ECONOMIC AND TECHNICAL FACTORS INFLUENCING REGIONAL RESEARCH PRIORITIES IN THE HUMID AND SUB-HUMID ZONES OF WEST AND CENTRAL AFRICA

Centre
de coopération
internationale
en recherche
agronomique
pour le
développement

Pierre-Marie Bosc and Ellen Hanak Freud

CIRAD

October 1993

42, rue Scheffer
75116 Paris
France
téléphone :
(1) 47 04 32 15
télécopie :
(1) 47 55 15 30
télex :
648729 F

EPIC-SIRET
331 596 270 00016
RCS Paris B
331 596 270

Study prepared for the regional initiative on the revitalisation of agricultural research in the humid and sub-humid zones of West and Central Africa under the auspices of SPAAR (Special Programme for African Agricultural Research) and the Conference of Ministers of Agriculture of West and Central Africa.

Economic and technical factors influencing regional research priorities in the humid and sub-humid zones of Western and Central Africa

Pierre-Marie Bosc and Ellen Hanak Freud
CIRAD

Authors' note

The authors are, respectively, agronomist, *Unité de recherche sur les innovations dans les systèmes agricoles et agro-alimentaires*, CIRAD-SAR, and economist, *Unité de recherche en prospective et politique agricole*, CIRAD-GERDAT. This study has been undertaken as an input into the regional initiative on the revitalisation of agricultural research in the humid and sub-humid zones of West and Central Africa under the auspices of SPAAR (Special Programme for African Agricultural Research) and the Conference of Ministers of Agriculture of West and Central Africa, and has been jointly financed by the SPAAR secretariat and CIRAD.

The study was commissioned as a follow-up to a paper presented at the regional workshop launching this initiative, held in Abuja, Nigeria, in October 1992 entitled, "The Economic Challenges for Agricultural Research in the Humid and Sub-humid Zones of West and Central Africa," by Ellen Hanak Freud. The objectives of this follow-up study are to provide a more detailed view of the challenges for technology development and transfer in the Region, related to constraints operating within the farming systems and in the various crop sub-sectors, or commodity systems (*filières*). Issues specific to livestock and fisheries are outside the scope of this study, and are being dealt with by other studies for the initiative.

The Region is defined to include the following 15 countries: Guinea, Liberia, Sierra Leone, Côte d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, Equitorial Guinea, Central African Republic, Congo, Gabon, Zaïre, and Sao Tomé; throughout the text, the proper noun "Region" is used to refer to this grouping.

Although this report is primarily a "desk study", drawing on materials presented at Abuja and other bibliographic works, the authors have benefitted from discussions with a number of persons involved in agricultural research and technology transfer in the Region. We wish in particular to thank the many officials in Nigeria and Ghana who met with us during a brief fact-finding mission to these countries, and the numerous researchers at CIRAD who granted us interviews. A special thanks is due to Ms. Antonia Obeya of the SPAAR secretariat, who accompanied us on the visit to Nigeria, and to the World Bank resident missions in both countries, who organised the visits. We also thank Mr. Moctar Touré, executive secretary of SPAAR, and the members of the SPAAR Regional Task Force for the initiative, Messrs. Ajibola Taylor, Bakary Ouayogode, Yunusa Yusuf, Gerard Boukambou, and Mohammed Danihya, for their guidance and suggestions. Responsibility for the interpretations, and for any errors or omissions, rests entirely with the authors, and engages neither SPAAR nor CIRAD.

Economic and technical factors influencing regional research priorities in the humid and sub-humid zones of West and Central Africa

Summary and Conclusions

1. The role of agriculture in the Region's economic development and the challenges for agricultural research.

1.1 **Agriculture in this Region must fulfill a multi-fold challenge:** to feed rapidly growing populations, generate foreign exchange, and foster growth in per capita income through the creation of direct and indirect employment opportunities. Yet to date, the performance record has been uneven. Although food production per farmer appears to have risen over time, this has not kept pace with the growth of the nonagricultural population, and food imports have increased. In the industrial/export crops, many countries have seen their shares in world markets diminish. Technical progress has mainly been witnessed through the introduction of new crops into many areas, under extensive methods of cultivation. With few exceptions, small farmers have not adopted science-based techniques to increase yields.

1.2 **Efforts of the research system alone will be insufficient** to ensure agricultural growth and the technical progress which will be essential to the sustainable development of the sector over the years to come. To prosper, agriculture requires hospitable policies which have often been lacking: above all pricing policies which reward producers, and a climate which encourages both investment in the sector and its supporting infrastructure, and the development of institutions able to efficiently manage the various economic activities associated with commodity production (input distribution, marketing, processing,...)

1.3 **But the research system will need to play a major role in the sector's development.** To do so, the system will need to find ways to improve the setting of research priorities, to ensure that it allocates resources towards meeting the economy's greatest needs. Up to now, these decisions have been made without sufficient reference to the constraints under which the majority of small farmers operate, and without an adequate understanding of the role that research can best play (as compared with other actions) to keep agricultural output competitive in domestic and international markets, and to ensure its long-term sustainability.

2. The dynamics of agricultural growth in the Region

2.1. **A history of successive growth dynamics.** Over the past five decades, the Region has witnessed successive positions of leadership in agricultural growth, until recently based essentially on booms in traditional **export crops** and on the exploitation of the **tropical forest**. The Belgian Congo, Nigeria and Ghana all experienced rapid growth in the colonial period. As these countries began to experience problems in the decade after Independence, the agricultural economies of several of the franc zone

countries took off (esp. Côte d'Ivoire, but also Cameroon, and a larger number of counties in cotton). Most recently, these latter countries have been experiencing difficulties - slow growth, stagnation, and even decline in output levels - while there has been a modest comeback in the industrial crop sectors of Ghana, Nigeria, and, from a small base, Guinea.

2.2. The humid forest zone has always been characterised by a dichotomy in the organisation of agriculture, with a **strong role for large-scale plantations.**

2.3 In **food crops**, the Region has always been relatively self-sufficient. The only clear exceptions to the phenomenon of local supply are Gabon and Guinea, with towns highly dependent on imports.

2.4 **The conditions favoring a strong growth dynamics have been principally associated with favorable conditions of sale.** Important have been both the level of producer prices and the ease of access to markets. The development and maintenance of transportation infrastructure has been important in this respect (contrast the Côte d'Ivoire and Nigeria, countries having made substantial progress in this area, with Zaïre and the Central African Republic). But a good road network does not work miracles. Transport costs still impose substantial obstacles to food crop marketing at long distance, and form an important barrier to hooking up the sub-humid savanna zones with the large urban markets in the coastal humid zone. Only in Nigeria has this link been well established, under conditions of much larger markets and extremely low fuel costs.

2.5 For certain commodities requiring primary processing before sale, a **precondition to growth has been the development of processing capacity** (oil palm, rubber, cotton, coffee, rice, cassava,...). Within the Region, the investment choices have typically favored large-scale industrial techniques, rather than artisanal methods. This presents a marked contrast with the developments in South-East Asian agricultural sectors, which have left much more room for artisanal techniques.

3. The contribution of research to the development of the Region's agriculture

The institutional background

3.1 **The history of the Region's agricultural research has also been subject to successive dynamics.** The earliest large programs were in the **export crops**, first launched in Belgian Congo (INEAC) in the interwar period, from the 1940s in the anglophone countries as a group (Ghana taking the lead for cocoa, Nigeria for oil palm), and in the former French colonies. Independence led to a number of ruptures: the dissolution of INEAC (some of whose results were retained by transfers to the French system - coffee, cocoa, oil palm), and the breakup of the regional networks of the colonial period into national systems. The major post-Independence research programs are in Côte d'Ivoire (all perennials, cotton and fruits), to a lesser extent Cameroon (cocoa, coffee, rubber, cotton) in the francophone zone; Nigeria (all perennials and fruits) and Ghana (cocoa) in the anglophone countries.

3.2 **Large programs in food crop research in the Region are more recent, and remain limited in scope.** They function to a large extent in association with the two IARCs, IITA (maize, roots and tubers, plantain) and WARDA (rice), both established since Independence.

3.3 **The absence of linkages among national systems is most marked across the language barrier, and among anglophone countries.** In the francophone case, and particularly for the export crops, there has been the possibility to maintain more links among the national systems, owing to the maintenance of large expatriate presence through overseas institutes (IRCT, IRCC, IRHO, IRCA, former institutes now forming part of CIRAD). The progressive withdrawal of these former institutes poses questions for the continuity of these links across countries.

3.4 **Across the language barrier, the lack of contacts can be especially important in the cases where the research strength in the Region is highly localised.** For instance, the French-speaking world is largely uninformed about the dynamics of cassava improvement occurring in Nigeria.

Overview of research strategies and results

3.5 **Some important findings.** The dominant orientation of research in the Region has been the selection of high-yielding varieties which respond favorably to the application of chemical fertilisers (and to mechanisation in the savanna zones), in monocropping situations. Although the primary means promulgated for containing pests and disease continues to be via chemical control, tolerance/resistance has also been an objective of a number of breeding programs, as have, in some cases, other characteristics attractive to growers such as precocity. The results have been a set of important findings for a number of the Region's crops:

- **Oil palm** hybrids (*tenera*), first developed in the 1930s in the Belgian Congo, are now able to yield 3 to 4 tonnes of oil per ha. under plantation conditions, as compared with well under 1 tonne for the unimproved varieties found in nature (*dura*). The hybrids also have superior oil quality (lower fatty acid content), earlier maturity, and a slower trunk growth (which eases harvesting).

- **Cocoa** hybrids now available in the principal producing countries of the Region obtain 2 to 3 tonnes per ha. in station (as opposed to under 400 kg/ha obtained with unimproved material in the interwar period).

