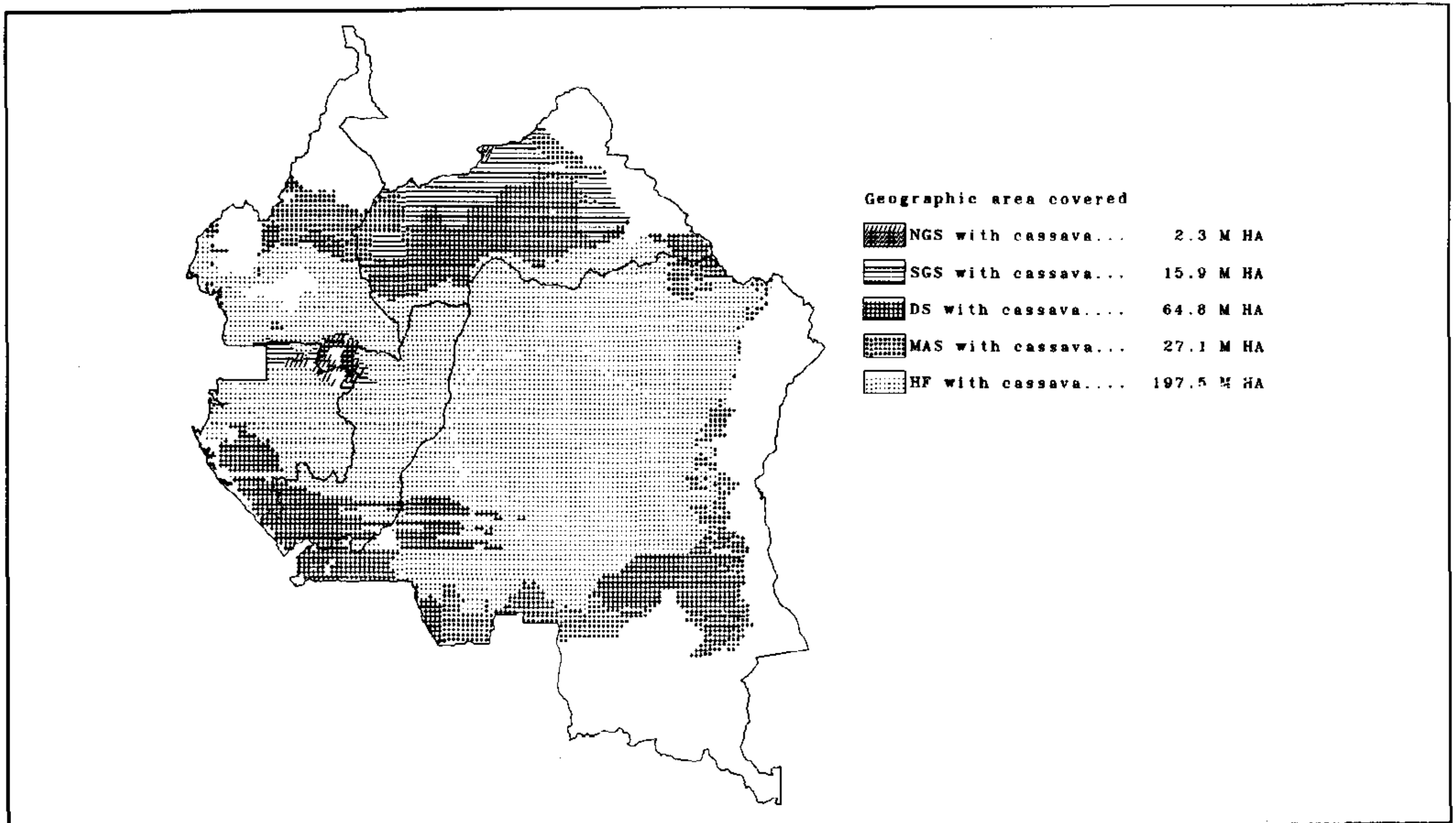
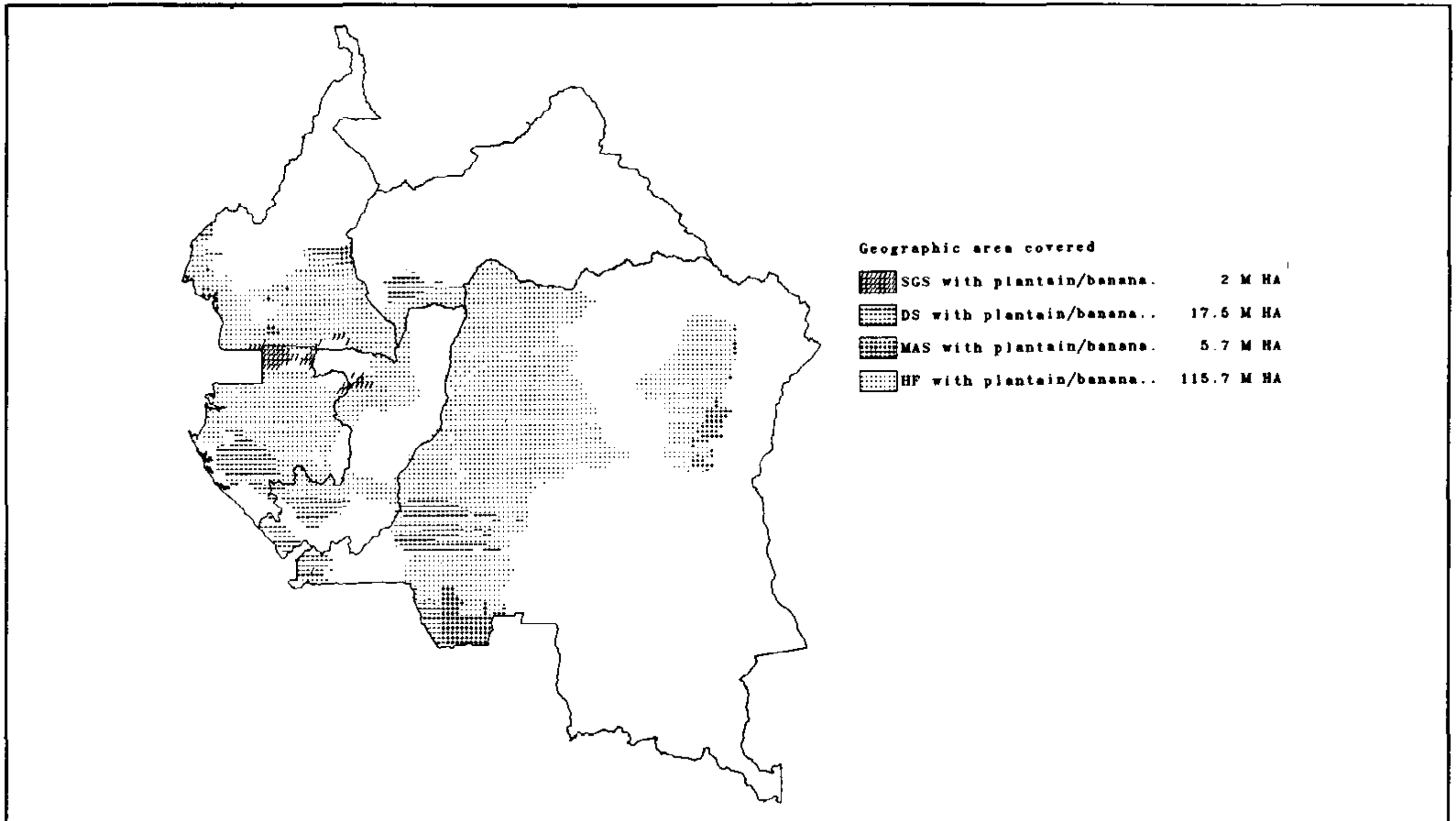


