COSCA
Collaborative Study of Cassava in Africa
Working Paper No. 9

9

The Dynamics of Cassava in Africa

An outline of research issues

Louise O. Fresco

COSCA: PROJECT AGENCIES AND COLLABORATORS

Executive Agency
International Institute of Tropical Agriculture (IITA), Ibadan

Collaborating Agencies
Centro International de Agricultura Tropical (CIAT), Cali, Colombia
Natural Resources Institute (NRI), London
International Child Health Unit (ICHU), Uppsala, Sweden
National agricultural research systems (NARS) of Burundi, Cameroon, Congo, Côte d'Ivoire, Ghana, Kenya, Malawi, Nigeria, Rwanda, Tanzania, Uganda, Zaire and Zambia

Primary Funding Agency
The Rockefeller Foundation

Steering Committee
D. Spencer, IITA (Chairman)
S. Hahn, IITA
R. Best, CIAT
R. Barker, IITA, Board of Trustees
J. Lynam, The Rockefeller Foundation
T. Philips, University of Guelph
J. Strauss, Michigan State University
M. Dahniya, University of Sierra Leone
F. Nweke, IITA (Secretary)

Project Leader
F. Nweke

National Research Coordinators
K. Ngoran, Côte d'Ivoire
C. N'dri, Côte d'Ivoire
B. Konassi, Côte d'Ivoire
I. Quattara, Côte d'Ivoire
R. Al-Hassan (Ms) Ghana
S. Asuming-Brempong, Ghana
A. Kissiedu, Ghana
A. Cudjoe, Ghana
I. Bondzie, Ghana
A. Abubaker, Kenya
R. Sauti, Malawi
M. Chibwambo (Ms) Malawi
E. Nkhonje, Malawi
G. Thaulo, Malawi
B. Ugwu, Nigeria
O. Ajobo, Nigeria
C. Asinobi (Ms), Nigeria
A. Nwosu (Ms), Nigeria
M. Ibedu, Nigeria
B. Rwenyagira, Tanzania
R. Kapinga (Ms) Tanzania
E. Ruzika, Tanzania
A. Makbel, Tanzania
G. Otim-Nape, Uganda
A. Bua, Uganda
H. Masembe-Kajubi, Uganda
Y. Baguma, Uganda
B. Bukaka, Zaire
N. Kalombo, Zaire
D. Lutete, Zaire
A. Sumani, Zambia

IITA Scientists
D. Spencer, Agricultural Economist, Resource and Crop Management Division (RCMD)
F. Nweke, Agricultural Economist (RCMD)
S. Hahn, Breeder, Root and Tuber Improvement Program (TRIP)
W. Jeon, Postharvest technologist (TRIP)
M. Bokanga, Biochemist (TRIP)

non-IITA Scientists
S. Carter (CIAT)
N. Poulter, Food Processing Technologist (NRI)
A. Westby, Economist (NRI)
J. Gillings, Economist (NRI)
J. Lynam, Agricultural Economist (The Rockefeller Foundation)
S. Romanoff, Anthropologist (The Rockefeller Foundation)

Consultants
E. Okorji, University of Nigeria, Nsukka
C. Asadu, University of Nigeria, Nsukka
W. Jones, Stanford University, USA
L. Fresco (Ms) University of Agriculture, Wageningen, Netherlands
M. Akoroda, University of Ibadan, Ibadan

Data Base Manager
S. Folayan, IITA

Administrative Assistant
J. Ojetade, IITA

C O S C A
Collaborative Study of Cassava in Africa

The Dynamics of Cassava in Africa
An outline of research issues

Louise O. Fresco
University of Agriculture
Wageningen, Netherlands

COSCA Working Paper No. 9, 1993

COSCA Working Paper No. 10

First Printing 1993

Collaborative Study of Cassava in Africa
Resource and Crop Management Division
International Institute of Tropical Agriculture
P.M.B. 5320
Oyo Road
Ibadan, Nigeria

Produced for COSCA in cooperation with
African Book Builders, Ltd.
26 Arigidi Street
Bodija Estate,
Ibadan, Nigeria

CONTENTS

PREFACE

THE Collaborative Study of Cassava in Africa (COSCA), is an inter-institutional effort. The aim is to provide baseline information on cassava over a wide area. Such information is needed to improve the relevance and impact of agricultural research on the crop in Africa in order to realize the potential of cassava in increasing food production and the incomes of the people of Africa.

The COSCA working paper series is published informally by COSCA to disseminate its intermediate output. Publications in the series include methodologies for, as well as preliminary results of, the various components and phases of the COSCA surveys. The series is aimed at scientists and researchers working with national agricultural research systems in Africa (NARS), the international research community, policy makers, donors and members of international development agencies that are interested in cassava. As these papers are not in their final form, comments are welcome. Such comments should be addressed to the respective authors or to the COSCA project leader.

Individuals and institutions may receive single copies free of charge by writing to:

The Project Leader
Collaborative Study of Cassava in Africa
Resource and Crop Management Division
International Institute of Tropical Agriculture
P.M.B. 5320, Oyo Road
Ibadan, Nigeria

1. Introduction

SINCE its introduction into the African continent in the course of the 16th century, cassava has gradually become one of the dominant starchy staples, in particular in the humid lowlands, where it may provide over 50 per cent of the local diet. The successful integration of cassava in African cropping and dietary patterns takes on special importance as Africa is the only region where per capita food production has apparently been declining in the last two decades. According to official statistics, overall cassava production in Africa has nearly doubled during this period. However, these increases have not been able to keep pace with the population increase (De Bruijn and Fresco 1989).

At the same time there are various, often unchecked and contradictory, indications of rapidly changing patterns of agricultural production accompanied by shifts in the relative importance of food crops. Cassava is said to be expanding by replacing traditional crops such as yam, millet, and sorghum, and by occupying new niches in the farming systems of the highlands, the semi-arid regions, and the urban peripheries. On the other hand, cassava seems to suffer competition from imported cereals and from government-supported crops such as maize.

Current understanding of long-term changes in the relative importance of cassava in different agroecological regions is extremely limited and often based on arbitrary speculation rather than on fact. Aggregated food crop statistics in Africa are noted for their poor quality, and cassava's special nature as a food reserve crop is likely to increase statistical inaccuracy. Although numerous studies by social scientists may contain important information on the crop, little effort has been made so far to view these in a comparative and historical context. Even fewer attempts have been made to relate their findings to crop science research which, in turn, has rarely been linked to the changing role of cassava in Africa. It is significant that no comprehensive review of quantitative and qualitative data on cassava in Africa has appeared since the publication of *Manioc in Africa* (Jones 1959).

The question of cassava's relevance to the African food crisis, and, more broadly, to African development, forms the background to this paper. An understanding of the complex factors that influence cassava production, processing, marketing, and consumption in Africa, as well as its future potential, requires a renewed effort to integrate the agricultural and social sciences. Taking a long-term view is inevitable, not only to correct information for seasonal and inter-annual variations, but, more importantly, to allow an investigation of the role of cassava under changing agroecological, demographic and socioeconomic conditions.