- **Robusta coffee** varieties now available in the Region enable yields of 2 to 3 tonnes of green coffee per ha. in station as opposed to only 250 kg/ha in the interwar period exhibit some resistance to rust.

- In **rubber**, while yields of 350 to 400 kg/ha were considered quite satisfactory in the 1920s, clonal material now available in the Region permits 2 to 3.5 tonnes/ha in station. Tapping techniques have also been improved, considerably lowering labor requirements.

- **Cotton** research has combined objectives of yield increases (now 2 to 3 tonnes/ha of seed cotton in station), fibre and seed quality improvement, and higher fibre extraction rates (moving from 30 to 40 percent since 1960).

- **Maize** research, drawing on results obtained elsewhere, has made available a wide range of varieties corresponding to different levels of intensification. Cultivated under optimal conditions certain hybrids are able to obtain 5 to 10 tonnes/ha, and a number of more "rustic" improved open pollinated varieties from 3 to 4 tonnes/ha.

- **Cassava** research, relatively neglected if one takes account of the importance of the crop in this Region, has nevertheless made some significant progress in both yield increases and disease resistance, particularly for the "bitter" varieties most commonly consumed in Nigeria. Several IITA varieties of this type generate roughly an increase from approx. 11 to 19 tonnes/ha on average under low input conditions.

- Breakthroughs in **yam** research, a crop even more neglected than cassava, have mainly been in multiplication techniques (the mini-sett, a method for reducing the quantity of planting material needed to be retained as seed yams). The technique has encountered substantial obstacles to widespread adoption, however.

- **Systems of production, natural resource management.** At present, the portfolio of research results concerning crop associations is extremely limited. Probably the best-known type of system proposed by research is IITA's alley cropping technique, designed to associate annual food crops with nitrogen-fixing trees. In savanna areas, some progress has been made in knowledge on introduction of leguminous plants into cereals cultivation, as well as on associations of crops with animal raising.

3.6 **But the record on adoption is highly mixed.** Research results are typically proposed to farmers as a package (new varieties to be used following improved practices including chemical fertilisers and pesticides, in single stand, with particular spacing and timing practices). Yet the only systematic cases of across-the-board adoption of packages are found in the large-scale plantations. In smallholder agriculture, the cases of intensification based on a package are few.

3.7 **In smallholder agriculture, there are many more cases of very partial adoption of technical recommendations.**

(1) The category of research results most interesting to farmers appears to be the **improved genetic material.**

(2) **When used, fertilisers are almost universally limited to annual crops.** Farmers recognize the yield-augmenting effect of fertilisers on annuals, and apply it when it is available and affordable. The effect of fertilisers on perennials is either too long term or not apparent.

(3) Apart from the cotton schemes of the CFDT network, the use of **chemical pest control is not undertaken by farmer initiative.**

(4) Evidence of **adoption of specific cultural practices recommended by research is extremely scant.**

- Farmers pass to monocropped systems only under special circumstances.

- Farmers are often not convinced of recommendations on spacing.

- Weeding recommendations rarely attain the levels recommended by research.

- For some crops, the same holds true for harvesting and post-harvest handling.

4. Conditions for the successful adoption of improved technology in the Region by peasant farmers

4.1 There is little mystery in the successful adoption of research results in the case of plantation agriculture; these systems have not been subject to capital constraints for machinery, inputs and labor, and moreover have typically operated under very close links with the research establishment, often receiving management advice from research institutes. For the future of agriculture in the Region, the more perplexing issue is to identify the conditions for successful adoption in peasant agriculture, and to see to what extent those conditions are reproducible elsewhere.

4.2 **Particular constraints in smallholder agricultural systems which may limit/prohibit adoption.** In contrast to plantation agriculture, smallholder farmers face conditions (shortages of manpower and capital, aversion to risk, combined in many cases with a lack of land pressure) which make the adoption of complete technical packages less attractive, if not impossible. Yet the experience of intensification in cotton, maize and cassava shows that these constraints are not insurmountable.

4.3 **A precondition for successful smallholder intensification is attractive and secure market access.** The marketing channels need not be official but they need to be reliable.

4.4 **For food crops, urban demand may be too limited to constitute a reliable market for intensive production.** Intensive maize production in the cotton schemes in Côte d'Ivoire, Mali dropped off dramatically once guaranteed official purchasing was stopped. In Ghana, rapid intensification of maize under the Global 2000 scheme met a similar fate.

4.5 **Secure market access may require access to processing facilities.** This is clear in the case of cotton, for which industrial processing facilities have been constructed in tandem with the expansion of output. Availability in a village of small-

scale mechanised facilities for processing gari has been a key factor in the expansion of intensive cassava production with the improved varieties in Nigeria.

4.6 **Intensification also requires favorable conditions "upstream".** The cases of successful intensification have in common: chemical input availability at affordable terms (input credit and/or subsidies in the cotton schemes, in Nigerian maize and cassava cases, and in coffee in Moungo), and official drive to distribute improved planting material in all the cases involving annual crops.

4.7 **The cases where there has been widespread adoption are marked by a close link between the research system and the producers,** parallel to the conditions of research linked to the large-scale plantations.

- Cotton research in the CFDT zone has been highly integrated into the development programs, providing new material and updating recommendations for extension services at frequent intervals.

- The cassava success story in Nigeria results from close interaction between international and national research and the various development projects responsible for diffusion of genetic material and the provision of extension advice (including extensive conduct of on-farm demonstrations).

4.8 **Too often, research has failed to make the transition from identifying a technical optimum to calculating the profitability of the packages being recommended.** In cases where intensification has failed to take hold, despite the presence of a support infrastructure upstream and favorable marketing conditions (e.g. cocoa throughout the Region, coffee outside of Moungo Valley area), the reason may lie in lack of profitability of the package being recommended. Are fertiliser applications profitable on perennials ? What are the cost:benefit ratios for treatments with pesticides and fungicides?

5. Key economic and technical challenges facing the development of the Region's agriculture in the years ahead

5.1. The identification of regional research priorities needs to take into account not only the past record of successes and failures in the development and transfer of technology, but also the key challenges of an economic and technical nature which will face the Region in the years ahead. We identify two issues of short to medium term urgency, and a third of medium to longer term concern.

(1) **Competitivity of the Region's export and food crops.** Especially in their export markets, producers in the Region face major challenges from competing sources of supply, and a situation of low world market prices which threatens the viability of these activities as sources of income and foreign exchange. Price projections, while uncertain, suggest that the Region should not count on any major turnaround in these markets over the next 5 to 10 years. The Region's food crops similarly face strong competition from low-cost international sources of rice, and to

a more limited extent wheat, meat and dairy products. To meet this competition, efforts will need to be undertaken at the stages of production, processing, and the organisation of the crop subsectors in order to lower costs and/or raise quality. In many cases, this exercise will need to begin by conducting in-depth analyses of the domestic cost structure to identify weak points within the sub-sectors.

(2) **The changing institutional context within the agricultural sector**. In the context of structural adjustment reforms underway in the Region since the mid and especially the late 1980s, the agricultural sector has been undergoing major institutional changes, characterised in most cases by a retreat of the parastatal input supply and marketing organisations, by the disappearance of agricultural credit, and by a withdrawal of subsidies on chemical inputs. Oftentimes these parastatal organisations had high fixed costs, and had difficulty reducing their operating margins. Nevertheless, the result of their withdrawal has been, at least temporarily, an institutional void, as private sector operators have been unable or unwilling to replace all of their functions.

- **The institutional void is most marked in the areas of credit and input supply**. Under unsubsidised conditions, demand for inputs has dropped dramatically (e.g. to one-third its previous level in Ghana), and few private sector dealers are willing to bear the risk of dealing in this area.

- **The combined result of these institutional changes, the fall in world market output prices and the removal of subsidies has been to jeopardise the conditions for agricultural intensification**. Intensive coffee growing in Cameroon has been abandoned, there has been a 20 percent decline in cotton yields in the CFDT zone (despite the fact that the governments have maintained subsidies on the output price since the last big decline in the world price in 1991), and a general drop in the use of inputs except in Nigeria, which has maintained its subsidy program.

(3) The third issue of medium to long term urgency is to find **technical solutions to deal with impending situations of land pressure in the countryside**. Soil fertility is a major agro-ecological constraint in the Region, and in areas of high population density (esp. the Delta area of Nigeria, and increasingly the south of the Côte d'Ivoire, Ghana, and the West of Cameroon), farmers will need alternatives to their earlier practices of planting on virgin land when existing soils are exhausted. Research on these issues is still at a very early stage. In the humid zone, it is clear that solutions will need to be found in some forms of agro-forestry, i.e. of associating tree crops with annual agriculture.

5.2 In light of these three challenges, here are some of the issues at stake for the development of some of the Region's major crops :

Oil palm is one of the crops in which the Region has clearly lost a natural advantage: more favorable conditions in South East Asia permit the obtention of yields at least 30 percent higher following the same cultural practices, a development largely responsible for the fall in the world market price. The future of this crop in the

Region will depend on its ability to make a successful transition to supplying the domestic market.

Robusta coffee, produced by many countries in the Region, is facing a generalised crisis situation in world markets, under which no producing countries seem to be covering all costs. African producers appear in a worse position compared with South East Asian competitors because of much higher intermediation costs including transportation, processing and marketing costs.

Cotton similarly is facing an acute crisis on world markets, and all the world's major producers are heavily subsidised (e.g. U.S. growers receive 50 percent over the world price, Uzbekistan is selling at a large discount in order to earn scarce foreign exchange). In contrast to the situation in coffee, producers in this Region have undertaken deliberate and successful cost-cutting measures both at the production and intermediation stages since the mid-1980s.