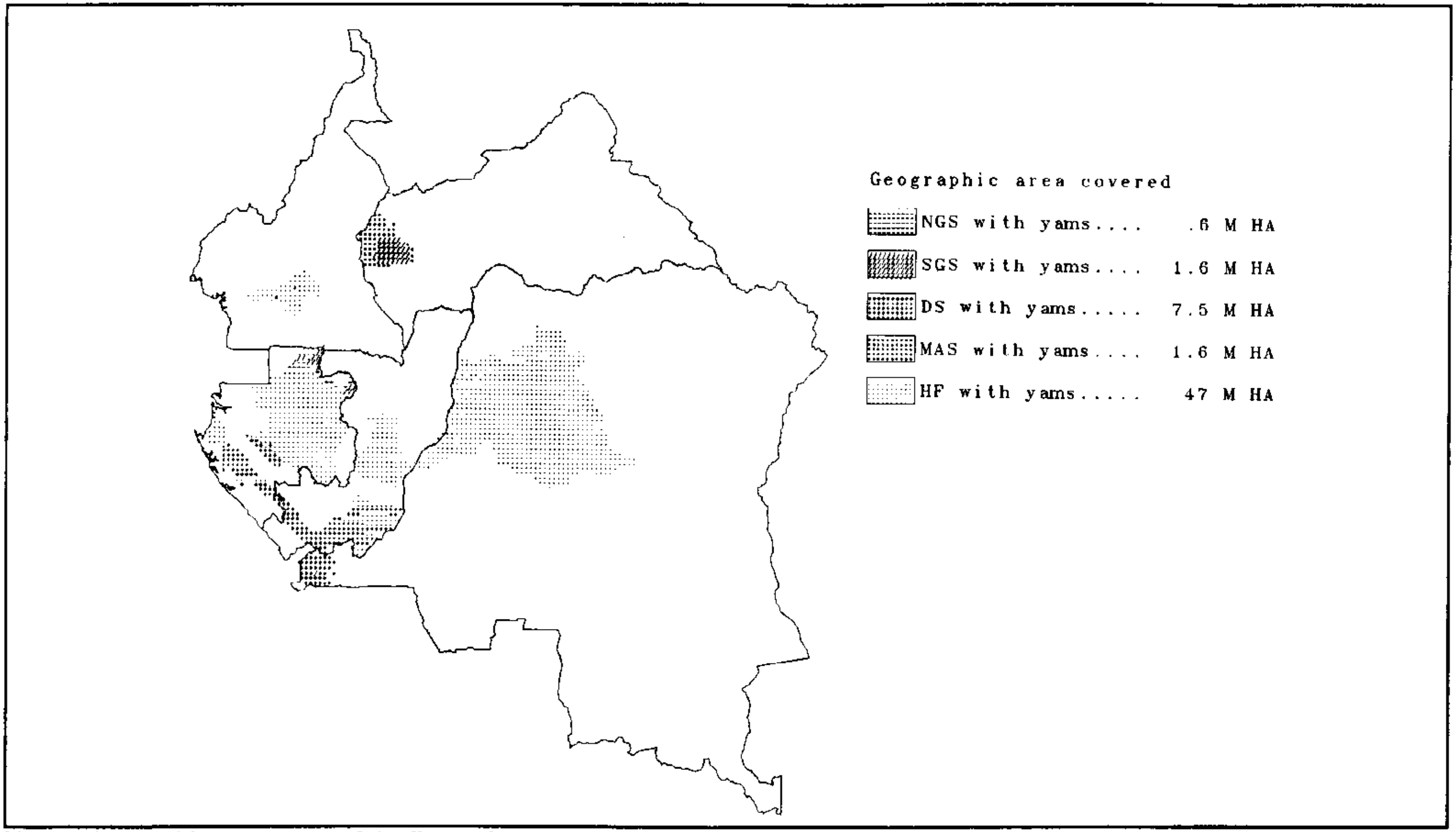
Figure 6b. Importance of maize and yam by agroecological zone



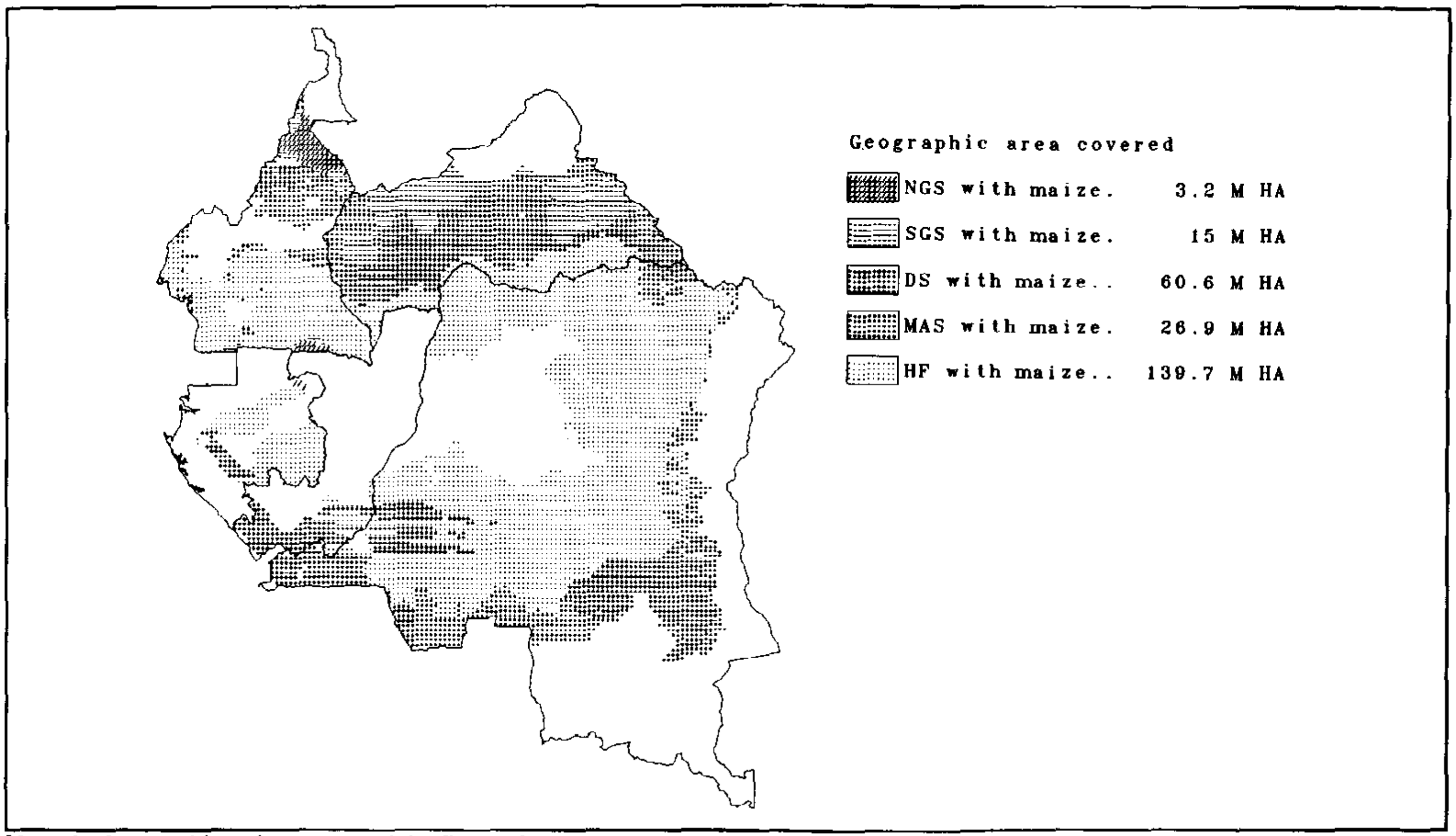
Map 7. Areas with cassava as one of the five main crops