This desk study assumes a dual objective, first, to review the existing literature and data on cassava in Africa, and secondly, to develop an interdisciplinary framework to generate hypotheses. More specifically, it aims to:

- identify long-term (statistical) trends, regrouping information on an agroecological as well as a country basis
- verify these trends with the help of local level data from various (colonial) agricultural and anthropological sources
- determine the factors influencing production, processing, marketing, and consumption of cassava in different agroecological zones
- suggest directions for future (crop science) research on cassava

This document presents an initial outline of the analytical framework as well as some thoughts on research methodology, in a very tentative way, since many of the issues involved are highly hypothetical. The fact that relatively more emphasis is placed on supply side factors does not reflect their priority but the author's disciplinary background.

2. Classifying African Cassava Regions

Agriculture in Africa is characterized by a high degree of location-specificity. The interaction of a wide range of agroecological and socioeconomic factors has resulted in a variety of conditions under which cassava is grown, processed, marketed, and consumed. In order to understand the changing role of cassava, ways must be found to disentangle these interacting factors. This framework subdivides the African continent into regions with minimal heterogeneity, and identifies the factors influencing cassava in each of the various cassava regions. The term *cassava region* refers, in a rather loose way, to a more or less homogeneous area or set of areas (that may be geographically separated) where cassava production, processing, marketing, and consumption are subjected to similar factors and where 'cassava scenarios' are therefore, likely to be similar. The assumption underlying this concept is that changes in cassava production, processing, marketing, and consumption can be explained by differences between the regions. This assumption will have to be verified through the analysis of empirical data.

There are many ways to classify African cassava regions, depending on the kind, number and scale of the factors involved. As always in these matters, a balance must be struck between the uniqueness of each small area and the characteristics it shares with other areas. To cluster areas that may be similar but cannot be identical is, of course, always risky, but essential if some degree of generality is to be reached. The operative principle here is relevant similarity for the purposes of the study. In other words, it is assumed that agroecological, demographic, socioeconomic, and agricultural factors explain changes in the role of cassava. An attempt will be made to map each of the following three sets of classificatory characteristics through a GIS (geographic information system), (Higgins 1987), and to superimpose the resulting maps in order to determine the most appropriate combinations of African cassava regions. Cell size will depend on the availability of primary data. The Food and Agriculture Organization (FAO) uses GIS cells with an approximate size of 150,000 ha each, but this seems detailed for the purpose and time frame of this analysis.

Agroecological zones

Climate in sub-Saharan Africa can be broadly subdivided into four classes (Jackson 1977, Webster and Wilson 1980) according to long-term average annual rainfall and rainfall distribution: wet equatorial, humid, subhumid and semi-arid. This excludes the arid zone, defined as having less than 350 mm and less than 2 wet months, where cassava is not found. Highland zones (above 1000 m) constitute a separate ecological zone. These zones cut across national boundaries, and for some purposes it may be useful to follow the FAO subdivision of sub-Saharan Africa into five regions (FAO 1986).

- the Sudano-Sahelian region (11 countries)
- the humid/subhumid West African region (9 countries)
- humid Central Africa (7 countries)
- subhumid and mountainous East Africa (9 countries)
- subhumid/semi-arid southern Africa (10 countries)

In a general way, the zoning of African soils matches the climatic zones. While variations across toposequences may be locally significant, variability is relatively limited over large areas (e.g., West Africa, Congo Basin, East Africa highlands). Climate, soil, vegetation, and crop production potential have already been mapped in a combined way as zones with similar lengths of growing season by FAO (1978), but the specific conclusions with respect to cassava may need review. For example, no region of the African continent is classified as 'very suitable' for cassava grown with low inputs (i.e., traditional cropping practices), and the central Congo basin is considered only marginally suitable. The highlands are classified as unsuitable, even when high inputs are used. The definition of suitability is derived from a comparison of potential yields (FAO 1978, p.4).

To these five zones correspond five types of climax vegetation and characteristic crops. Cassava is common in all except the West African semi-arid zone. It is, however, found in semi-arid East and Southern Africa, although there are indications that it is grown in depressions with a sufficiently high water table.

Demographic and socioeconomic settings

Although Africa is considered to be generally sparsely populated, there are several noteworthy exceptions such as the East African highlands and southeastern Nigeria, the major urban centers and their peripheries. Differences in population density are central to any classification of African cassava regions. In order to compare different regions, however, absolute average population/km^2 is not the relevant measure, but population as related to agroecological potential (Higgins et al. 1982, Binswanger and Pingali 1988), resulting in a standardized population density (i.e., number of people per million kilocalories of production potential). In this perspective, equatorial and humid lowlands have a lower carrying capacity, and therefore less potential for land-use intensification, than semi-arid and subhumid areas. However, another factor, i.e., the degree of self-sufficiency, needs to be taken into account in rural areas, in addition to standardized population density. Such considerations as to what extent does an area have market access to urban enclaves? Is it feeding neighboring cities with rapid population growth and demand? Or, on the contrary, does it obtain staple food from outside? A compound measure comprising standardized population density, self-sufficiency, and dependency by urban populations as well as income growth, the demographic dependency ratio (DDR) might take this into account. The DDR is thus, also an inverse measure of land scarcity. This would result in the identification of regions with similar ranges of DDRs. Initial mapping by Centro Internacional de Agricultura Tropical (CIAT) shows a net correlation between population and cassava distribution. Spatial concentrations of cassava production include the following high population density/urbanization belts: southern Ghana, southern Togo, southern Benin, southern Nigeria, central Cameroon, southern Zaire, Brazzaville, Kinshasa, northern Great Lakes region, eastern Tanzania, southeastern Tanzania, Zanzibar, northern Mozambique, southeastern Mozambique. Table 1 provides a rather crude correlation between the CIAT climatic classification and population density zones in Africa.

Types of farming and cropping systems

To a large extent, the characteristics of agricultural production are a function of ecological and demographic/socioeconomic factors, but they also constitute a separate set of classification criteria. Ruthenberg (1980) has analyzed in detail the types of farming and cropping systems that occur in various agroecological zones, as well as their evolutionary pathways. There seems little doubt that the original form of land-use has been, possibly without exception (at least outside the semi-arid zones), some form of shifting cultivation. Depending on the ecology, patterns of land-use diverge as the population grows into regulated ley, irrigated, perennial, and permanent upland systems (Ruthenberg 1980, p.358).

Figure 1 provides a simple overview of how farming systems evolve as a result of combinations of agroecological and demographic characteristics. While these three sets of criteria provide the basis for a classification of cassava regions, the latter two are obviously subject to change. In the time span considered here, climate and soil are thought of as stable properties. The comparison between regions, therefore, must be done in a synchronic and a diachronic way, matching and contrasting regions in time and in space.