For **cocoa,** this Region is the largest producing area, and in contrast to oil palm appears to be well-placed in terms of costs of production and quality. The big question for the future of cocoa in the Region concerns the conditions for replanting as the existing cocoa farms age; the dynamics of growth in this crop have been based on planting on virgin forest, a source of fertile land which is rapidly running out, and there appear to be constraints to replanting on old stands - at the least higher investment costs, at the worst substantially lower yield conditions.

Rubber production in the Region does not appear to suffer from natural disadvantages, either, in relation to South East Asia, although there are higher management costs under local conditions. This crop has some favorable properties with respect to soil fertility which suggest that it might be usefully explored as a diversification crop in smallholder (not outgrower) agro-forestry systems.

Cassava is already a staple food in much of the humid zone of the Region, and has been spreading to the Nigerian savanna in the form of gari. The key issues for the further expansion of this crop on a commercial basis concern the ability to spread the conditions for the Nigerian success to other countries.

Maize is often considered to have great potential as an answer to the Region's food needs, in large part because of high technical potential with available improved varieties. Yet an important constraint to its expansion as a commercial crop will be market size. There appear to be important differences within the Region concerning the acceptability of maize as a staple food in areas with large population concentrations.

Rice is a traditional crop in the Western part of this Region, and yet it faces serious problems of competition from lower priced imports. Many of the rainfed and valley bottom rice-growing areas are subsistence-based, while the towns are mainly supplied by imports. There is insufficient knowledge about the Region's rainfed and valley-bottom production systems to establish whether output can be expanded to serve the market at low production costs.

Plantain, a staple in the humid zone, also suffers from a lack of knowledge about production systems. In addition, the demand aspects of this crop (including the marketing flows) are poorly understood. Agronomic research on plantain (as distinct from dessert bananas) has begun only recently in this Region, and it would be beneficial if a region-wide study on demand and supply issues were undertaken, along the lines of the COSCA study for cassava.

Commercial fruit crops such as banana, mango and pineapple are often signalled as a potential channel for export diversification, since their external market conditions appear less unfavorable. Within the Region, the only large-scale producers of these crops for export are Côte d'Ivoire (all three fruits) and Cameroon (banana); other countries (Guinea, Ghana) promoting this strategy have smaller sectors (under 10,000 tonnes), currently limited to air transport. It is therefore unlikely that such diversification crops can be seen as a replacement for export earnings on some of the more traditional primary commodity exports, at least into the foreseeable future.

6. The Specific Challenges for Agricultural Research

6.1 Looking ahead, we identify four specific challenges for agricultural research, of which three thematic and one organisational:

6.2 **Research on the profitability of technical messages.** This approach needs to be systematically integrated into the applied research process:

- To start with, there needs to be a systematic effort to understand the cost:benefit relationship of existing research recommendations on elements of the "package", particular on fertiliser and pesticide use.

- This can help to guide research on the next stage, of finding ways to cut down on the costs of the recommendations. Progress in this area has already been made in the CFDT cotton zone, and has begun in coffee for both treatments and harvesting techniques. It needs to become a generalised approach.

- A medium to long term goal of such a focus is to be able to provide more nuanced recommendations to farmers, depending on the specific conditions at hand (effects of annual rainfall variation on planting and fertiliser recommendations; variations within a country on the amount needed of phytosanitary treatments, ...)

- This approach will imply a revolution in the type of messages given by extension services, which currently tend to be uniform and insensitive to changing profitability conditions. The difficulties experienced by cotton extension in Côte d'Ivoire with "decision matrices" designed to cut down on input waste highlight the need for carefully conceiving the messages to be conveyed, and for a close working relationship between research and extension.

6.3 **Research which takes into account the constraints in peasant farming systems: labor constraints, capital shortages, and risk aversion.**

To more effectively serve its smallholder clients, research needs to continue its move away from a "productivist" approach concerned with raising yields under high input conditions, to an approach concerned with raising yields under constraints likely to be faced by farmers. Through interdisciplinary work, including breeding, agronomy, and plant protection, there is a need to tackle objectives of:

- **resistance to diseases and pests through genetic work and integrated pest management**

- **other plant characteristics which increase the "rusticity" of the crop under farmer conditions** such as drought tolerance, lower sensitivity to following a strict cultural schedule for various agricultural tasks (planting, weeding, harvesting). There may be particular need for attention to these concerns in the industrial crops which have had impressive breeding programs, but which have traditionally been large-scale plantation oriented.

- **plant characteristics which reduce labor requirements and/or investment costs.** Some successful examples are early maturing cassava, cocoa, and oil palm varieties; slower growing oil palm trunks which cut down on harvesting costs; improved rubber tapping techniques; and the introduction of animal traction in the savanna zones through the cotton projects. On coffee, steps are needed to reduce labor cost for harvest. Solutions which cut down on weeding needs are required for many crops.

- In many cases tradeoffs will exist between the choice to focus on characteristics for market-oriented or subsistence-oriented farmers. Given the strong links between innovation and the market, and the high diversity of the needs in subsistence-oriented systems (IITA's "population-driven" systems), there is probably more to be gained by focusing efforts on the characteristics enhancing conditions of crops destined for the market.

6.4 **Research to tackle problems related to sustainability of the agricultural systems.** The search for modes of intensification which are not highly capital intensive (and therefore affordable by the Region's farmers) is mainly a challenge for agronomic research involving crop associations. To date there has been limited progress in this area : the alley cropping approach has hardly been adopted, after a decade of on-farm testing.

- **In the humid zone, the preoccupation with introducing leguminous trees into the system may have precluded the consideration of integrating some perennials with economic value** (rubber, oil palm, various local trees with medicinal and food values). Although non-leguminous, these other trees can have value in certain aspects of soil fertility retention, at the least in preventing leaching).

- **One obstacle to research in this area has been institutional: the separation of perennial crop research from the research on food crop systems,** and frequently the separation among researchers working on various perennial crops and other trees.

- **In the subhumid zone, work needs to be expanded on the introduction of legumes and livestock into annual cereals and roots/tubers systems.**

- The nature of devising systems solutions is more complex than agronomic work in monocrop situations, and **will need to involve substantial on-farm trials** to understand the functioning of the associations and devise modifications. Such on-farm research should receive a high priority (examples are initiatives in this direction through the TRIPS and COMBS networks associating national researchers and IITA).

6.5 **To ensure that they are focusing on the right problems, research systems need to establish closer links with producers.** This has been a natural part of the development process in plantation agriculture, where the producers are in a position to articulate their concerns and needs. The challenge ahead for research looking for solutions to peasant agriculture is to find ways to integrate these farmers into the research process: through contacts with farmers' associations where they exist, through joint work with extension services, through on-farm trials,....

7. Complementary actions necessary for technical progress in the Region's agriculture

7.1 In the current climate of liberalisation and the retreat of the state from many of its service roles in the agricultural sector, there are nevertheless some areas where public support is likely to remain a prerequisite for agricultural innovation. At a minimum, we identify two areas:

(1) **Support in the diffusion of genetic material** Special conditions in the supply of improved genetic material (hybridisation, cloning, slow multiplication processes for some crops) suggest that there is a public sector role to be played in getting genetic material out to small farmers. Private sector suppliers are unlikely to step in on the scale warranted, given the risks involved (fragility of seedlings, uncertain demand under commercial conditions). This is less of a problem in the cereals (e.g. maize).

(2) **Support in the diffusion of artisanal processing technologies.** Actions appear warranted in two respects: the location of techniques from elsewhere (esp. Asia) which can be used (adapted in some cases by research), and support to establishment of distribution networks for machines which are suitable (already the case for cassava, oil palm, rice, coffee). This may require subsidised credit, support to cooperatives, etc. in order to make the initial investments possible.

7.2 Thirdly, **the experience of successful innovation also suggests cause to reexamine the policies of taxing petroleum products and of eliminating all subsidies on inputs.** Despite their important role in public revenues, taxes on fuel appear to cause important dislocations in domestic and regional agricultural trade. Even if one agrees that input subsidies are a poor means of lowering the costs of production, they should be considered, given their role in the reduction of risk. Fertiliser subsidies in particular can encourage farmers to innovate, and to sedentarise their production systems.

ECONOMIC AND TECHNICAL FACTORS INFLUENCING REGIONAL RESEARCH PRIORITIES IN THE HUMID AND SUB-HUMID ZONES OF WEST AND CENTRAL AFRICA

Table of contents

I. INTRODUCTION: OBJECTIVES, APPROACH, AND SCOPE

1. The economic challenges for agricultural research in the Region
2. Approach and scope of the study

II. AGRICULTURE IN THE REGION: AN OVERVIEW OF THE RESOURCE BASE AND OF THE DYNAMICS OF AGRICULTURAL GROWTH

1. Characteristics, potential and constraints of the natural environment
2. Demographic and infrastructural resources: market accessibility and the scope for intensive land use
3. The dynamics of agricultural growth in the Region

III. THE CONTRIBUTION OF RESEARCH TO THE DEVELOPMENT OF THE REGION'S AGRICULTURE

1. The institutional context
2. Overview of research strategies and results
3. The record on adoption
4. Conditions for the successful adoption of improved technology in the Region by smallholder farmers

IV. KEY ECONOMIC AND TECHNICAL CHALLENGES FACING THE REGION'S AGRICULTURE IN THE YEARS AHEAD

V. THE SPECIFIC CHALLENGES FOR AGRICULTURAL RESEARCH

VI. COMPLEMENTARY ACTIONS NECESSARY FOR TECHNICAL PROGRESS IN THE REGION'S AGRICULTURE

Bibliography

Statistical Appendix

Maps

ECONOMIC AND TECHNICAL FACTORS INFLUENCING REGIONAL RESEARCH PRIORITIES IN THE HUMID AND SUB-HUMID ZONES OF WEST AND CENTRAL AFRICA

Main Report

I. INTRODUCTION: OBJECTIVES, APPROACH, AND SCOPE

I.1. The economic challenges for agricultural research in the Region

The ultimate goal of agricultural research is to foster economic growth. Research's role has been conventionally thought of as **productivity enhancement**: to promote technical change either by enabling farmers to lower their unit costs of production or processing, and/or by making techniques available which add value to their output, such as quality improvements. The first is the classic case of "shifting the supply curve downwards;" the second is sometimes thought of as "stimulating demand." More recently, an additional research mission, **to promote environmentally sustainable technologies**, has been increasingly emphasized in light of concerns that some common agricultural practices may be undermining longer run growth and development prospects.