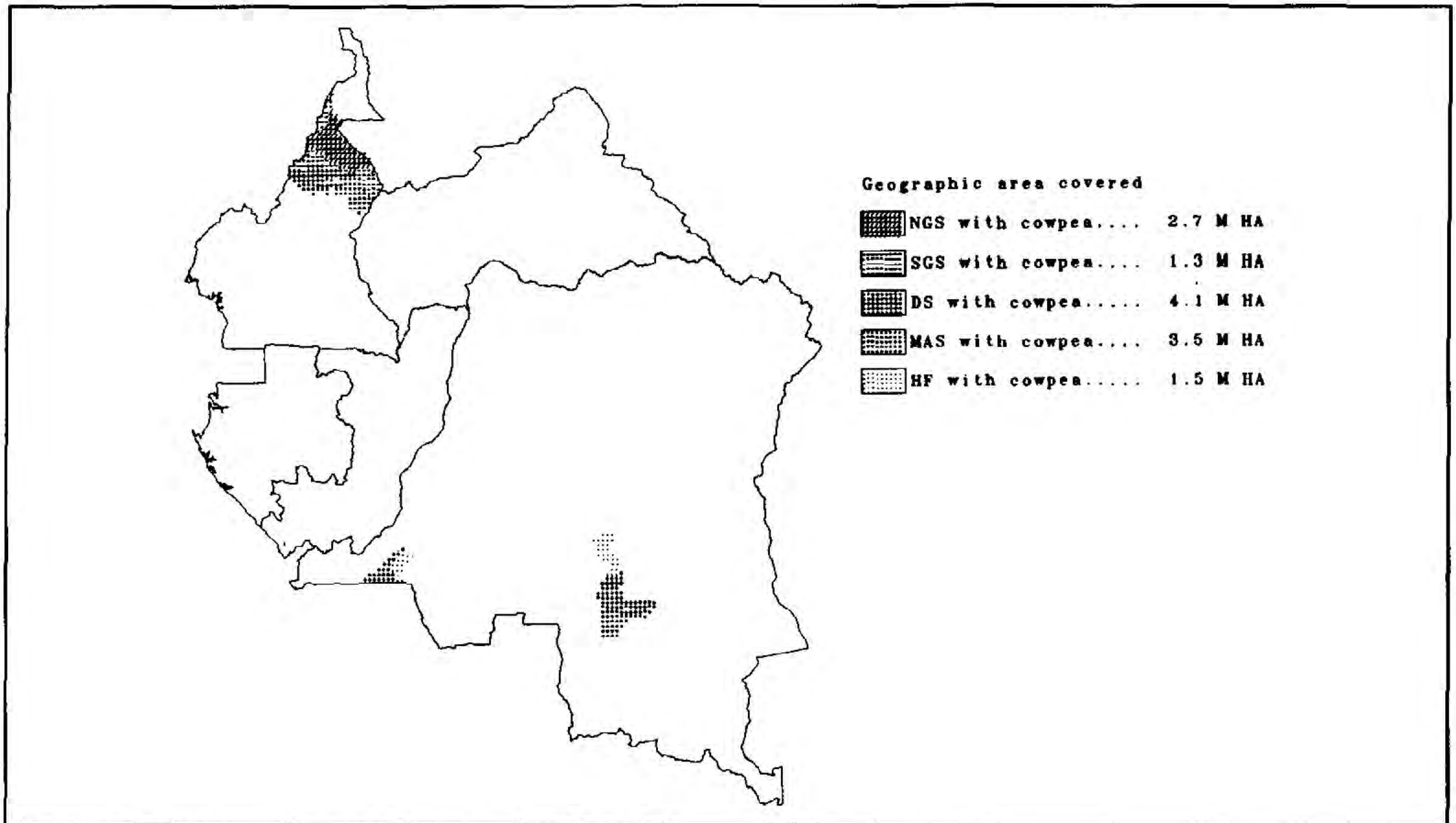
Map 8. Areas with plantain/banana as one of the five main crops



Map 9. Areas with yam as one of the five main crops



Map 10. Areas with maize as one of the five main crops



Map 11. Areas with cowpea as one of the five main crops

Table 9. IITA mandate crops as one of the top five crops by agricultural systems in Central Africa (% of area)

	Maize		Cassava		Yam		Plantain/Banana		Cowpea	
	MD	PD	MD	PD	MD	PD	MD	PD	MD	PD
NGS	45.2	54.8	-	100	-	100	-	100	53.8	46.2
SGS	37.1	62.9	31.9	68.7	68.7	31.3	-	100	33.3	66.7
DS	13.2	86.8	14.0	1.3	1.3	98.7	-	100	37.5	62.5
MAS	20.5	79.5	30.7	100	100	-	-	100	19.4	80.6
HF	0.6	99.4	0.5	-	-	100	-	100	33.3	66.7
IITA[a]	8.6	91.4	7.4	4.6	92.6	95.4	-	100	35.5	64.5

Notes
Consider only figures in a row for each crop and for each agroecological zone. Population-driven (PD) and market-driven (MD) percentages add up to 100
NGS, SGS, DS, MAS, and HF: see table 1
a = IITA mandate area

Table 10. Dynamics of the mandate crops in Central Africa (% of agroecological zone)

	Maize		Cassava		Yam		Plantain/Banana	
	E	D	E	D	E	D	E	D
NGS	59.6	0	7.7	0	0	0	11.5	0
SGS	8.1	0	57.9	3.8	5.3	0	2.4	3.8
DS	27.1	10.8	42.5	0	0.2	0	5.8	0
MAS	49.7	0	50.9	0	5.3	0	0	0
HF	35.9	0.9	29.5	0.1	2.1	0.1	7.8	0.1
IITA[a]	33.9	2.8	35.7	0.3	2.2	0.3	6.3	0.3

Notes
E = Expanding D = Declining *a* = IITA mandate area

Dynamics of the mandate crops

Apart from the areas where the mandate crops are among the five main crops grown, there are also areas where these crops are either expanding in importance or declining (table 10). Cassava is expanding more than it is declining in all the agroecological zones. Plantain and banana are expanding in all the zones where the crops are produced, except in the southern Guinea savanna. Maize is expanding in all the agroecological zones but faster in the northern Guinea savanna where extension agents place more and more emphasis on cotton/maize rotation and early-maturing varieties. Most of these crops are expanding largely because they are taking over from traditional crops such as sorghum, coffee, cocoa, and cotton as food and cash crops. Cassava, in particular, is emerging as the regional super-crop, first because it has a dual-purpose role as a cash and food crop, and secondly because tree cash crops are declining within the zone. Yam is expanding, albeit slowly, because virgin uncultivated land is abundant. However, the expansion of yam is limited by its high labor requirements. Cowpea and soybean did not show any sharp trend worth mentioning.

Implications for research

The research focus on cassava should be concentrated in the southern Guinea, derived, and midaltitude savannas. The zones are highly suitable for cassava production (FAO 1978). Given the fact that cassava is also expanding in the forest margins of the humid zone that is marginally suitable for the crop, adapted germplasm is required for cassava to contribute substantially both to productivity and sustainability in the Central African zone.

Plantain and banana. Once the black sigatoka problem is removed, plantain and banana can become a major food and cash crops complementary to cassava in the humid zone. Research should focus on processing to enhance storability.

Maize. Research should focus on increasing the yields for maize to play the dual role of a new food and cash crop more effectively in the market-driven areas of the northern Guinea savanna.

Yam. Research efforts should be directed to conserving soil fertility and saving labor on which yam production basically depends. Yam is first and foremost a food crop with traditional values. Its ownership and consumption have always been status symbols in most African societies where a higher value is usually attached to its quality rather than its quantity.

Soybean. Soybean is relatively new in the Central African subregion. It has only recently started to become established in parts of Zaire. Almost all production is consumed by humans. Soybean has a great potential both as a food and cash crop in the Guinea savannas that needs to be exploited. From their analysis of the production and utilization of soybean in Zaire and Nigeria, Shannon and Mwamba (1994) have identified five elements for the expansion of soybean in sub-Saharan Africa: (1) locally adapted foods in which soybean does not displace traditional legumes, (2) promotion of soybean, (3) diffusion, (4) technological breakthroughs, and (5) response to local markets.

V

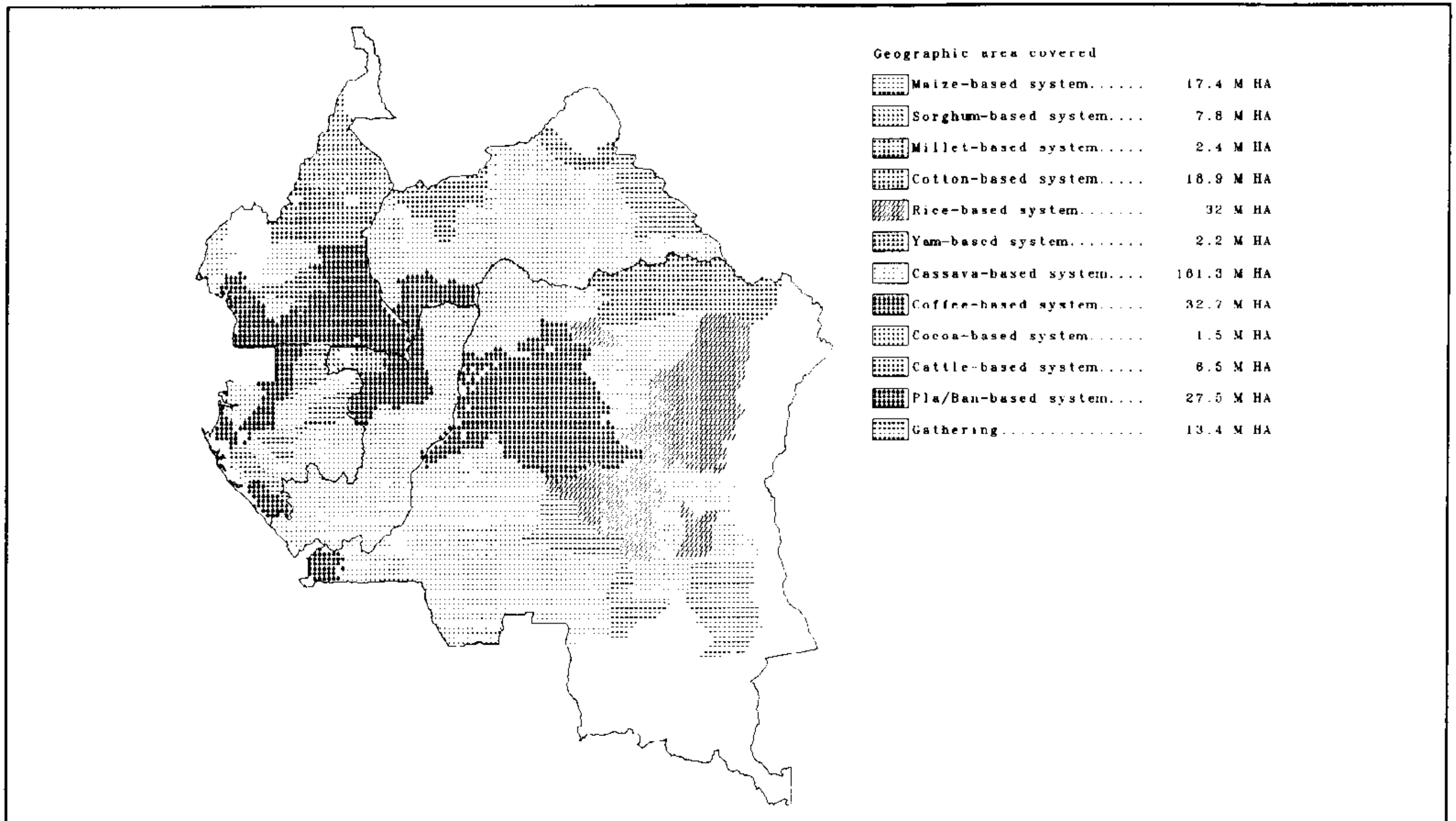
Characterization of the Cropping Systems