Table 1. Climate, cassava areas and population density zones

SAMDATA	CLIMATE CLASS	% CROP AREA	HIGH POPULATION DENSITY	LOW POPULATION DENSITY
(A)	Lowland humid tropical	33.26	I southwest Zaire Ghana	II Zaire Congo Central African Republic Côte d'Ivoire
(C)	Lowland semihot isothermic	16.62	III southwest Nigeria central Côte d'Ivoire	IV northwest Tanzania central Nigeria Cameroon
(E)	Lowland hot isothermic	9.45	V?	VI central Zaire
(J)	Highland humid tropic	7.17	VI Rwanda east Zaire southwest Cameroon	(?)
(M)	Highland Brazilian isothermic	7.15	VIII Burundi northeast Tanzania western Kenya (?)	(?)
(G)	Lowland semi-arid isothermic	4.84		IX southeast Tanzania Sudano-Sahel (northern Nigeria, northern Ghana)
(F)	Lowland hot non isothermic	4.39		X Mozambique south Angola (?)

3. Dynamics of African Farming Systems

The mapping of African cassava regions according to climatic, demographic, and agroecological characteristics provides a starting point for a discussion on the dynamics of African farming systems. African agriculture has been subject to considerable change, at a more rapid pace, and over a longer period than one would be led to believe from some snapshot studies of traditional farming. J. Wigboldus has observed that the coastal zones of West Africa and the Sahelian zone have experienced periods of intense agricultural transformation over several centuries (personal communication). However fascinating, such an extensive period falls outside the scope of the present study. Within the constraints of climate and soils, the two major interrelated elements contributing to agricultural change are population growth and incorporation, i.e., the compound set of market access, urbanization, agricultural policy, prices, institutional development, the introduction of cash crops, and the availability of cost-effective crop production and processing technology (Hayami and Ruttan 1971, Ruthenberg 1980).

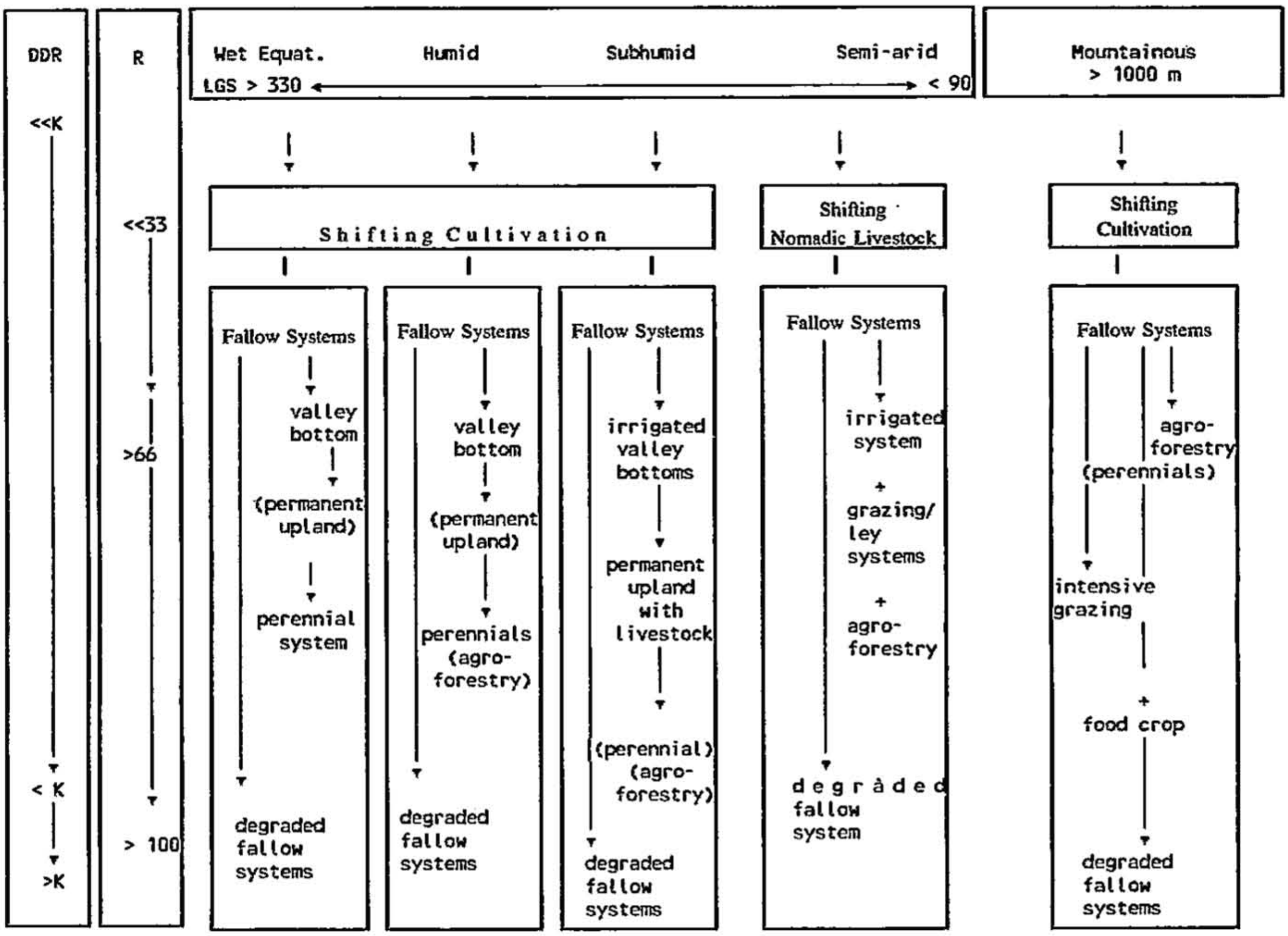
Evolutionary sequences of farming systems

While the causes of population growth and incorporation may vary according to location, they result, according to most authors, in an evolution of farming systems towards land-use intensification. This process has been analyzed in detail by Boserup (1965), Ruthenberg (1980), Grigg (1979) and Pingali et al. (1987). It is usually described as an increase in the frequency in the use of land, and therefore, in the use of inputs for a given land area, leading ultimately to a decrease in the cultivated area per capita. The ultimate result of this sequence is the emergence of annual/continuous cropping, either multiple (more than one crop cycle/year) or perennial (tree cropping). Depending on the combination of agroecological, socioeconomic and demographic characteristics, farming systems follow divergent evolutionary pathways towards land-use intensification (figure 1).

However, this model of the evolution towards land-use intensification is rather general and leaves many facets of African agriculture unexplained, even if differences in agroecological zones are taken into account. An attempt is made here to elaborate this model and relate it more closely to cassava. To avoid confusion, the terms land-use intensification and extensification are exclusively related to land-use here, i.e., they refer to increasing/decreasing use of inputs, in particular, but not exclusively of labor, per unit of land area. Thus, it is the ratio of labor (and other inputs) to land that determines the characteristic response of farmers, not the size of the holdings per se. This paper argues that, notwithstanding the overall trend towards land-use intensification, different forms of extensification may be an important feature of African farming systems, in time and in space.