These broad research goals are applicable to **any** economy--be it high- or low-income, resource-rich or resource-poor. Yet the magnitude and orientation of the task before agricultural research depends in great measure on the **specific development challenges** facing individual countries or regions. This depends in part on objective factors: the quality and composition of the resource base, and the options for growth and employment in sectors other than agriculture, both of which are anchored in the context of international market conditions. And, it depends in part on policy goals for agriculture which may seek to transcend these conditions: providing food security, preventing the erosion of farm incomes, preserving the natural environment,... These factors jointly influence the economy's agricultural research priorities, not only in terms of commodity focus, but also in terms of the types of productivity enhancements most needed (yield-augmenting, yield-stabilising, labor-saving, soil fertility-conserving, on-farm or post-harvest,...).

For the humid and sub-humid zones of West and Central Africa [1]--a vast area of 15 countries that extend along the coast from Guinea to Gabon, and inland including the Central African Republic and Zaire--the agricultural sector is a major source of employment and domestic food requirements. It is also a major source of

[1] The Region is defined to include the following 15 countries: Guinea, Liberia, Sierra Leone, Côte d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, Equitorial Guinea, Central African Republic, Congo, Gabon, Zaïre, and Sao Tomé; throughout the text, the proper noun "Region" is used to refer to this grouping.

export earnings in all but those few countries which have important mineral wealth (Gabon, Congo, Nigeria, Zaire, and Cameroon).

As elsewhere on the continent, the countries of these agro-ecological zones have been experiencing severe overall economic difficulties, and stagnating or declining per capita incomes, for at least a decade. While the crisis has most often been triggered by debt repayment obligations and adverse shocks to the terms of trade, it is clear that the underlying economic performance of the countries without major mineral wealth over the three decades since independence has been closely linked to the performance of the agricultural sector. The wealth of Côte d'Ivoire, which experienced exceptional agricultural performance both in terms of overall output growth and introduction of new commodities, stands in contrast to the lack of substantial growth of the economies where agriculture has made little progress since independence, such as the Central African Republic, Guinea, and Ghana. Overall, agricultural growth in the Region has been insufficient to substantially raise per capita incomes. Although food production per farmer appears to have risen over time, this has not kept pace with the growth of the nonagricultural population, and food imports have increased. In the industrial/export crops, many countries in the Region have seen their shares in world markets diminish.

Even mineral exporters like Nigeria need to rely on the agricultural sector as they move out of the crisis and regenerate a broad-based development process. The economic challenge for agriculture is multi-fold: to feed rapidly growing populations, generate foreign exchange, and foster growth in per capita income through the creation of direct and indirect employment opportunities. This challenge is heightened in relation to the past. It comes at a time of increased concerns about the deterioration of the natural resource base under current agricultural practices, and at a time when profitability in most of the Region's tradeable commodities is being undermined by a protracted period of low international prices, a phenomenon due in large measure to increased competition from producers in Asia and Latin America.

How can the agricultural research system help the countries of the Region to meet this challenge? Technical progress in agriculture will be essential to the sustainable development of the sector over the years to come. Yet bold actions will be needed to enable the research system to meet the challenge. Under the current economic crisis conditions, the most apparent dimension of the problem is the system's very ability to conduct research. Financial distress permeates large parts of the system, with dire consequences for the productivity of researchers. This budgetary crisis has helped expose other obstacles to researchers' productivity which are more institutional in nature: incentive structures which do not sufficiently reward dynamic researchers, lack of effective linkages within the scientific community, leading to isolation, lack of "critical mass", duplication of efforts,... These financial and institutional obstacles to the effective conduct of research are the subject of other studies for the regional initiative on revitalising agricultural research; creative solutions are needed which tackle them jointly.

The focus of this study is on a set of concerns which may be less apparent, under the current crisis conditions, but just as essential to the ability of the research

system to provide the results that are needed to transform the Region's agriculture: **the setting of research priorities in line with the needs of the economy**. The orientation of research activities, both with respect to commodity focus and to the types of productivity changes aimed for, has increasingly come into question. In part, this stems from the low adoption rates for many of the research results which the system has produced over the past decades--especially those varieties and techniques which substantially augment yields and intensify land use. While a case can be made that adoption is impeded by policy-related factors outside of the research orbit, such as low farmgate prices or poorly functioning marketing and input distribution infrastructure, it seems clear that part of the problem lies in the failure of the research system to sufficiently take into account the resource constraints which prevent farmers from making use of the results. The questioning also stems from the perception that research has not found answers for some of the Region's most serious problems, such as soil fertility maintenance and productivity increases in some of the major food crops. While the lack of solutions may reflect the intractability of the problems themselves, there is again reason to doubt that the research system has given them sufficient attention.

I .2. Approach and Scope of the Study

For agricultural research to have an important impact on the economy's development, it needs to gear its efforts toward relieving the most pressing technical constraints. What these constraints are will depend on the interdependence of the agro-ecological conditions of the Region with two interlocking systems: the **farming system** and the **commodity system**. By **farming system**, we refer to the entire range of resources, or factors of production, which combine at the farm level to produce agricultural output: the natural resource base, labor, and various types of capital inputs. Since it lies directly within their technical competence, agricultural research scientists have most naturally focused on the characteristics of the first of these--climate (temperature, rainfall quantity and distribution), soil quality, and presence of pests and diseases which determine growing conditions--without considering adequately the role of the other resources. Labor and capital constraints can have a decisive impact on the types of technology which farmers can and will use.

Recognition of this interdependency has been behind the emergence over the past decade of "farming systems research." When applied to the agronomic, rather than socio-economic, disciplines, this usually refers to adaptive research seeking solutions across combinations of crops (and livestock) which are grown by farmers, often in association. It is therefore important to emphasize that understanding the resource constraints of the farming systems can provide guidance for the full spectrum of agricultural research, ranging from basic genetic work to input trials on farmers' fields.

Whether or not research can have an impact depends, as well, on the conditions in the wider economy in which producers operate: the level of prices for agricultural outputs and purchased inputs, and the reliability of both of these markets, are key determinants of the profitability of the activity for the farmer. These

conditions depend, to some extent, on factors which are given: price movements in international commodity markets set limits on the output price; distance from marketing outlets and poor transportation infrastructure raise costs of inputs and output marketing margins. But there are clearly areas where government intervention affects profitability: input and output price policy may be the most obvious channel, but "non-price" policies, such as investments in road networks can be equally important.

A useful framework for analysing this interdependence is as **commodity systems** (in French, *filières*): the successive chain of activities from input delivery to the final sale of the output (in local or export markets), including the production activities, transportation, and, where relevant, primary processing. Information on the structure of costs across successive activities in this chain, and on the market situation, can reveal the weak points within the system, where changes are needed to increase profitability. This provides perspective on the relative importance, first, of research versus other actions (such as cutting marketing margins), and second, of various research strategies: reducing production costs or the costs of processing, raising yields versus improving quality,... By helping to identify the best opportunities, this analysis can also help in the choice to allocate research resources among the various commodities. Too often, the research system has allocated resources without the benefit of this type of perspective.

In this study, we draw on these two frameworks to review the nature of agricultural growth in the Region and the contribution of agricultural research to that growth, and to raise issues for the future orientations of agricultural research and the supporting policy environment.

Given the great diversity of the agriculture of this vast Region, it has been necessary to limit the focus of the analysis to the commodity systems which are of major economic interest at the regional level; other crops which may have a more local significance are mentioned in passing. By the same token, the treatment of issues relating to the farming systems is illustrative of major tendencies, and by no means exhaustive. Livestock issues are dealt with in the present study only insofar as they relate to the farming systems (animal traction, integration of livestock with crops); for specific treatment of livestock the reader is referred to a parallel study done by ILCA.[2] To the extent possible we have cited references providing more detailed information; we refer the interested reader to the bibliography, which is organised by topic.

There is no perfect overlap between political and agro-ecological boundaries. Although we consider the Region's countries in their totality in the analysis of global issues such as production and consumption trends and the policy environment, we have used agro-ecological cut-off points in the discussion of specific issues related to agricultural technology and transfer. Specifically, we have confined our focus to the two broad agro-ecological zones, humid and sub-humid (described in some detail

---

[2] ILCA, "Preliminary Review and Proposals on Research in Animal Agriculture," Addis Ababa, July 1993.

below), which cover the majority of the agricultural areas of the countries in the Region. Some of the countries within the Region also include drier areas more similar in characteristic to the semi-arid areas of the Sahelian countries (northern Nigeria, Cameroon and Central African Republic); issues specific to these areas will not be discussed here. For an overview of the agricultural challenges in these zones, the reader is referred to the documents issued for an earlier SPAAR regional initiative covering the CILSS countries.[3] Nor will there be specific treatment of the conditions relating to the small number of high altitude areas within the humid zone (above 1000 m around the equator, and above 700 m in the wider tropical zone to the north and west), situated in Cameroon, Nigeria and Zaïre, where certain crops can be grown that cannot be found at the lower altitudes more common to the Region (arabica coffee, tea), and where agriculture is on the whole quite different. The characteristics of these zones are more germane to those of the high altitude regions of East Africa, where a parallel SPAAR regional initiative is currently underway.