The study area of five countries contains about 80 different farming systems (on the basis of a vector of 37 variables) consisting mainly of crop enterprises. Cattle are important in the Adamoua plateau of Cameroon and in the Central African Republic. Other important income-generating activities that are nonfarm are fishing, trading, traditional mining, and salaried work. Fishing is common in the coastal areas of Cameroon, Gabon, and along the river banks in the Congo, Central African Republic, and Zaire. Traditional mining is a major income-earner in parts of the Central African Republic and Zaire, while trading and salaried work are the main activities around big centers all over the five countries. From the maze of about 80 farming systems, a few predominant systems can be discerned based on the leader crop/activity of such systems. Hence, there is the cassava-based system, plantain/banana-based system, cattle-based system, and so on. The representations of the geographical areas of the crop/livestock-based systems in Central Africa are shown on map 12 (the details for each country appear in the annex 1–5). The proportions or percentages occupied by each crop or livestock-based system are described in table 11.

Table 11. Characterization of the crop- and livestock-based systems in Central Africa (% of area)

System based	Area covered)[a]	Agricultural system)[a]	
		MD	PD
Maize	5.4	10.5	4.4
Sorghum	2.4	0	1.9
Millet	0.7	0	0.8
Cotton	5.8	27.8	4.7
Rice	9.9	0	10.8
Yam	0.7	0	0.7
Cassava	49.8	35.1	51.3
Coffee	10.1	0	11.1
Cocoa	0.5	0	0.5
Cattle	2.0	26.6	0
Plantain/Banana	10.5	0	11.4
Gathering from the bush	2.2	0	2.4
Total	100	100	100

Notes
a Consider only figures in a column (Total for each column = 100%)
PD = population-driven system
MD = market-driven system



Map 12. Crop/livestock-based systems

The most important systems are cassava-based (49.8%); plantain/banana-based (10.5%); coffee-based (10.1%); rice-based (9.9%); cotton-based (5.8%); maize-based (5.4%); sorghum-based (2.4%); and cattle-based (2%). This approach, to characterize a farming system on the basis of a single crop (or activity), was adopted for simplicity. Indeed, cropping systems are often complex in tropical agriculture: sorghum is always associated with maize and cotton in the same growing areas in the Guinea savannas just as plantain and banana, cassava, and coffee are associated in the humid forest.

Analysis by agricultural system shows cassava/vegetable-based and cassava/cocoa-based systems to be the most important (35.1%) in the market-driven path, followed by cotton-based (21.8%); cattle-based (26.6%); and maize-based (10.5%). In the population-driven path, the cassava-based system remains the most important system (51.3%), followed at a distance by plantain/banana-based (11.4%); coffee-based (11.1%); and rice-based (10.8%). Table 11 also shows a smaller number of systems in the market-driven path than in the population-driven path. This is an indication that there is less variability and hence less heterogeneity in market-driven than in population-driven environments.

VI

Characterization of the Constraints

Farming constraints

Key informants from national institutions were asked to list the five most important constraints faced by smallholders in each of the 80 farming systems. A list of 34 types of constraint was compiled, grouped in classes and subclasses as follows:

Class 1: Market-related constraints

Subclass 1.1: Infrastructure-related constraints

1. poor access of rural areas to markets
2. poor infrastructure for storage
3. lack of inputs

Subclass 1.2: Economics-related constraints

4. low price of agricultural products
5. low demand for agricultural products
6. high cost of inputs
7. no capital

Class 2: Resource-related constraints

Subclass 2.1: Soil-related constraints

8. soil fertility (acidity, N-deficiency, P-deficiency)
9. erosion
10. overgrazing

Subclass 2.2: Climate-related constraints

11. drought
12. heavy rains (lack of water control)
13. extreme humidity

Subclass 2.3: Vegetation-related constraints

14. weeds
15. deforestation

Class 3: Culture-related constraints

Subclass 3.1: Population-related constraints

16. land tenure
17. high population density
18. scarcity of labor
19. tradition
20. low population density

Subclass 3.2: Management-related problems
21. old plantations
22. low productivity
23. poor management

Class 4: Agricultural policy-related constraints
24. no extension service
25. inefficient extension service

Class 5: Technology-related constraints
Subclass 5.1: Variety-related constraints
26. lack of improved varieties
27. seeds of poor quality
28. inappropriate varieties
Subclass 5.2: Tool-related constraints
29. elementary farm tools
30. lack of mechanization

Class 6: Pest-related constraints
31. crop diseases
32. crop insects
33. birds
34. roaming livestock

Results from the analysis of the 80 farming systems of the Central African zone showed that important farming constraints are market-related, technology-related, and resource-related (figure 7). Details on the subclasses of constraints give the results, listed on page 40.

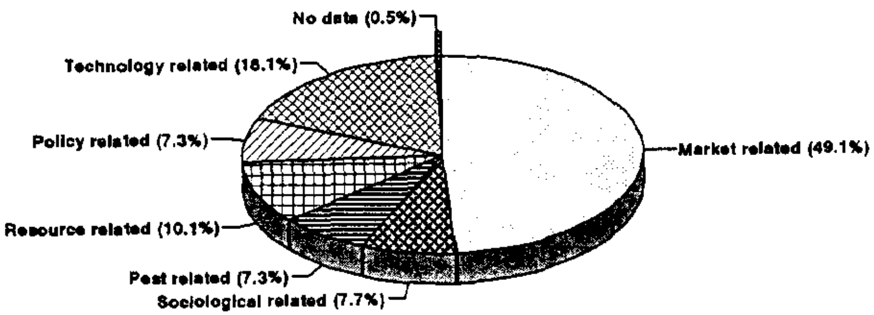


Figure 7. Characterization of farming constraints in Central Africa

• Market constraints: constraints related to infrastructures are predominant (89.4%) and the others are related to economics. These figures reinforce the results on poor accessibility analyzed earlier in this monograph.

• Resource-related constraints: climatic constraints are predominant (51.6%) because of heavy rains in the vicinity of the equator. Extreme humidity also makes it difficult to store agricultural products safely because of poor storage infrastructure. Constraints related to soils (42%) and vegetation (6.4%) rank second and third. Soil fertility is the most important (94.7%) in subclass 2.1.

• Culture-related constraints: population-related problems represent the main proportion of the class (81.9%) and the remaining problems (10.1%) are management-related. Scarcity of labor (73.6% of the population-related problems) has been already mentioned earlier in this monograph as a major constraint to the expansion of farming activities in forested areas.

• Technology constraints: lack of improved varieties or appropriate technologies is the most important technology-related problem (67%) of the sub-region. For the cassava-based systems, the Collaborative Study of Cassava in Africa (IITA 1991) identified investment in research, multiplication, and distribution of planting materials as factors limiting the development of the use of improved cassava varieties in five out of six African countries in their study. Available improved germplasm developed for *gari* production often does not meet the Central African consumers' requirements for cassava (Dr Nzonge, Gabon: personal communication). Tools used in farming constitute another group of technology-related problems (33%). Tools (axes, cutlasses, and hoes) are elementary and the mechanization of agriculture is difficult without credit mechanisms in favor of smallholders in this harsh environment (dense forest, scarcity of labor).