The need for an increase in total food production triggered off by a growing population may be met through an expansion of cultivated area, or an increase in land productivity, or both. An expansion in cultivated area *per se*, without further qualifications, is therefore, not necessarily an indication of extensification of land-use.

Area expansion is nearly always the primary response to growing population pressure. Through the burning of vegetation, more land can be brought under cultivation with very little extra effort, until infra-marginal land scarcity emerges. Infra-marginal land scarcity, however, is a relative concept that must be related to the distribution of population. There is a clear limit to the distance/time farmers are willing to travel to cultivate fields. The concentration of settlement under the late colonial and post-independence administrations (e.g., along roads) has in fact further reduced the area that can be cultivated by the inhabitants of a given village by artificially creating land shortage (cf. Central African Republic, Fresco 1984). This may concern new land that was not previously included in the total land area under fallow,



LGS = length of growing season (days)
R = land-use intensity factor
DDR = demographic dependency ratio
K = critical value depending on carrying capacity

Figure 1. Climate, demographic dependency ratios, land-use intensity and the evolution of farming systems

or 'old' fields already in the rotation that are cultivated more frequently, either by an increase in the number of consecutive cropping years or by the shortening of fallow from forest to grass fallow. If farmers return to the same plots more frequently, this results in intensification (high labor inputs for the total land area). Once the forest vegetation disappears, the clearing of new land may place a heavy burden on farmers and require additional labor inputs to destroy perennial weeds without parallel increases in yields. Both approaches, the cultivation of 'new' land and 'old' fields may also be combined and lead to overall extensification, i.e., a declining labor-to-land ratio because of a more rapid growth in land area than in population. This phase may be more important and last longer than is often realized.

Ultimately, the evolving scenario is reflected in aggregated African statistics, namely that of stagnating or declining per capita food production. Stagnation may be the result of shortening fallows and declining soil fertility without changes in land-use patterns, but it could also be caused by shifting food crops to more marginal soils while the best soils are used for cash crops. Another form of stagnation could result from a shift to lighter, less fertile soils that demand less labor for clearing and allow labor inputs/ha to remain low. Another alternative would be to shift to less (field) labor-demanding crops or to crops such as cassava that increase labor productivity even at low or declining levels of labor inputs. Irrespective of whether land area increases or not, the result would be a lower labor input/ha and land and labor productivity are likely to remain low or stagnant. Ruthenberg (1980) has described the degradation of fallow systems as an *involutionary* process if fertilization does not compensate for nutrient extraction. Involution does not seem to be the appropriate term for degraded shifting cultivation if one follows Geertz's description of agricultural involution as a process leading to 'tremendous populations absorbed on minuscule (rice) farms... consequent rises in per hectare productivity... extraordinary ability to maintain levels of marginal labor productivity..' (Geertz 1966, p.80). Stagnation or stagnating systems seem to reflect falling labor and land productivities and the inability to absorb more labor with existing technology levels.

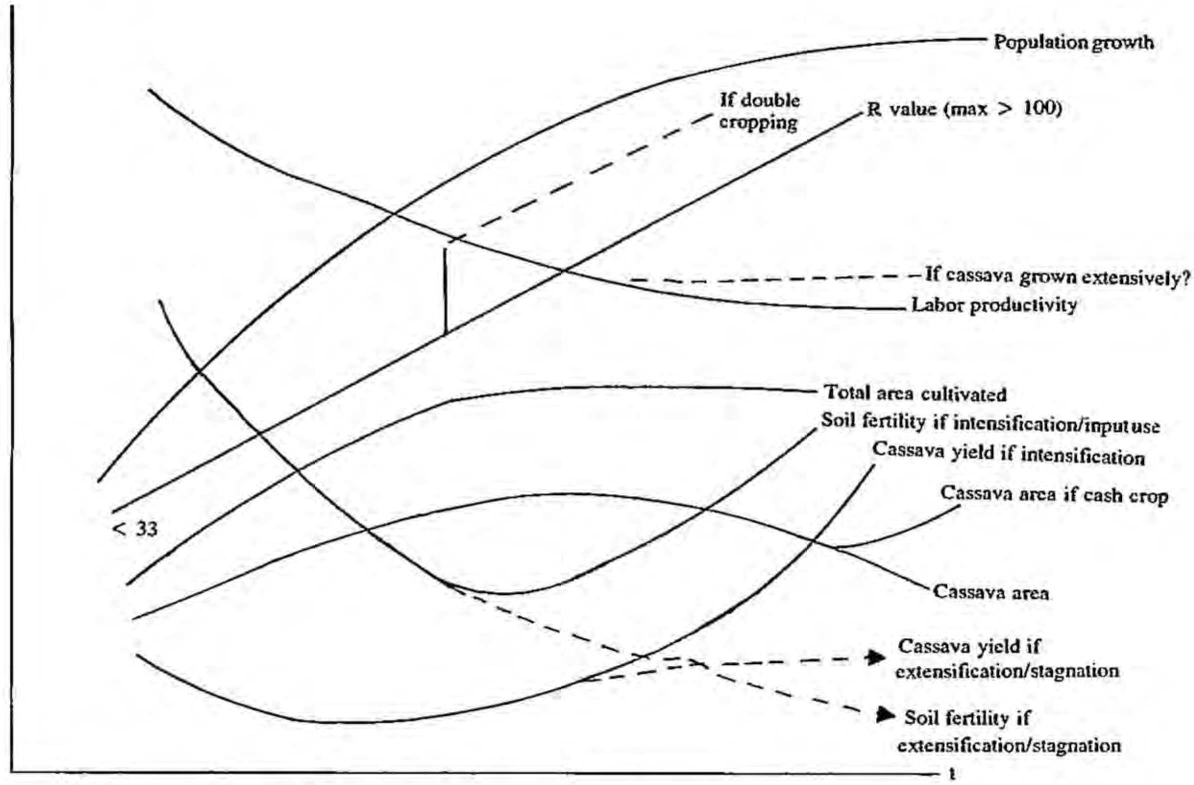


Figure 2. Cassava in extensive and intensive farming systems

Increases in land productivity may result from increased labor input (in land preparation, weed control, or timeliness of operations), the shift to new, higher-yielding crops or varieties, the use of yield-increasing inputs such as fertilizer and biocides, the introduction of additional crops, in space (intercropping) or in time (relay or rotational cropping), or a combination of any of these. Yield increase normally implies an increase in total dry matter produced, but an increase in economic value, which would then allow the farmer to purchase more food, could also be considered an alternative response. While shifting cultivation is most likely to take place on the middle slopes of the toposequence, (this applies also to the gently undulating landscape of West Africa, where toposequence variations may be less marked), population pressure is likely to lead to the cultivation of heavier soils on the lower slopes and in the depressions. These soils require a heavier labor input for clearing and water management, and often animal traction. Productivity per unit of land area tends to increase while labor productivity gradually declines. In some relatively dense population areas, e.g., in Northern Nigeria, indigenous rice (*Oryza glaberrima*) has been cultivated in depressions and wetlands for centuries. This is probably a sign of early intensification due to infra-marginal land scarcity. A further consequence is the change in the preference for certain crops to hydromorphic (and ultimately irrigated) rice, possibly in association with vegetables. In the course of this process, biological and chemical technology (improved varieties, fertilizer, biocides) substitute for the scarcest resource: land, and to a lesser extent also for labor in peak periods. All these changes would fall under the heading of land-use intensification. However, if better, heavier soils are taken into production that were hitherto unused (having been unexploitable with existing equipment and labor) this constitutes in fact a form of extensification. Mechanization theoretically affects both area expansion and productivity of land, but its primary effect in the African context seems to have been area increase (Pingali et al. 1987).