The detailed analysis of institutional factors affecting the research systems of the Region is beyond the scope of this study. Nevertheless, since the focus of the study is on agricultural research and development issues of regional significance, we do consider one aspect of an institutional nature related to the scope for regional collaboration. Specifically, we have attempted to point out areas where it will be important, if not necessary, to create or reinforce regional linkages in order to tackle research issues which extend beyond national interest.

The richness of the Region's plant populations suggest that biodiversity issues should be a privileged topic of investigation at the regional level. Although we take note of genetic resource issues in the context of the analysis of particular crops, we do not undertake any systematic analysis of this issue. A detailed study on the topic is currently underway under the auspices of the United Nations University in Nairobi.

---

[3] SPAAR and INSAH, 1991, Revitalizing Agricultural Research in the Sahel: A Proposed Framework for Action.

II. AGRICULTURE IN THE REGION: AN OVERVIEW OF THE RESOURCE BASE AND OF THE DYNAMICS OF AGRICULTURAL GROWTH

Since the natural resource base is a primary determinant of the potential of agriculture in the Region, we begin with a brief review of its main characteristics, and the potentials and constraints which they impose for the development of the sector. If these characteristics determine the **quality** of the land available for agricultural purposes, other elements of the resource base are key for whether and how this land is put to use: (i) demographic patterns, which play a dual role in determining the location of markets and the availability of labor resources for putting the natural resource base to use; and (ii) the state of physical and communications infrastructure, which affects the degree of ease (and cost) of transporting inputs and outputs from production to consumption zones. We examine the status of these other elements briefly before turning in the following section to the analysis of how they have interacted with the overall policy environment and international market conditions to determine the dynamics of agricultural growth.

II.1. Characteristics, potential and constraints of the natural environment

Altitude is the key determinant of temperature in the wet tropics. Outside of the few highland areas excluded from specific consideration in this study, the Region is not characterised by pronounced fluctuation in altitudes, with the result that temperature variation is very slight, and practically non-existent around the equator. The boundaries of the Region therefore present an essentially uniform agro-ecological context as concerns agro-physiological production conditions for the main crops. These conditions are on the whole quite favorable to crop growth, which is not constrained by sharp drops in temperature. For the same reason, they pose constraints for those crops whose cycle depends on a lower temperature, such as certain horticultural crops which need low temperatures for seed production.

Rainfall appears as the key differentiating factor. Whether there is one or two dry seasons, how long each lasts, and the intensity of the rains, are criteria that are at least as important as the amount of water available. Between the north and the equatorial zone, the rainfall regimes pass from monomodal, in the 800-900 mm isohyet to rainy regimes without dry seasons or where the dry season is very short and precipitation levels reach 2000 mm, via a host of in-between situations where, for instance, there may be two dry seasons of varying duration and intensity. Schematically a distinction can be made between a humid zone and a sub-humid zone as follows:[4] (See Maps)

---

[4] For this section, we draw on work being done in a variety of institutional contexts: IITA's Agro-ecological Studies Unit, the working group of on "The future of the humid inter-tropical zones" of the French-based "Research-Development Network" (especially the study done by Labrousse, 1992), and CIRAD's ongoing (continued...)

The humid zone is generally considered to encompass areas with over 2000 mm of annual rainfall and a maximum dry season of no more than four months. It also includes regions with less precipitation where "dry" seasons receive an average monthly rainfall of 10 to 50 mm or where atmospheric humidity is high enough to offset the effects of the dry season. Within these two broad groupings, Labrousse (1992) recognises several sub-zones, in application of the above-mentioned criteria:

(i) **A vast zone with, generally, over 2000 mm of rainfall**, which, on the whole, corresponds to the "Lowland Warm Humid" zone according to IITA's classification. This can be broken down into two sub-zones, based on the characteristics of the dry season:

- **a dry season of under two months**, or no dry season at all, viz., the Congo River Basin (Congo and Zaire) which extends to the Ogooué Basin in Gabon, the Cameroonian coast and the delta of the River Niger in southern Nigeria. Crops can be grown all year long in such areas, but the moisture conditions can pose important constraints for harvesting, since sun-drying is next to impossible.

- **a pronounced 2-4 months dry season**, and annual rainfall of between 1800 and 2500 mm, viz., certain regions of Congo, Gabon, Cameroon and Zaire that are complementary to the regions cited above, the southern regions of Liberia, Côte d'Ivoire, Ghana, Nigeria, and CAR. In this sub-zone, a distinction should be made between two situations related to the sequence of the dry season: those with a single dry season lasting three to four months, e.g., Guinean forest region; and those with two dry seasons whose relative importance can be clearly distinguished, one being called the "short dry season" (1-2 months with possibly a little rainfall) and the other the "longer dry season" (2-3 months with no rainfall). The distinction is important for the choice of crops which can be grown in each wet season. In the areas with the longer dry spell, short-cycle cereal crops may be necessary in the period preceding it. Roots and tubers, which can survive a several month dry spell, generally provide more security in such areas.

- **a long dry seasons that lasts about five months**, but with high precipitation. The isohyet may span from over 2000 mm to 5000 mm, viz., parts of Guinea and Sierra Leone. In these areas, there are generalised risks of hydric stress during the dry season, most critical for the young perennials.

---

[4](...continued)
work on the problems of forest and post-forest regions of West and Central Africa. (See Maps).

(ii) **A zone with relatively little rainfall (800 to 1300 mm), and, usually, two dry seasons** of varying duration, viz., the south of Togo and Benin, part of Côte d'Ivoire, certain regions in the south of Congo and northwest of Zaire. In Congo, the shortest of the two dry seasons is sometimes considered to be "capricious" (Sautter, 1958) since there may be some slight, randomly distributed rain spells. Although the rainfall levels of these areas correspond to the areas in the sub-humid classification, the bimodal distribution contributes to sufficient atmospheric humidity to permit the cultivation of some perennial crops normally requiring higher rainfall levels (particular various palm trees). In the IITA classification, these areas fall under the "Moist Savanna Zone".

Crop aptitudes related to the rainfall regimes of the humid zone: The high moisture conditions of this zone facilitated the development of the vast tropical forests, and likewise permit the cultivation of a number of perennial tree crops: cocoa, robusta coffee, oil palm, coconut palm, rubber. As concerns food crops, the conditions similarly favor the cultivation of roots and tubers (cassava, yams, cocoyam, sweet potato), of plantains, of fruits (sweet bananas, pineapple, avocado), and of a variety of local vegetables (especially leafy varieties).

The moisture conditions are favorable for rice cultivation in many parts of the humid zone (notably in the Western areas, such as Sierra Leone, Liberia, and Côte d'Ivoire, where rice is a traditional staple); water management poses a productivity constraint in some of the wetter areas. Cultivation of cereals such as maize, which have high light requirements, is more circumscribed: if the high (and relatively reliable) moisture conditions are favorable (and in some cases permit double or triple cropping cycles within the year), the thick cloud cover screens sunlight necessary for optimal crop development during the dry season in many areas. The sunlight constraint can diminish oil palm yields as well. Too much rain can similarly be a constraint if it falls during the flowering period (a limiting factor for maize in this zone). On the whole, the rains in this Region are accompanied by relatively mild winds, posing less threat of crop damage than in parts of South-East Asia and some other tropical zones subject to monsoon weather.

The lengthier dry seasons pose constraints to the optimal development of perennials, which are highly sensitive to hydric stress at the nursery stage. This appears to be a particular problem in the "boundary" areas of the zone, which some observers argue have been expanding southward as agriculture has replaced forest cover.[5]

The sub-humid zone, as considered in this study, corresponds more or less to the "Lowland sub-humid" zone in the IITA classification, comprising the zones

---

[5] The problem in the eastern cocoa-growing areas of Côte d'Ivoire is noted by Ruf and others (1992); this issue was similarly cited by officials of the Cocoa Research Institute of Ghana for the Brong-Ahafo area.

generally known as the "Guinean Savanna" and "South Sudanian Savanna."[6] Whereas the entire humid zone lies within the 15 countries of the Region under study, a number of adjacent countries contain areas which would fall into the sub-humid classification (the southern areas of Mali, Chad, Burkina Faso, and Guinea Bissau). This factor could be important to consider when embarking on multi-country research initiatives; in some cases collaboration with these "Sahelian" countries could prove fruitful.

This zone also has particular conditions as concerns total rainfall and the distribution of the dry spells. A sketchy distinction can be made between the northern zones where rainfall varies between 800 and 1200 mm and the dry season lasts from 5 to 6 months, and the more southerly zones with 1200 to 1500 mm rainfall and two pronounced rainy seasons separated by a period of very low rainfall. In between these two extremes there is a large range of variation, with weather events that are more or less intense. In the centre of Côte d'Ivoire, for instance, the first rainy season and the first dry season become gradually more pronounced as one moves westward into an area with a monomodal rainfall pattern. Further to the south, on the other hand, the first rainy season and the first dry season are more pronounced and the rainfall pattern tends to become more decidedly bimodal. The risks associated with rainfall variability increase as one moves from the higher to lower rainfall areas within this zone, although even at its dryer limits, rainfall conditions are considerably more reliable than in the semi-arid zones to the north. At the same time, dryness poses its own advantages in terms of plant protection, since the longer dry seasons are a natural aid in the fight against various pests. Post-harvest treatments and storage are also easier to accomplish, and exact lower losses, in the dryer areas of the zone.