The breakdown by agricultural systems reveals tremendous differences in the distribution of farming constraints (figure 8).

• The frequency of constraints indicates that only 11 out of 34 types are present in market-driven areas while 27 out of 34 types were identified in population-driven areas.

• Constraints in the market-driven pathway cover an area as small as 6.2% against 93.8% in the population-driven pathway.

• The nature of constraints is also different: constraints related to technology, extension services, and culture are of less importance in market-driven area. Of the market-related constraints, those related to infrastructure (i.e., bad roads, poor storage, lack of inputs) are the most important in population-driven areas while constraints related to economics (low demand and low prices for agricultural products) predominate in market-driven areas.

The above results clearly show that the two paths of agricultural intensification lead to different types of constraints and that there are proportionately fewer farming constraints in market-driven areas than in population-driven areas.

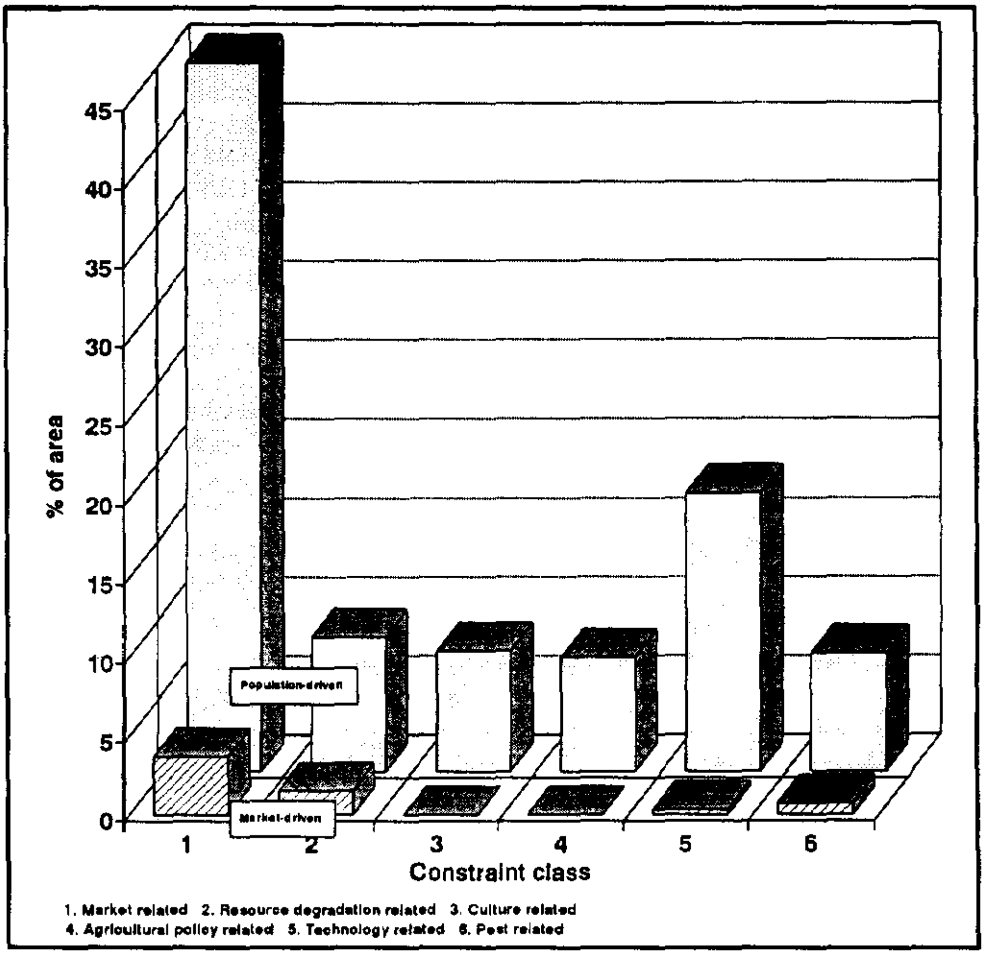


Figure 8. Characterization of farming constraints in Central Africa

Biotic constraints for the mandate crops

Pest-related constraints were assessed to be important in farming (figure 8). Biotic constraints in farming include both pests and weeds in fields and pests in storage. This analysis restricts itself to field diseases, insects, and weeds. Four ratings were used to reflect the incidence of the biotic constraints on crop as follows: very severe, severe, moderate, and not mentioned. Only the first two ratings were considered in subsequent analysis because they were hypothesized to be of economic importance on the productivity of the crops. Results given below are tentative and need to be validated. The information was not always available or was of poor quality because informants lacked the required expertise on field insects and diseases.

Biotic constraints on cassava

Data on field constraints for cassava were collected in all the five countries of the Central African zone for cassava mosaic virus; in four countries for cassava mealybug (Cameroon, Central African Republic, the Congo, and Zaire) and for cassava bacterial blight (Cameroon, the Congo, Gabon, and Zaire) and in three countries for cassava green mite (Cameroon, the Congo, and Zaire). Other constraints mentioned for cassava were root rot, *Imperata cylindrica* (speargrass), *Chromolaena odorata*, and *Zonocerus variegatus*.

Cassava mosaic virus is the most important biotic constraint for the crop in the subregion (table 12). The disease increases from the savannas towards the humid forest zone. Cassava mealybug, cassava bacterial blight, and cassava green mite have spread through the humid zones but are less important than cassava mosaic virus. Other factors, such as the management of the system, population density, and relative soil fertility, show little effect on the intensity of the constraints (table 13). Indeed, through the entire region, the distribution of the biotic constraints by socioeconomic factors (table 13) is close to that of land-use intensity (figure 2b) or soil fertility status (table 1), or agricultural systems (figure 4). These findings suggest that appropriate control measures would require farmer-neutral adoption technologies, i.e., technologies that do not require farmers to take any direct action for the adoption, such as biological control and resistant varieties.

Table 12. Areas with severe to very severe biotic constraints on cassava by agroecological zone in Central Africa (% of area)

AEZ	CMV n=5	CM n=4	CBB n=4	CGM n=3
NGS	17.3	0	19.2	0
SGS	36.8	27.3	7.6	0
DS	60.6	29.1	24.6	18.6
MAS	64.9	27.5	33.1	22.2
HF	68.3	23.1	30.4	6.9
Central Africa	63.5	24.6	27.8	10.2

Notes
n = number of countries covered for the analysis
CMV = cassava mosaic virus
CM = cassava mealybug
CBB = cassava bacterial blight
CGM = cassava green mite
AEZ, NGS, SGS, DS, MAS, and HF: see table 1

Biotic constraints on maize

Five field constraints for maize were surveyed as virulent: *Striga hermonthica*, streak virus, stemborers, downy mildew, and speargrass. Data were available from four countries for both *Striga* and stemborers (Cameroon, the Congo, Gabon, and Zaire), from two countries for streak virus (Cameroon and Zaire) and for speargrass (the Congo and Zaire), and from one country for downy mildew (Zaire).

Table 13. Effects of the socioeconomic and soil fertility factors on the biotic constraints on cassava in Central Africa (% of infested areas)

Factor	CGM	CMV	CM	CBB
Intensification path				
Market-driven	19.8	10.0	11.5	7.1
Population-driven	80.2	90.0	88.5	92.9
Population density				
Low (0–50)	100	99.8	99.7	100
Medium (50-100)	0	0	0	0
High (>100)	0	0.2	0.3	0
Relative soil fertility				
status: poor	74.2	80.9	61.1	87.5
good	25.8	19.1	38.1	12.5
Land-use intensity				
Low (<34%)	30.6	41.6	44.1	49.0
Moderate (34–66%)	69.4	57.5	54.3	49.4
High (>66%)	0	0.9	1.6	1.6

Note
CGM, CMV, CM and CBB: see table 12

Table 14. Areas with severe to very severe field constraints on maize by agroecological zone in Central Africa (% of area)

AEZ	*Striga* n = 4	Streak virus n = 2	Stemborers n = 4	Speargrass n = 2	Downy mildew n = 1
NGS	51.9	7.7	0	0	0
SGS	6.2	1.0	4.3	0	0
DS	9.9	18.3	25.7	32.6	10.2
MAS	22.2	31.1	26.2	38.4	13.2
HF	0	28.8	11.1	26.2	3.8
Central Africa	5.2	24.7	14.9	26.6	5.7

Notes
n = number of countries covered for the analysis
AEZ, NGS, SGS, DS, MAS, HF: see table 1

Results extrapolated to the entire region (table 14) indicated that speargrass is the most destructive problem followed by streak virus and stemborers. Analysis by agroecological zone shows that *Striga* is predominant in the Guinea and midaltitude savannas, while the other constraints prevail in subhumid and humid zones. The humid zone is not naturally suitable for maize (FAO 1978) and improved resistant materials are needed if maize is to play its role as a crop for the hunger gap. Socioeconomic factors, such as type of agricultural intensification, population density, and land-use intensity, have various effects on the intensity of maize constraints (table 15). Systems in the market-driven path of intensification face less *Striga* incidence than those in the population-driven path. *Striga* is a main constraint in low-populated zones where scarcity of labor often impedes farmers from tending their crops better. *Striga* is also predominant when fallow periods are not long enough to allow natural vegetation to re-establish. But the status of soil quality does not show differences between good and poor soils since *Striga*-infested areas are equally distributed on both types of soil. The above results suggest that *Striga* is probably a constraint induced by sociocultural factors and the climate. The same conclusions can be highlighted for the other maize constraints except that infestation was found to be more severe in poor soils than in good soils.