In other words, one finds a variety of responses to increasing food needs. These different responses—land-use intensification, extensification and stagnation — are schematically represented in figure 3. This form of representation cannot do justice to the fact that various forms of land-use intensification and extensification exist, and that the two may occur simultaneously, so that a farming system may be moving gradually to land-use intensification, while some of the fields, perhaps for a long time, are extensively cultivated. They are separate pathways, however, and the transition from extensive to intensive agriculture, i.e., the substitution of land and/or labor by inputs or machinery often implies a 'quantum jump'. It is possible to distinguish farming systems according to their degree of intensification and the degree to which intensification and extensification occur simultaneously in a given area or village. Farmers may cultivate both the lower and upper ends of the toposequence at varying degrees of intensity; some farmers may have access to lower-lying fields, while others are limited to the hill sides; in other cases, entire villages may be considered 'plateau' villages that have no fields in the valley.

The agroecological and socioeconomic conditions that promote the emergence of any of these patterns need further study. Generally speaking, in the different agroecological zones these processes have so far led to divergent patterns. In the sparsely populated Central African humid lowlands, extensification prevails: production growth is nearly exclusively explained through an increase in cultivated area, that is sometimes accompanied by a sharp decline in yield. In the densely populated lowlands and in the (wet/dry) savanna, agricultural production has expanded onto the more marginal, outlying fields, while intensification of production has occurred simultaneously in the valleys and in the urban peripheries, where perennial cash crops are also grown. In the semi-arid, medium density areas of East and West Africa, intensification occurs through the introduction of animal traction, and the cultivation of *dambo* depressions. In the densely populated highlands, where soil fertility is generally relatively high, annual cropping in combination with some erosion control measures is the rule, leading to relatively high labor inputs/ha.

4. Cassava in Changing Patterns of Land-use

To what extent land-use extensification and stagnation present long-term, unstable, alternatives to intensification remains to be seen, but they appear very relevant to a study of cassava. It might be suggested that cassava delays intensification in some cases by enabling farmers to produce a crop under marginal circumstances instead of shifting to crops that require higher inputs, and by increasing farmers' flexibility in the face of agroecological and socioeconomic instability. The general hypothesis put forward here is that cassava plays different roles depending on the development pathways of the farming systems in which it is found. By implication, this means that in comparing cassava output, reference must be made to the developmental stage of the farming system under which the crop is produced. Cassava displays a number of botanical characteristics that make it suitable for diverse niches in cropping systems — wide adaptation (as a species) to a range of climatic and edaphic conditions, tolerance of low soil fertility, poor soil structure and drought, existence of numerous early-and late-bulking varieties, relative tolerance to pests and diseases; growth can be stopped at almost any time and yet the storage root is not damaged.

Cassava and extensification

The most important effect of these characteristics is the suitability of cassava under low input conditions. Nearly all cassava in Africa is produced on small farms and is processed at the household level with the noticeable exception of large-scale production in a few densely populated areas such as southwestern Nigeria. Smallholder production is marked by flexible and and low labor inputs without distinct labor peaks, as well as flexibility in planting dates and harvesting strategies.

Moreover, cassava is ideally suited as a food reserve crop on marginal soils, soils that are for agroecological or economic reasons unsuitable for other crops. In cases of labor shortage, whether absolute or relative because of farmers' inputs in other crops, cassava may also provide food security. These features give cassava a comparative advantage over other crops in those situations where extensification of land-use takes place. This also suggests that where the ratio of labor to land decreases, cassava will be grown increasingly on expanding land areas and more and more depleted soils, not only as the last crop in the rotation but earlier in the rotation up to the point that no other major staples will be grown. The result will be the replacement of more demanding crops in terms of soil and labor,(such as yam, sorghum or millet) with cassava. The result of this scenario will be an expansion of cassava production and declining yields.

Cassava's comparative advantage under these conditions will need to be documented more fully in terms of the range of labor inputs and yields, the increase in farm and field sizes, the replacement of crops such as yam (in the humid tropics) and sorghum/millet (in semi-arid regions), etc. Furthermore, it is unclear whether extensification is necessarily linked to an expansion of cassava, or if other patterns occur. In some high fertility areas, extensification seems to take place without an important role for cassava. For example, in Kisii, Kenya, where farmers switch immediately to maize from their traditional cereals while expanding land area and, apparently, without increasing the ratio of labor to land. In adjacent, less fertile areas but with lower rainfall (Lake Victoria shore), however, cassava figures quite predominately (B. Meetens, personal communication). This might suggest that while cassava has a comparative advantage in the humid lowlands, in all other areas cassava will only be important in the process of extensification if soil fertility, rainfall and/or labor are deficient.

Stagnation

How long expansion onto more marginal soils can compensate for declining yields needs to be reviewed. The question is whether a growing dependence on cassava ultimately leads to stagnation, or whether cassava can provide the key to land-use intensification once the infra-marginal land frontier is reached.