Crop aptitudes related to the rainfall regimes of the sub-humid zone: In this zone, growing conditions are good not only for roots and tubers, but also for a large variety of cereal crops (maize, sorghum, in addition to upland rice) and legumes (cowpeas, groundnuts). The rainfall conditions generally preclude the cultivation of the perennials, except for oil palm in low-lying areas. This limits the range of industrial crops mainly to cotton, with sugar and soybean as minor crops facing marketing problems. Mangoes and citrus fruits thrive in these climates. Vegetables such as onions and tomatoes can do well in this zone if cultivated in valley bottoms or with irrigation (in the humid zone, they suffer many more pest problems).

The soil resources of the Region cannot be assessed independently of rainfall. The main soil types are ferrallitic in the equatorial zones where there is no dry season and ferruginous in the sub-humid zones. Between the two there are intermediary profiles whose evolution depends on the canopy cover, rainfall patterns, and land use practices.

---

[6] The "Moist Savanna Zone" of IITA includes, in addition, the wooded savanna and the coastal zones of eastern and southern Africa, which are outside the scope of this exercise.

In the **humid zones**, where the ultimate stage of pedologic evolution is evidenced by ferrallitic soils, rainfall intensity and abundance have caused primary materials to be seriously weathered, and much of the nutrients to be leached away. These biochemical phenomena explain the character of the base exchange complex: poor capacity to fix nutrient substances because of very limited exchange capacities, and the problem of acidity and high rates of exchangeable alumina.

The ferruginous soils covering much of the **sub-humid zone** are clay-sand to clay-kaolinite type soils, of very varying thickness, depending on the topographic position, the presence or absence of hardpan and the type of bedrock. The relief is often undulating with generally gentle graded glacis that connect to summits with hardpan mounds and, at the bottom of the slope, hydromorphic clay soils. Soil fertility here is affected by the tendency for the structure of the surface horizon to break down, and the soil profile to be saturated during the rainy season and compacted during the dry season. Since the degree of soil damage caused by rainfall is highly correlated with its level, the conditions of this zone become more acute, and more closely approximate the problems of the humid zone, as one moves from north to south.

Because these natural handicaps of soil quality in both zones can be quickly compounded when the land is put to agricultural uses, it is fair to say that **soil fertility retention** is the predominant agro-ecological constraint in the Region.

The problem has been examined at some depth for the **sub-humid zone**, for which a synthesis of results from long-term research experiments now exists.[7] The process of degradation is now well understood. Cultivation causes the soil surface to suffer serious loss of organic matter, which makes the soil structure fragile, causing pulverulence, crusting, run-off, and top soil erosion. Although the role of chemical degradation in the reversal of the soils' productive potential should not be underestimated, weed invasion and acidification of the growing layers are the two primary factors at play.[8]

The synthesis study documents the often-made observation that traditional farming methods based on long periods of fallow followed by short periods of cultivation can main soil fertility at moderate degrees of crop intensification. The fallow favors the development of two fertility-restoring effects in what one might consider the "live" phase of the soils: rooting, which spreads organic matter

---

[7] Piéri, C., 1989, Fertilité des terres de savanes. Bilan de trende ans de recherche et de développement agricoles au sud du Sahara, (Fertility of the savanna lands. Thirty years of agricultural research and development south of the Sahara°. CIRAD, French Ministry of Cooperation and Development, 444 P. (also available in English).

[8] On cleared forestlands, yield levels diminish somewhat for 2 to 4 years, then level off for 7 to 8 years before declining sharply after 10 to 15 years of cultivation. On cleared grasslands, the first negative trend seems to be avoided but, after a 3 to 6 year period of stability, the yields drop off.

throughout the profile, facilitates water and gas circulation, and contributes to soil fixation; and biological activity of both the soil's fauna and its micro-organisms, which contribute respectively to humification and mineralisation of the soil. But the land requirements of such a system are high: the land held in reserve must be three to four times greater than the land being cropped at any given time. In areas with greater land pressure, the fallowing period becomes too short for this method to be effective, and other systems of fertility reconstitution have to be considered.

In policy discussions of this issue, the focus tends to be on the **need to augment the quantity of inorganic fertilisers**, presently in very low use in these production systems if compared with agriculture elsewhere in the world. For many crops grown in this zone, ample evidence exists to show that mineral fertilisers can augment the productivity of the soils, thereby enabling substantial yield increases. To wit, agricultural research has formulated reference standards for all of West Africa that provide data on the best quantities, forms, application methods and mineral balances on a crop-by-crop basis. Yet though they may need to be a key component of high-yielding agriculture in this zone, **mineral fertilisers alone will not solve the problem of long-term soil fertility decline**. If used exclusively, they contribute to acidification of the soils, regardless of the cropping system. For instance, drops in fertility levels in mineral fertiliser-based monocropped systems using cotton-cereals rotations have been shown to require rapidly increasing amounts of fertiliser applications (by a factor of 4 or 5!) to maintain stable yields (Hien et. al. as cited in Piéri, 1989).

Alkaline amendments (liming) present a technical solution to the acidification problem, but one which is costly to implement, and which does not compensate for another dimension of fertility loss under mineral fertiliser use: the loss of organic matter. Organic fertilisers (both plant and animal-based) exhibit greater restorative properties, and as such represent an important complement to mineral fertilisers. The practices can include cultivation of (nitrogen-fixing) leguminous crops, recycling of plant residues into the soils, and spreading of manure. Although they do not necessarily require purchased inputs (manure is in fact often sold), these practices are not without costs, either, in terms of both labor time (which can be high in some of the plant associations)[9], and transport costs to bring manure to fields.

On the basis of these combined practices, the synthesis study concludes that soil fertility **can** be maintained in the savanna zones. Given obstacles to implementation of these practices, there remain considerable research challenges for finding suitable and techniques to propose to farmers. We explore some of these themes is in a later section of the report.

Fertility issues in the **humid zone** have not benefitted from a comparable synthesis on the nature of the problems and the scope for technical solutions. Certain

---

[9] This is a particular problem in the alley cropping systems which associate leguminous trees and annual food crops, introduced by the International Institute for Tropical Agriculture (IITA) (See CGIAR-TAC, 1990; Carr, 1989).

elements of the diagnosis for the sub-humid zones also apply here, in particular as concerns the phenomena which cause soil degradation in the cultivated lands. Cropping the lands in the humid zones degrades the soil's structural properties and negatively impacts the water holding capacity, causing crust formation, surface layer compacting and poor water infiltration. Mechanisation apparently increases these phenomena, particularly because it requires much more radical land-clearing techniques than the traditional methods, which leave trees and stumps in place (Lal and Okigbo, 1990; Leduc, 1984). This problem is of course also relevant in the sub-humid areas (Freud and others, 1991). As in the sub-humid zone, mineral fertilisers alone are insufficient tools for fertility restoration. This being the case, certain practices seem to make the soils break down more quickly, in particular, sole cropping with short-cycle varieties, which leave soils exposed for longer periods.

The aggressiveness of the climate in this zone compounds the problems of fertility retention that are present in savanna areas. In particular, the forcefulness of the rains leads to serious erosion in annual crop systems. Perennial crops and trees therefore play a key role in this zone, as the cover they provide can go a long way toward preventing leaching. Many perennials contribute naturally to regeneration of the organic matter through residue deposits; they also enable the vertical transfer of fertility (mobilisation and upward biological transport of minerals from the deepest layers of the soil). But even perennial crops do not live forever, and there appear to be problems associated with direct replanting of perennials on old stands: higher incidence of weed and pest infestation, higher mortality of seedlings, even in cases where the chemical nutrient base has not been seriously depleted (Ruf, 1987 and 1992). The problem may be most acute for cocoa.

Fallowing of crop land can also restore fertility in this zone, but there is a debate on the length of an "adequate" fallow time: does it require the 20 or so years that it takes to reestablish a secondary forest, or are 7 or so years of natural regrowth, often characterised by the presence of a nitrogen-fixing weed known as *C. odorata*, adequate? It is with reference to the former view that forestry researchers have developed recommendations to "speed up" the fertility reestablishment phase by the planting of nitrogen-fixing trees: results indicate that this could cut the waiting time down to ten years.[10] The advantages of such a solution obviously need to be weighed against the costs to farmers of actively engaging in a tree-planting exercise. François Ruf's research on replantation of cocoa and coffee in Côte d'Ivoire suggests that farmers are finding ways to replant with success after the shorter, bush-based fallows where *c. odorata* is present, but that they only take this step if there is no virgin or secondary forest land available for the taking. These efforts are "home-grown" experiments by farmers themselves, who for the moment receive little guidance from the agricultural research system.

What combinations of inorganic and organic materials will enable fertility restoration in this zone? With what types of crop associations? These are some of the

---

[10] Information gathered for the external review of CIRAD's forestry research department (CIRAD, Revue Externe du Centre Technique Forestier Tropical, 1992.)

challenges to the research system for the future of agriculture in this zone, to which we return at a later point in the report.