Table 15. Effect of the socioeconomic factors on the distribution of maize constraints in Central Africa (% of infested areas)

Factor	*Striga*	Streak virus	Stemborers	Speargrass	Downy mildew
Intensification path					
Market-driven	35.3	14.5	16	4.5	21.7
Population-driven	64.7	85.4	84	95.5	78.3
Population density					
Low (0–50)		99.6	99.4	99.8	100
Medium (50–100)		0	0	0	0
High (>100)		0.4	0.6	0.2	0
Relative soil fertility					
status: Poor	54.7	76.8	72.6	75.3	73
Good	45.3	23.2	27.4	24.7	27
Land-use intensity					
Low (<34%)	38.2	43.9	23.8	15.2	11.9
Moderate (34–66%)	56.5	56.1	76.2	84.7	88.1
High (>66%)	5.3	0	0	0.1	0

Biotic constraints on plantain/banana

Data were collected in four countries out of five in the study area, namely: Cameroon, Congo, Gabon, and Zaire. Black sigatoka was found to be a serious constraint in the humid zone. An area as large as 82.4 million ha is severely to very severely infested by black sigatoka out of 192.8 million ha in which plantain and banana were found to be grown. The breakdown by agroecological zone is as follows: 6.2 million ha out of 46.4 million ha in the derived savanna; 2.6 million ha out of 8.3 million ha in the Guinea

Table 16. Areas with severe to very severe field constraints on yam (nematode) and plantain/banana (black sigatoka) by agroecological zone in Central Africa (% of area)

AEZ	Black sigatoka (plantain/banana) n=4	Nematode (yam) n=1
NGS	22.9	0.0
SGS	42.8	0.0
DS	13.4	6.0
MAS	1.8	2.0
HF	42.7	12.9
Central Africa	33.9	7.9

Notes
n = number of countries covered for the analysis
AEZ, NGS, SGS, DS, MAS, and HF = see table 1

savannas, and 0.4 million ha out of 22.6 million ha in the midaltitude savanna (table 16). Results also indicated that infested areas are concentrated in low-populated areas, in population-driven areas, and in environments with poor soils. These findings support a research policy towards the development of technologies with low external input, such as resistant varieties against black sigatoka.

Biotic constraints on other IITA mandate crops

Cowpea: field insects are the most important. In Zaire where information was available, infested areas in which cowpea is grown were as large as 31.9 million ha or 18.6% of the study area in the country. Low yields (100 – 300 kg/ha) in farmers' fields were attributed mainly to insect attacks in the extreme northwestern region (Gemena region) in the western region (Cataractes region), and in the center-south (Kasai region) of Zaire (République du Zaire 1987). *Striga gesnerioides* was mentioned as severely infecting the cowpea fields in the Kasai region within an area as large as 13.2 million ha or 7.7% of the study area of Zaire.

Yam: from Cameroon, severe nematode infestation on yam was mentioned in 2.2 million ha or 5.3% of the humid and subhumid parts of the country. The same relationships to the socioeconomic conditions (intensification path, population density) and to soil fertility status were observed as for the other mandate crops.

Implications for research

Both physical factors (soils, climate) and socioeconomic factors (market opportunities, population density, land-use intensity) have shown great effects on the biotic constraints. While ecological conditions determine the nature of the biotic constraints, soil status and socioeconomic conditions determine the severity of attacks, thus the economic incidence of the constraints on the sustainability of the production system. It is important to consider these conditions when targeting improved technologies.

VII

Targeting of Technologies to Agricultural Systems

Matching the characteristics of agricultural systems with the technology requirements allows technologies to be targeted to the most suitable environments for adoption. Resource endowment of the agricultural systems for the basic factors of production are given in table 17. Systems in the expansion phase (low intensity of land use) are characterized by the abundance of land but the endowment in variable factors (labor and capital) is either scarce or moderate (as compare to those in the intensification phase). Systems in the population path lack capital as compared to those in the market path. So targeting of technologies requires consideration to be taken into the nature of the technology as well.

Table 17. Resource endowment of the agricultural systems in Central Africa

System	Population-driven			Market-driven		
Land-use intensity	Low	Moderate	High	Low	Moderate	High
Areas (%)	39.0	52.5	0.8	2.2	5.1	0.4
		Resource endowment				
Land	A	M	S	A	M	S
Labor/land	S	S/M	M/A	S/M	M/A	M/A
Working capital/labor	S	S	S	M	M/S	M/S
Fixed capital/ labor	S	S	S	M	M/S	M/S

Note
S = scarce M = moderate A = abundant

Farmer-neutral adoption technologies are suitable for all the systems in Central Africa but they are particularly indicated for the population-driven areas (92% of the study area). Technologies that require the farmers' involvement for successful adoption need to be targeted on the basis of their complexity. Single component technologies, such as resistant materials or high-yielding varieties that fit into existing systems, are potentially easier to adopt than complex technologies that create a new system at the farmers' level. The socioeconomic conditions of Central African farmers, as described earlier, appeal to the single components such as resistant materials and postharvest technologies.

Table 18. Mode of introduction of legumes (herbaceous and shrubs) into agricultural systems in Central Africa

System	Population-driven			Market-driven		
Land-use intensity	Low	Moderate	High	Low	Moderate	High
Areas (%)	39.0	52.5	0.8	2.2	5.1	0.4
	Mode of introduction					
Rotation (fallow)	NS	NS	S	NS	S	NS
Relay cropping	NS	S	S	S	S	S
Multiple cropping	S	S	NS	NS	NS	NS
Alley cropping	NS	NS	S	NS	S	S

Note

NS = not suitable S = suitable

High-yielding germplasm of crops that multiply vegetatively are suitable for Central Africa, provided that postharvest technologies are developed. Improved germplasm of crops that require continuous renewal of seed should be targeted to the market-driven area of the Guinea savannas. Complex technologies such as alley farming need careful thought prior to their introduction in the Central African zone. The forest zone is not appropriate for alley farming. But other agroforestry technologies, such as economic trees producing fruits, medicinal, and ratan products, might be accommodated in the forest margins. Herbaceous legumes may also play a positive role in the forest margins but their mode of introduction determines the adoption (table 18). Hence, the relay cropping mode is suitable where the labor/land ratio is moderate-to-abundant, while the multiple cropping mode should be ideal in the population-driven system. Alley cropping should perform well in the late intensification phase in the subhumid areas.

VIII

Conclusion and Recommendations

Subhumid and humid regions of Central Africa cover an area twice as large as that of west Africa. Population density is low and virgin land is still abundant, thus offering opportunities for both biodiversity and conservation programs. Where land is being cultivated, the characterization of farming systems has resulted in as many as 80 types on the basis of a multivector of 37 variables. If only one predominant rural activity is considered, Central Africa is mainly a root and tuber-based system.

Analysis on the dynamics of systems has shown that most of the study area (92%) follows a population-driven pathway of intensification because of poor market opportunities. Differences have been noticed among agroecological zones and countries because market-driven areas are prevalent in the savannas.

Although the intensity of land use is still low-to-moderate, there is evidence that forest margins are experiencing serious resource degradation which needs increasing attention to sustain the productivity of the home gardens. Complex technologies that result in new systems at farmers' level such as herbaceous legumes are needed in the forest margins but both the type of technology and its mode of introduction are crucial to the success of adoption. Elsewhere, the research strategy should be oriented towards the development of single component technologies, preferably the small-scale farmer-neutral adoption ones such as classical biological control or resistant materials technology. But a big breakthrough would not be achieved without improving the market infrastructure of the subregion. This is supported by the results which showed that systems in favorable market environments are less heterogeneous and face fewer constraints, hence they are probably easier to manage. Here policy-decision makers have to play a major part in solving the problem. This is a precondition if products from agricultural research are to make a substantial contribution to the improvement of smallholders' welfare in Central Africa.