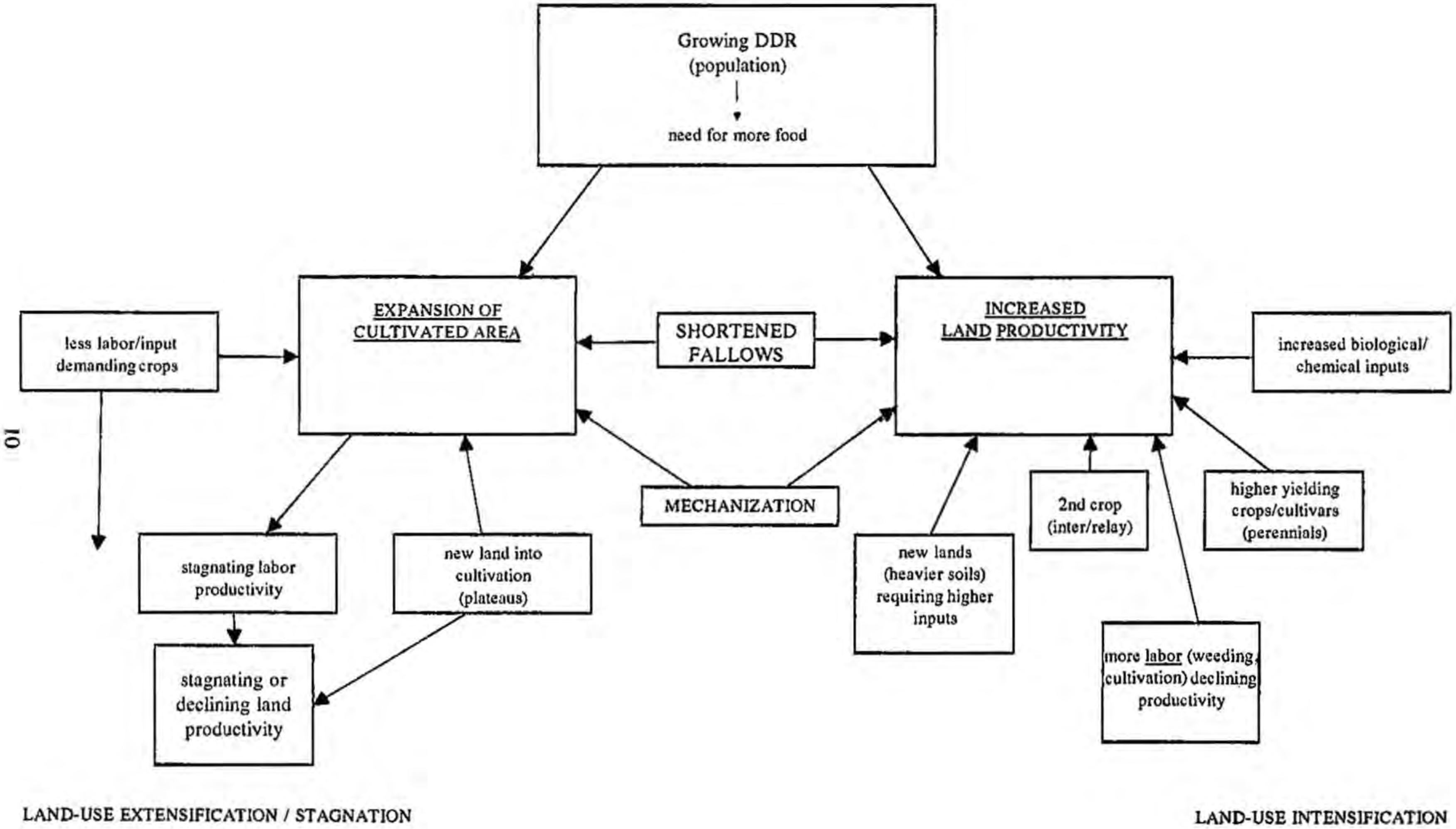


Figure 3. Pathways of land-use intensification and extensification

More specifically, once the transition to land-use intensification is made, one wonders whether cassava is then replaced by cash crops such as maize, groundnut, cotton or perennials on the higher slopes and by rice in the lower areas and how these patterns relate to the different cassava regions.

Because there is no need to leave the land fallow to restore fertility before cassava can be grown, it may play a key role in cases of very rapid area expansion. This scenario leads from extensification to stagnation and can be found in those countries where large area increases have been coupled with declining yields (Zaire, Nigeria, Madagascar). Again, cassava's botanical properties allow this kind of stagnation to be carried to great lengths: premature and repeated harvesting of minuscule roots, harvesting of growing points as vegetables, the planting of diseased stem cuttings out of season — the crop will tolerate almost anything and still produce some, albeit infinitesimal, yield.

Land-use intensification

Where overall land-use intensification occurs, two basic pathways are open to cassava, but the picture is more complex and diverse than in extensifying systems. On the one hand, given a stable effective demand, there seems to be no reason why cassava could not be grown intensively as a cash crop for urban consumers (Berry 1986). Ruthenberg (1980, p.361) even predicts a shift from traditional cereals to higher yielding roots and tubers under increasing intensification. The main body of his work does not show this, however, but such a hypothesis requires further investigation.

Emerging patterns in Nigeria appear to forecast large-scale production on plantations, mechanized processing, and specialization of labor and management of cassava production, processing and marketing.

On the other hand, the intensification of agricultural production and growing incorporation may increase the need for a cheap food crop that can be grown with low labor and minimal inputs on poor soil and harvested according to need, for example, when cash income is low just before the harvest of cash crops. Also, where the labor demand in cash crops is high, or where the burden of food production falls on women who place a premium on flexibility, cassava for subsistence may provide a better alternative than cereals that are more seasonally constrained. In the land-use intensification scenario, cassava is the cheap staple that allows farmers to allocate resources, (land, labor, and possibly cash) to high-risk crops (e.g., cotton) with potentially high returns on investment. Depending on the degree of heterogeneity of the village territory, this may occur in a spatially separated way, with cassava on separate fields at the highest levels of the catena, or in an integrated way, when cassava is grown in rotation, or even in intercropping with a cash crop (which may also be a food crop). The association of cassava with cash crops needs to be more clearly documented, in dry climates as well as in the humid tropics where, in yet a different pattern, cassava could be grown in association with perennials (coffee), either on the same field, or on outlying fields. Theoretically, one might find, within the same farming system or area, intensively cultivated fields where cassava is grown as a cash crop, as well as plots on which it is kept as a food reserve crop. The existence of different types of cassava fields, with corresponding cultural practices, labor inputs and yield levels, has been documented before (Lagemann 1977, Fresco 1986, Ikpi et al. 1986). It is not inconceivable that farmers grow more than one type of cassava crop (independent of variety), i.e., as an intensive crop, for example, in rotation with a cash crop, as well as an extensive crop on outlying fields, and also a sweet cassava variety as a preferred weaning food in home gardens. Cassava varieties, both traditional and improved, may displace specific characteristics that may make them more or less suitable for intensified and extensified cropping patterns, and there is merit in investigating farmers' knowledge of their adaptability.

In highland areas which are generally densely populated, small plots prevail. Cassava is also of importance here under intensive management because of its high dry matter production potential (Jones and Egli 1984). Some evidence suggests that cassava will be replaced by crops that are more responsive to higher labor and fertilizer inputs, e.g., maize. It can be hypothesized that finally the most marginal land will then be taken out of production and converted to grazing land, although some cassava might be kept as a reserve crop. At first sight, cassava does not seem to be compatible with animal traction, because of the higher input/ha which requires a crop with a high value output, and perhaps also because cassava, as one of the few leafy plants during the dry season, needs to be protected from animals. This may imply that the scope for cassava is limited, once farming systems reach the stage of ley systems. Yet cassava could be grown as a second crop in rotation on fields that have been originally plowed for a cash crop. In general, the role of cassava as a second crop during the second or minor rainy season is very poorly documented. The growing of cassava after or in relay with the main (cash) crop may be a very important way to intensify farming systems. Cassava could either replace a less productive minor crop, such as beans or vegetables, or simply be added to the rotation which previously consisted of only one crop annually. Such cultural practices are likely to be overlooked in the official statistics that classify fields only according to the first crop.