Susceptibility to pest and disease attacks is the other main environmental factor that affects the geographical distribution of agricultural potentials and constraints in the Region. In livestock, there is a widespread problem of *trypanosomiases* which limits the ability to raise cattle; this constraint is extremely limiting in the more humid zones. In the sub-humid areas, there is some scope for raising cattle based on trypano-tolerant species (N'dama, Baoule), and it appears in some areas (e.g. Nigeria) that the zone of high morbidity may be being pushed back as more and more bushland is put under cultivation.[11]

For crops, many of the phytosanitary problems of the Region have a multi-country range, e.g. *striga*, a parasitic weed particularly damaging to cereal cultivation in the savanna zones; cocoa swollen shoot virus disease, which is a menace to this crop in Ghana, and to a lesser extent Togo and Nigeria; *phytophtora megakarya*, a fungus causing serious yield loss in cocoa in Cameroon and Nigeria; leaf diseases in rubber in the Central African countries; black sigatoka (*cercosporiosis*) in banana and plantain cultivation, again in the Central African countries, etc. In many cases, there is a high likelihood of such diseases and pests spreading to other countries in the Region. The multi-country nature of plant protection problems suggests that these will frequently be issues on which collaboration among national research systems could be highly beneficial.

II.2. Demographic and infrastructural resources: market accessibility and the scope for intensive land use

Despite the many variations in climatological and soil quality factors which one can observe throughout this Region, there are sufficient overall similarities in the basic traits to merit its consideration on the basis of the two broad agro-ecological zones, humid and sub-humid. If one were instead to use demographic characteristics as a dividing line, it is unlikely that the same regional boundaries would have been retained. One finds within this Region both the most and least densely populated areas of Sub-Saharan Africa.[12] All along the coast of the Gulf of Guinea, and further to the north in Nigeria, are located some of the largest cities of the continent, centers of commerce and important sources of demand for food products coming from the hinterland. In the western part of the coastal zone (Côte d'Ivoire, Ghana, and especially Nigeria), the countryside is also relatively densely populated, at least by

---

[11] This observation was made by researchers at NAPRI, the Nigerian Animal Production Research Institute.

[12] Tables 1 and 2 in the Statistical Appendix provide estimates of population densities and urbanisation rates at the national level for the countries in the Region.

African standards. It is in reference to these areas, with 10 ha of agricultural land or less per farmer, that one often hears the reflection that "there is no more forest in the forest zone." By contrast, the countryside of the forest zone in the Central African countries (Zaïre, Congo, Gabon, Central African Republic) has in places such low population concentrations--around 5 persons per km^2 or less--that systems of hunting and gathering remain economically viable alternatives to agriculture. Although population densities do not fall to these extremes in the savanna zones of most countries in the Region, the absence of large population centers limits the viability of selling agricultural produce, since the distances to the coastal areas impose high unit transportation costs.

Some countries, most notably Nigeria and Côte d'Ivoire, have managed to diminish such locational handicaps through the improvement of transportation and communications networks over the years. The handicaps have been reinforced in others, such as Zaïre, Guinea, and until recently Ghana, where the infrastructure has seriously deteriorated through lack of investments and maintenance. Most countries in the Region (even those with comparatively good networks) continue to have regions with high production potential which are virtually cut off from the market because of their remoteness. Although the policy discussions on this question have tended to focus on the need for more rural (i.e. tertiary) roads,[13] the problem often relates to the lack of good trunk and secondary road connections as well.

It is important to bear in mind the contrasts in population densities when considering the challenges facing the Region's agriculture. While soil fertility may be the greatest agro-ecological constraint, the relatively low population densities in most parts of the Region have limited the extent to which it has become a limiting factor in practice for the development of the sector. Overall, although the Region has been experiencing rapid population growth since the 1950s, land has been plentiful, and farmers have been able to open up new areas for cultivation when fertility declines. The question on the horizon concerns the limits to the practice as the population continues to expand: at some point, the agricultural land-to-labor ratios will have declined enough that farmers will need to take measures to maintain fertility on the existing farmlands.

It is a matter for debate as to where these limits are technically, depending on how much land one judges should be left in its natural state. Some argue that the point has already been attained (or indeed overstepped), in much of this Region as throughout the continent, because of the lack of governmental and social controls on the occupation of new lands.[14] Such assessments are difficult to verify by comprehensive statistics, since the national level data on land use and land available for agriculture are notoriously poor. For what they are worth, these numbers (presented in Tables 3 and 4) suggest that most countries in the Region still contain vast uncultivated areas which could be suitable for agriculture: as little as 1-3% of

---

[13] See, for example, Riverson and others (1991) and Gaviria and others (1989).

[14] See, for example, Cleaver and Schreiber (1992).

the land in Gabon, Zaire, Congo and the Central African Republic was devoted to crops in 1991, and from 12-16% in Benin, Togo, Cameroon, Côte d'Ivoire, and Ghana, all countries with relatively developed agricultural sectors. By contrast, in Nigeria 36% of the area was estimated to be under crops (subject to downward revision with the latest census results). In all countries except Gabon, comparisons of these data over the decade 1980-90 suggest that land-use per rural inhabitant has been on the decline (Figure 1).[15] There are two competing interpretations to these statistics: either that land pressure has forced rural dwellers to reduce their per capita holdings, or that there has been a natural (if mild) intensification process associated with the development of the sector over the period.

One conclusion does seem clear: that the point where fertility maintenance measures become an absolute necessity will come sooner in those areas where population densities are highest, as in the delta area of Nigeria and the coffee/cocoa areas of western Cameroon and central Côte d'Ivoire, than in the sparsely populated areas of Congo, the Zairian Basin and Gabon.

If land has not yet been registered as an overriding constraint in most of this Region, the corollary is that labor shortages have posed a major obstacle within the farming systems in all but the most densely populated areas. The typical family farm faces sharp seasonal labor constraints associated with key points in the agricultural calendar: planting, weeding, and harvesting. This is augmented by the fact that health conditions are typically worst during the prime agricultural months (when food reserves are lowest and climatic conditions most favorable for vectors of various diseases).

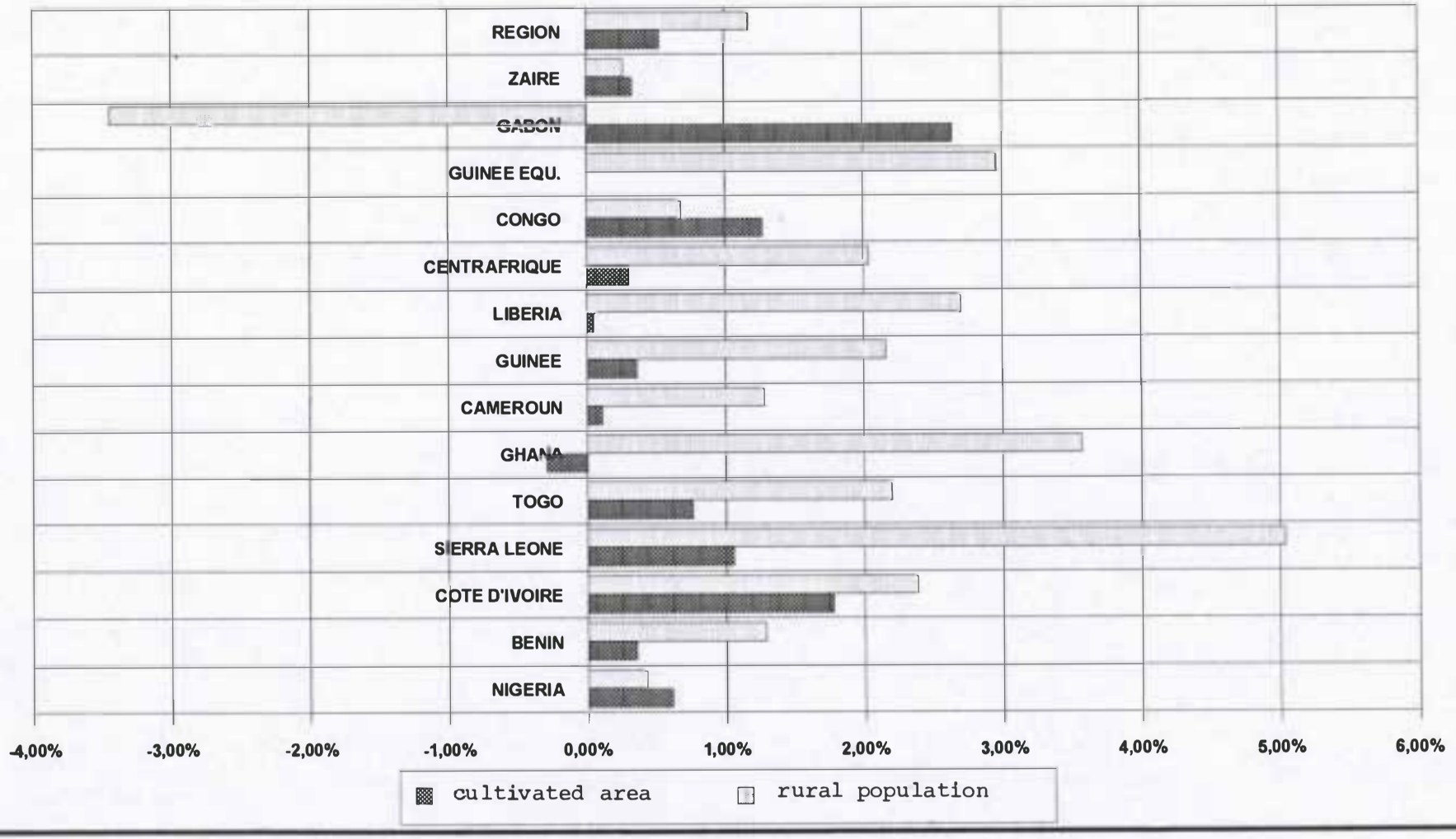
The relative abundance of land, combined with the fact that land holdings are distributed widely across the population, has meant that there do not exist large local pools of low-cost agricultural laborers. To supplement family labor with substantial quantities of hired help, it is generally necessary to import labor into the area, from other regions or neighboring countries, where economic opportunities are more limited, and where the peak agricultural season falls at a different time. Farmers are typically only interested in hiring help for commercial crops which produce monetary revenue. Whether or not this has been an attractive option has depended, of course, on the profitability of the crops in question. It has also depended on government policy with respect to the labor market: countries which have encouraged labor movements, like Côte d'Ivoire, and like Nigeria before the oil price decline in the early 1980s, stand in contrast to countries which have prevented this, like Cameroon and Gabon.