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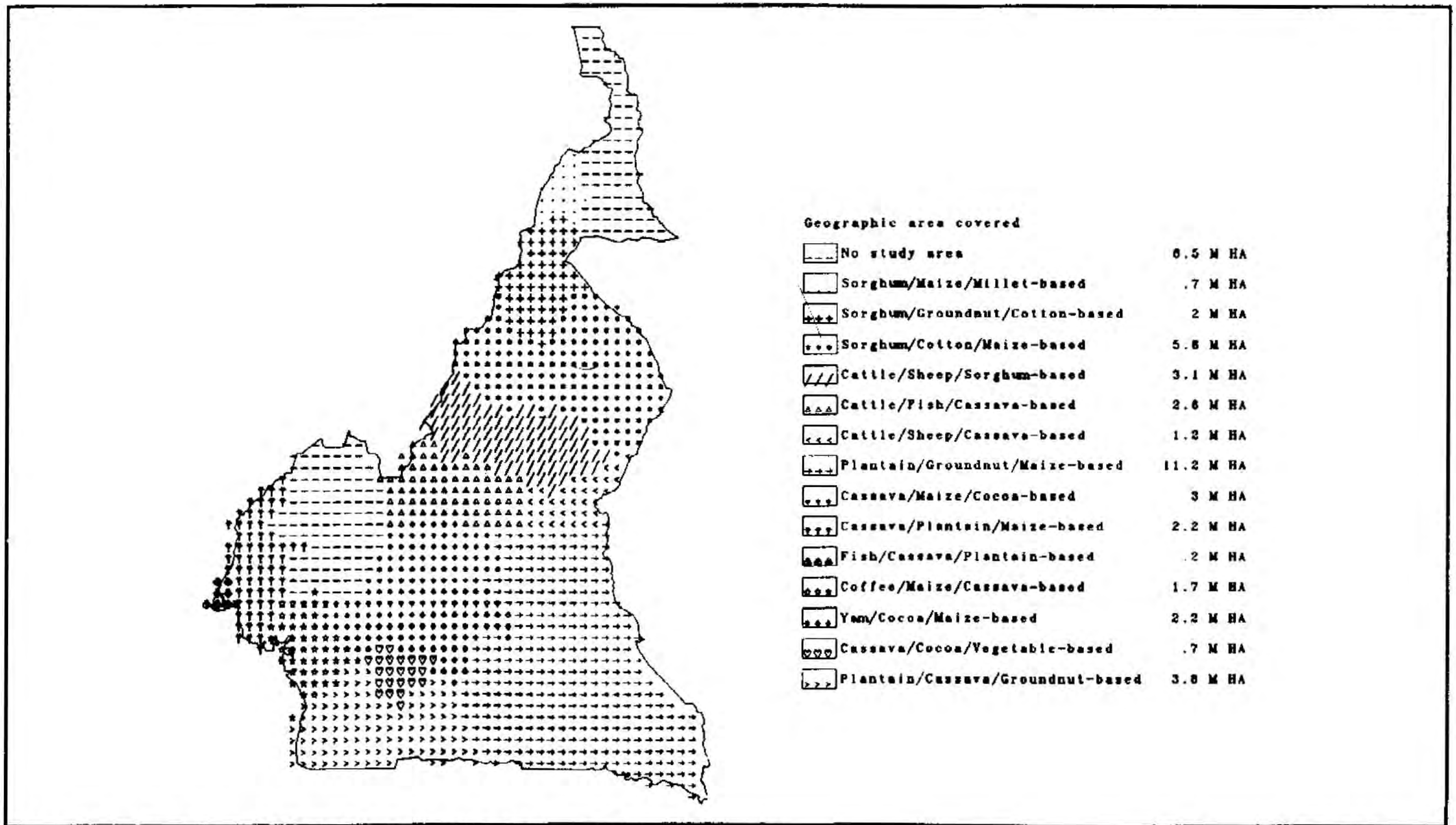
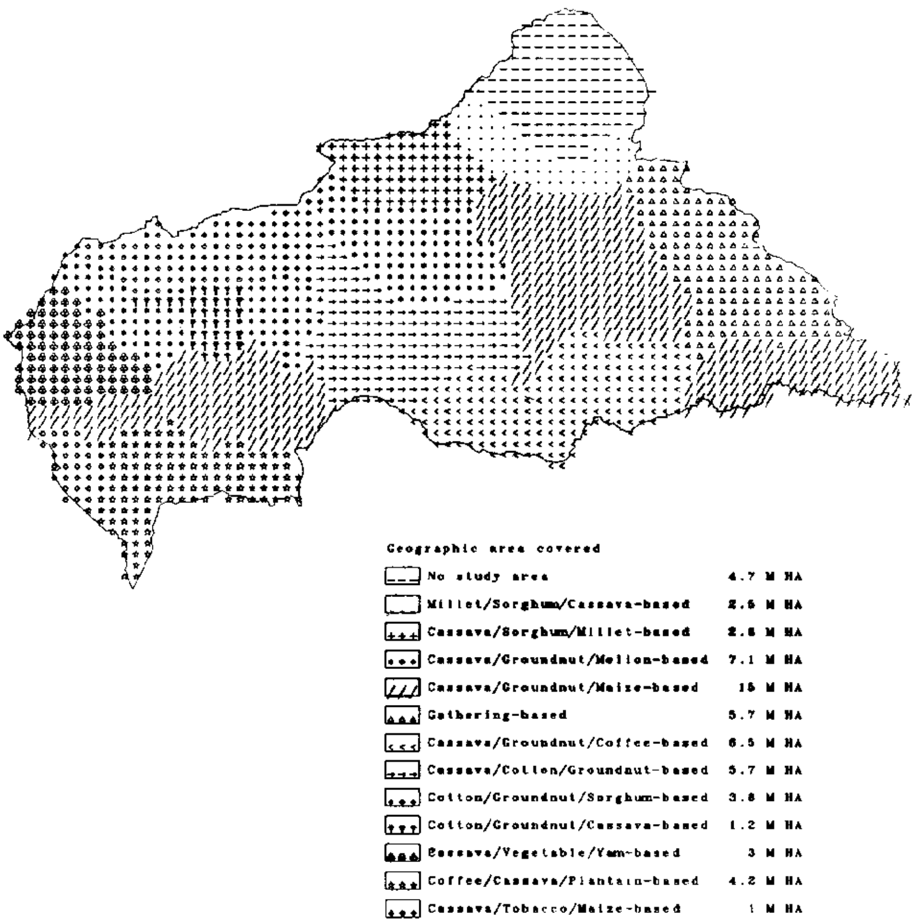
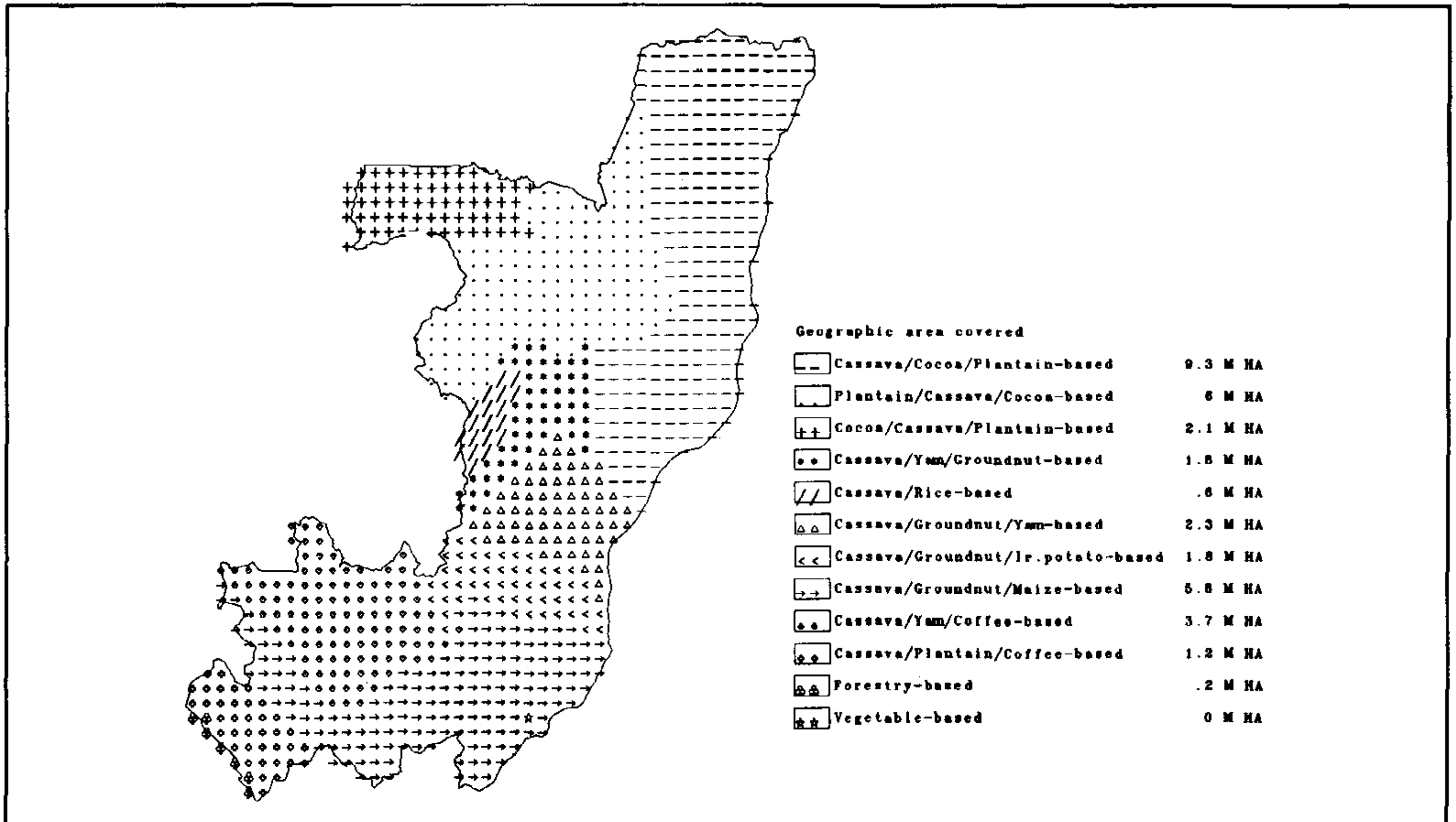