An important issue in the intensification scenario relates to labor needs for processing. If cassava is grown as a commercial crop, one may expect the use of hired labor and/or mechanization instead of (unpaid) family labor. In cases of rapidly growing urban demand, or sudden shortages, mechanisms to replace or supplement household labor may not yet be in place, and this could seriously affect the quality of processing (Rosling, personal communication). To what extent labor needed for processing becomes prohibitive when land-use is intensified, needs to be substantiated. In general, however, cassava's remarkable versatility explains how the integration of the crop has been so successful in the past, irrespective of overall changes in patterns of land-use. It remains to be seen whether cassava can meet the new challenges of growing dependency ratios and land-use intensification.

Figure 2 provides a schematic overview of how the role of cassava could change as farming systems react to increasing population pressure and market expansion.

5. Future Scenarios for Cassava in Sub-Saharan Africa

While it would be presumptuous to draw any conclusions on the future of cassava at this stage, a few issues may be raised here for further discussion. The study assesses the shifting importance of cassava in traditional cassava regions, its penetration into new regions such as semi-arid West Africa, and its potential contribution to the food crisis in Africa.

Cassava supply

The supply of cassava is governed by its comparative advantage as a crop in a given farming system, the ease with which it can be processed, stored, and marketed, and relative market prices.

Improved technology could affect any of these factors. The induced innovation theory suggests that technical change will respond to economy-wide factors (Hayami and Ruttan 1971). In the different cassava regions, the varying degrees of land scarcity, labor and capital availability as well as market access suggest that divergent technical pathways may be emerging in cassava production and processing, and perhaps also in marketing and consumption. The induced innovation hypothesis, however, needs to be corrected for pathways of land-use intensification and extensification. While a close correlation may be supposed between land scarcity, intensification, and labor-intensive crop production, with an emphasis on land-saving biological and chemical technology, this does not determine, a *priori,* the kind of technology required for cassava production. Agricultural intensification may imply an intensification (cassava as a cash crop) or an extensification pathway for cassava (cassava as a food reserve crop) with parallel technology needs in processing. Even before land in a given area becomes absolutely scarce, one would expect the substitution of land through the introduction of high-yielding varieties and inputs such as fertilizer. Even in highly populated areas, cassava follows an extensification pathway at present. This again might be supported by the fact that cassava shows a very low economic response to nitrogen (N) (Cock 1985, p.89) or to organic manure (Jones 1959, p.16), i.e., that the crop is perhaps not ideally suited to long-term intensified production. This does not hold true for potassium (K) and phosphorus (P) fertilization, however. On the other hand, research on cassava may not have been targeted to the correct type of environment (Binswanger and Pingali 1988) so that no improved technology has been available to farmers, or the available technology does not meet farmers' needs because it only addresses land productivity, whereas labor may be more constraining. Finally, the sustainability of cassava production under low input conditions deserves serious thought. Few cropping practices are probably as destructive as the unfertilized sole cropping of cassava on the fragile soils of the (sub) humid African lowlands.

Cassava processing

One of the unique paradoxes of cassava, where traditional methods are employed, is that its relatively low field labor requirements contrast with its relatively high processing labor demands. The effects of land-use intensification on labor and capital availability for processing are far from clear, but in production as in processing there is a need for technology to raise labor productivities. Where cassava as a market crop forms the key to agricultural growth, one would suppose the emergence of new labor-saving processing techniques, perhaps coupled with the use of hired labor. This pattern may take some time to establish, in particular if price fluctuations and economic instability induce farmers to produce a marketable crop at short notice. Hans Rosling (personal communication) has suggested that in Zaire this could lead to the sacrifice of quality and to unacceptable high toxicity levels. Under these conditions, the harvesting of large quantities of bulky cassava roots from distant fields and their transportation to processing sites constitutes an important constraint. Increased income from cassava and improved marketing might encourage investment in processing equipment. This is even more likely to happen if it is not cassava but other crops that form the driving force behind land-use intensification and income can be channelled into cassava production. Where cassava is grown as a food reserve crop supplementing income or food production from other sources, investments in processing seem less likely. In such a case, in particular, if women are burdened with various other (re)productive activities, the risks of inadequate processing should not be overlooked. The opportunity costs of labor, certainly for women, are often a function of time. The cost of processing large quantities of cassava may, therefore, become prohibitive if greater demands are placed on female labor. Specialization in cassava production, processing, and marketing by different rural and urban-based groups might be an emerging scenario, although there is little evidence of this yet for most of rural Africa.

A comparison of labor inputs into cassava processing with those in other crops is required in order to highlight some of the possible advantages of cassava, such as its steady flow throughout the year, and disadvantages, such as its bulkiness and perishability.

The demand for cassava

The determinants of the demand for (processed) cassava are urban-based and related to marketing mechanisms, income elasticity, alternative (non-food) markets, and relative prices. Phillips (1983) has suggested that income elasticity for cassava is low but positive, and higher in urban centers than in rural areas. To what extent the crop can compete with imported cereals and high status foods such as yam or rice remains to be seen. It can only become the preferred food of the urban poor if it is produced, processed, and marketed in sufficient quantities at attractive prices.

Methodological problems in cassava research

The study outlined here finds itself in the rather grey border area between many disciplines. Apart from the obvious need for an integration of the biological and socioeconomic sciences, it puts a special emphasis on a historical perspective. A study of processes of agricultural change during the last century requires a combination of historical field work (through observations and interviews) and the search for (quantitative) colonial and post-independence data.

One of the major methodological constraints is the poor quality of quantitative data on cassava area and production, and, to perhaps a lesser extent, population figures. Cassava is more likely to be the subject of measurement errors than almost any other food crop (Fresco 1986), and its importance has often been underestimated (Guyer 1984). Adequate correction factors may have to be designed to reflect the degree of intercropping, staggered harvesting, etc. To an unknown extent, the variability in cassava yields or area may be real and reflect farmers' responses to a rapidly changing ecological and socioeconomic environment. Another methodological problem relates to the decline of labor productivity. However important in this framework, labor is probably the most difficult variable to document accurately, certainly on a comparative basis. There is a need to review alternative indirect indicators of labor productivity. Land-use intensity also presents difficulties, but those could be solved through a direct measurement of cropping frequency, corrected by an indirect assessment of the intensity of labor inputs (e.g., contouring, terracing). The costs and benefits of cassava production in economic as well as ecological terms need careful investigation, at a micro-economic/farm level, as well as at regional levels (regional nutrient balances).