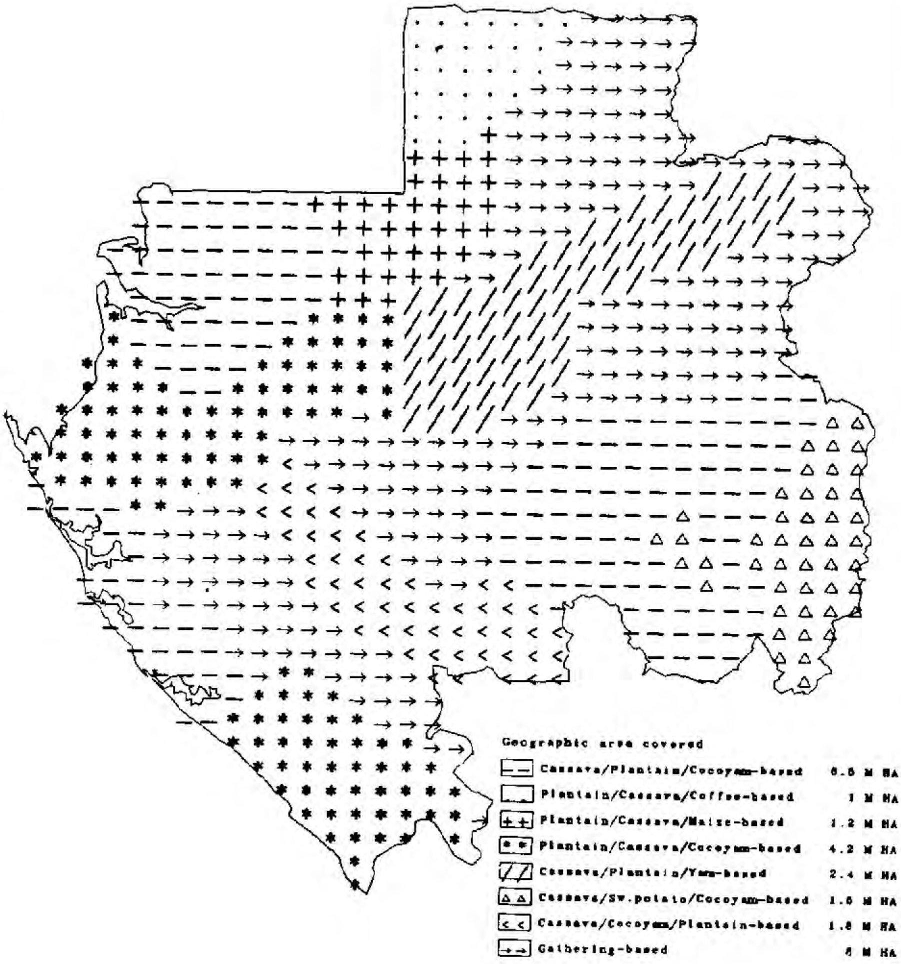
Annex 1. Cropping systems in the Republic of Cameroon



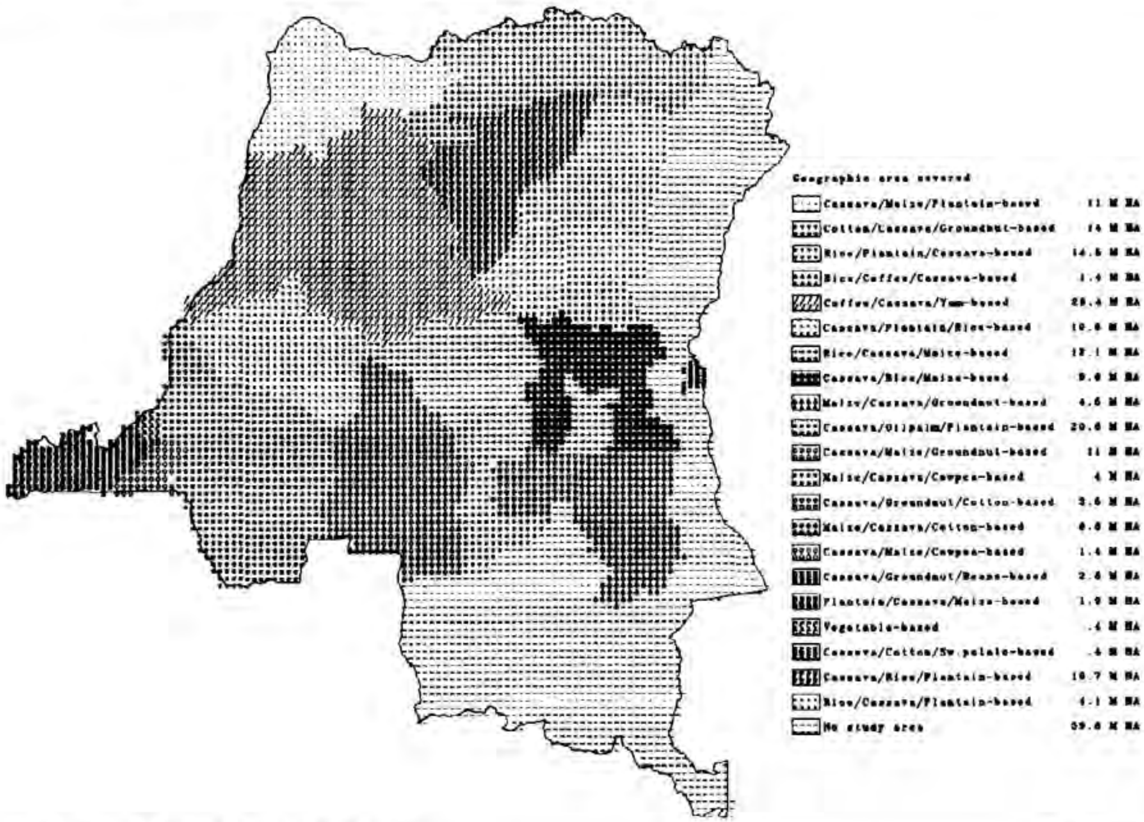
Annex 2. Cropping systems in the Central African Republic



Annex 3. Cropping systems in the Republic of Congo



Annex 4. Cropping systems in the Republic of Gabon



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IITA was founded in 1967. The Federal Government of Nigeria provided a land grant of 1,000 hectares at Ibadan, for a headquarters and experimental farm site, and the Rockefeller and Ford foundations provided financial support. IITA is governed by an international Board of Trustees. The staff includes around 180 scientists and professionals from about 40 countries, who work at the Ibadan campus and at selected locations in many countries of sub-Saharan Africa.

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