References

Berry, S. 1986. Socio-economic aspects of cassava cultivation and use in Africa: Implications for the development of appropriate technology. Informal discussion paper for the Rockefeller Foundation, New York.

Binswanger, H. and P. Pingali 1988. Technological priorities for farming in sub-Saharan Africa. *Research Observer*, World Bank 3(1): 81-98.

Boserup, E. 1965. The conditions of agricultural growth. George Allen and Unwin, London, 124 p.

Boserup, E. 1981. Population and technological change. University of Chicago Press, Chicago.

Bruijn, G. de and L.O. Fresco. 1989. The role of cassava in expanding world food production. *Netherlands Journal of Agricultural Science*, 1.

Bunting, A.H., ed. 1987. A shifting cultivation land-use system under population pressure in Zambia. *Agroforestry Systems* 5: 15-25.

Cock, J. 1985. Cassava. New potential for a neglected crop. International Agricultural Development Service, Westview Press, Boulder, Colorado.

Food and Agriculture Organization (FAO). 1978. Report on the agroecological zones project, Vol. 1 Methodology and results for Africa. World Soil Resources Report. Rome.

Food and Agriculture Organization (FAO). 1984. Agroclimatological data for Africa, Vol. 2. FAO plant production and protection series 22, Rome.

Food and Agriculture Organization (FAO). 1986. African agriculture: The next 25 years. Atlas of African agriculture. Rome.

Fresco, L.O. 1984. Agricultural production. Agricultural sector assessment. World Bank internal report, Washington.

Fresco, L.O. 1986. Cassava in shifting cultivation. A systems approach to agricultural technology development in Africa. Royal Tropical Institute, Amsterdam.

Geertz, C. 1966. Agricultural involution. The process of ecological change in Indonesia. University of California Press, Berkeley.

Grigg, D. 1979. Ester Boserup's history of agrarian change: a critical review. *Progress in Human Geography* 3 (1): 64-84.

Guyer, J.I. 1984. Family and farm in Southern Cameroon. Boston University, African Studies Center, African Research Studies 15, Boston.

Hayami, Y. and V.W. Ruttan. 1971. Agricultural development. An international perspective. The Johns Hopkins Press, Baltimore.

Higgins, G.M., A. H. Kassam and L. Naiken, G. Fischer and M.M. Shah. 1982. Potential population supporting capacities of land in the developing world. Technical report of the project INT/75/P13, Rome.

Higgins, G.M. 1987. Methods used by FAO to estimate environmental resources, potential output of crops and population supporting capacities in developing countries. In: A. H. Bunting, op. cit. 1987.

Ikpi, A.E., T. Gebremeskel, N. Hahn, H. Ezumah, and J. Ekpere. 1986. Cassava — a crop for household food security. A 1986 situation analysis for Oyo Local Government Area, Nigeria. IITA/UNICEF, Ibadan.

Jackson, I.J. 1977. Climate, water and agriculture in the tropics, Longman, London.

Jones, W.O. 1957. Manioc, an example of innovation in African economics, *Economic Development and Cultural Change* 52: 97-117.

Jones, W.O. 1959. Manioc in Africa. Stanford University Press, Stanford, 315 pp.

Jones, W.O. and R. Egli. 1984. Systemes de culture en Afrique. Les hautes terres du Zaire, Rwanda et Burundi. Doc. technique de la Banque Mondiale no 27 F., Washington.

Lagemann, J. 1977. Traditional African farming systems in Eastern Nigeria. Weltforum Verlag, München, 269 pp.

Meetens, B. no date. personal communication.

Phillips, T.P. 1983. Overview of cassava consumption and production. In: Cassava toxicity and thyroid: research and public health issues, Delange, F.F. and R. Ahluwalia, eds. Workshop proceedings. International Development and Research Centre, Ottawa.

Pingali, P., Y. Bigot and H. Binswanger. 1987. Agricultural mechanization and the evolution of farming systems in sub-Saharan Africa. World Bank/Johns Hopkins University Press, Baltimore. 216 pp.

Rosling, Hans. no date. personal communication.
Ruthenberg, H. 1980. Farming systems of the tropics. Oxford University Press, Oxford.
Webster, C.C. and P.N. Wilson 1980. Agriculture in the tropics, second edition, Longman, London.
Wigboldus, J. Department of Agrarian History, Wageningen. no date. personal communication.

COSCA Working Paper Series

No. 1 Nweke, Felix I. 1988. COSCA Project Description. International Institute of Tropical Agriculture, Ibadan, Nigeria.

No. 2 Carter, S. E. and P. G. Jones. 1989. COSCA Site Selection Procedure. International Institute of Tropical Agriculture, Ibadan, Nigeria.

No. 3 Nweke, Felix I., John Lynam and Coffi Prudencio, eds. 1989. Status of Data on Cassava in Major Producing Countries of Africa: Cameroon, Côte d'Ivoire, Ghana, Nigeria, Tanzania, Uganda and Zaire. International Institute of Tropical Agriculture, Ibadan, Nigeria.

No. 4 Nweke, Felix I., John Lynam and Coffi Prudencio, eds. 1990. Methodologies and Data Requirements for Cassava Systems Study in Africa. International Institute of Tropical Agriculture, Ibadan, Nigeria.

No. 5 Stoorvogel, J.J. and L.O. Fresco. 1991. The Identification of Agro-ecological Zones for Cassava in Africa—with particular emphasis on soils. International Institute of Tropical Agriculture, Ibadan, Nigeria.

No. 6 Ugwu, B.O. and P. Ay. 1992. Seasonality of Cassava Processing in Africa and Tests of Hypotheses. International Institute of Tropical Agriculture, Ibadan, Nigeria.

No. 7 Natural Resources Institute (U.K.) 1992. COSCA Phase I Processing Component. International Institute of Tropical Agriculture, Ibadan, Nigeria.

No. 8 Berry, Sara S. 1993. Socio-economic Aspects of Cassava Cultivation and Use in Africa: Implications for the development of appropriate technology. International Institute of Tropical Agriculture, Ibadan, Nigeria.

No. 9 Fresco, Louise O. 1993. The Dynamics of Cassava in Africa. An outline of research issues. International Institute of Tropical Agriculture, Ibadan, Nigeria.

MEETING the nutritional needs of the people of Africa has been of growing concern to both international bodies and national governments, especially as per capita food production has apparently been declining over the last two decades in Africa. During this period, however, overall cassava production in Africa has nearly doubled.

This desk study by Dr. Louise Fresco of the University of Agriculture, Wageningen, reviews the existing literature and data on cassava in Africa with the aim of identifying long-term (statistical) trends, and regrouping information on an agroecological as well as a country basis. Data from various colonial agricultural and anthropological sources were used to verify and cross check current statistical trends. A variety of farmer responses to increasing food needs are examined, these include: land-use intensification, extensification and stagnation. The question which arises, is whether a growing dependence on cassava ultimately leads to stagnation, or whether cassava can provide the key to land-use intensification.