The labor constraints are also augmented by the lack of capital resources available to most small farmers. In general farmers in the Region

---

[15] The Nigerian data also suggest greater expansion of cultivated land than of the rural population, but the population growth rate is probably underestimated, given the substantial downward revision of the 1990 figure with new census results (placing the total population near 90 million instead of over 120 million).

Figure 1. Evolution of cultivated area and rural population growth rates



(as in most other parts of Africa) have few assets other than their land. This sharply limits their willingness to take risks, such as specialization in commercial agriculture and reliance on local markets for the purchase of food staples. It also limits the ability to pay for farm equipment and inputs which could increase the productivity of labor.

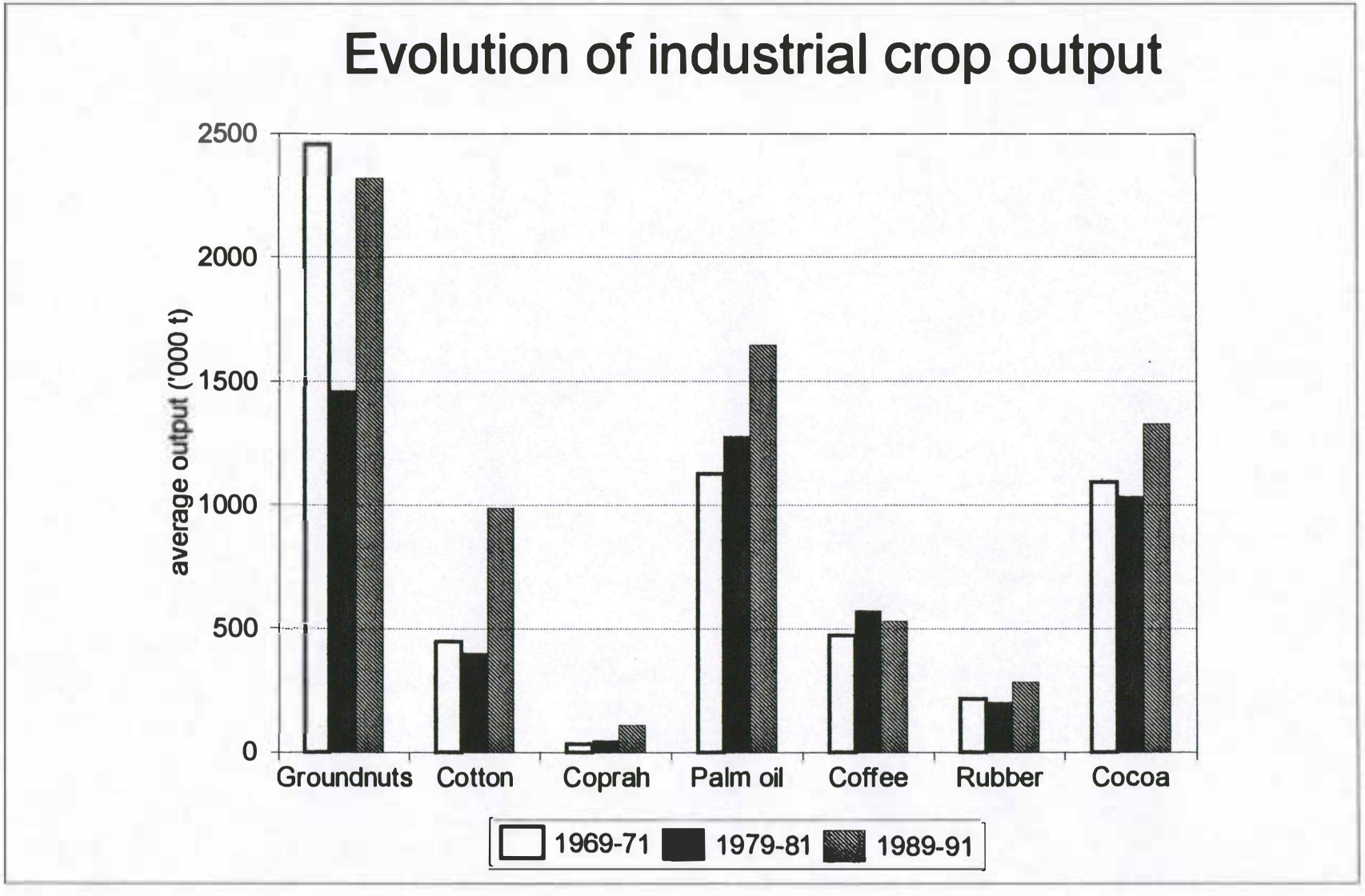
One area in which solutions need to be sought is in the organisation of rural capital markets, so that farmers can get production credit at reasonable rates. To date, it has proven to be extremely difficult to find policy solutions to this problem: projects providing input credits have generally operated with very high costs, and have not been able to ensure sufficient repayment levels. As a result, the rural development banks have gone bankrupt almost everywhere, and agricultural credit has all but dried up. There remain formidable institutional challenges to the restructuring and building up of rural credit markets. At the current interest rates of 25% per annum and more (compared with an inflation rate of under 5% in the CFA franc zone), it is highly unlikely that farmers could find it profitable to borrow for most production-related activities.

As we elaborate later in the report, agricultural research is also directly concerned by the labor and capital constraints in smallholder agriculture. A greater array of solutions is needed to problems of labor productivity, and in particular of how to relieve bottlenecks. Since access to credit is likely to remain limited, this implies the need for solutions which have low cash requirements.

II.3. The dynamics of agricultural growth in the Region

A history of successive growth dynamics. Over the past five decades, the Region has witnessed successive positions of leadership in agricultural growth, until recently based essentially on booms in traditional **export crops** and on the exploitation of the **tropical forest**. The former Belgian Congo, Nigeria and Ghana all experienced rapid growth in the colonial period. As these countries began to experience problems in the decade after Independence, the agricultural economies of several of the franc zone countries took off (esp. Côte d'Ivoire, but also Cameroon, and a larger number of countries in cotton). Most recently, these latter countries have been experiencing difficulties--slow growth, stagnation, and even decline in output levels--while there has been a modest comeback in the industrial crop sectors of Ghana, Nigeria, and, from a small base, Guinea.

Figure 2



Source : Table 6

The net result of these shifting dynamics is an overall picture of industrial crop production in the Region which appears to have been fairly stable over the past twenty years. As one can see in Figure 2, FAO estimates[16] of overall output of rubber, cocoa, and groundnuts has changed relatively little since 1970, cotton has grown substantially after an initial decline, and the only consistently upward trends have been witnessed in the produce of the two important palm trees, oil palm, and at a much smaller scale coconut. In almost every case, there has been substantial displacement among countries in the overall totals (Table 6): Ghanaian and Nigerian cocoa have diminished while Ivorian cocoa has expanded dramatically, Liberian rubber has made way for Cameroon and Côte d'Ivoire, Ivorian palm oil has displaced that of Zaïre. In cotton and groundnuts, Nigerian production took a major dip in the middle of this period, to be revived from the middle of the 1980s onward. In the meantime, numerous countries (Côte d'Ivoire, Benin, Togo, Cameroon) substantially increased their cotton output.

We highlight the distinction between the aggregate and the individual trends to challenge the conventional wisdom that loss of market shares for such products is a ubiquitous characteristic of African agricultural economies over this period. Industrial crop growth has been a major source of rural income growth as well as an important contributor to the foreign exchange earnings of many countries in the Region. The oil crops are also an important part of the local food supply. In Nigeria, exports of both palm oil and groundnuts have all but ceased in response to growth in the local demand.[17]

An assessment of the **staple food crop** situation in African countries is always fraught with difficulties, given the poor state of data collection for these items, large volumes of which are consumed by farmers or sold through informal channels. It nevertheless seems possible to make a rather positive assessment of the performance of the Region in this respect.[18] By the standards of the continent, the Region has always been relatively self-sufficient, thanks in part to the relatively stable growing

---

[16] Since the sale of many of these crops goes through formal channels, these output data are among the most reliable that exist concerning the agricultural sector. They are most questionable for groundnuts, and in some countries palm oil, both of which are characterised by a high degree of sale into "informal" channels in the domestic market, rather than for export or local industrial uses.

[17] It should be borne in mind that much of the market-oriented production of groundnuts in Nigeria (by far the largest producer in the Region) comes from the semi-arid zone to the north of the sub-humid zone considered in this study.

[18] For this section, we draw heavily on chapter 1 and the statistical appendix of the study prepared for the Abuja workshop launching this SPAAR regional initiative, by Bricas and others (1992), "La Valorisation des produits vivriers dans les pays d'Afrique humide et sub-humide. Situation et perspectives pour la recherche," CIRAD for SPAAR.

conditions afforded by the rainfall regimes. Despite some growth in food imports for rice, and to a more limited extent wheat, meat and dairy products, the large towns of the coastal area provide an important source of demand for local foodstuffs. Dishes based on the root and tuber crops continue to dominate the diets in these areas, even though there is an increasing diversity in the foods urban people eat. For towns and cities in the savanna zone, as well as some of the coastal towns with dryer climates (Accra, and the south of Benin and Togo), the locally-grown coarse cereals (sorghum and maize) are popular. The only clear exceptions to the phenomenon of local supply are Gabon and Guinée, with towns highly dependent on imports for their staple foods.

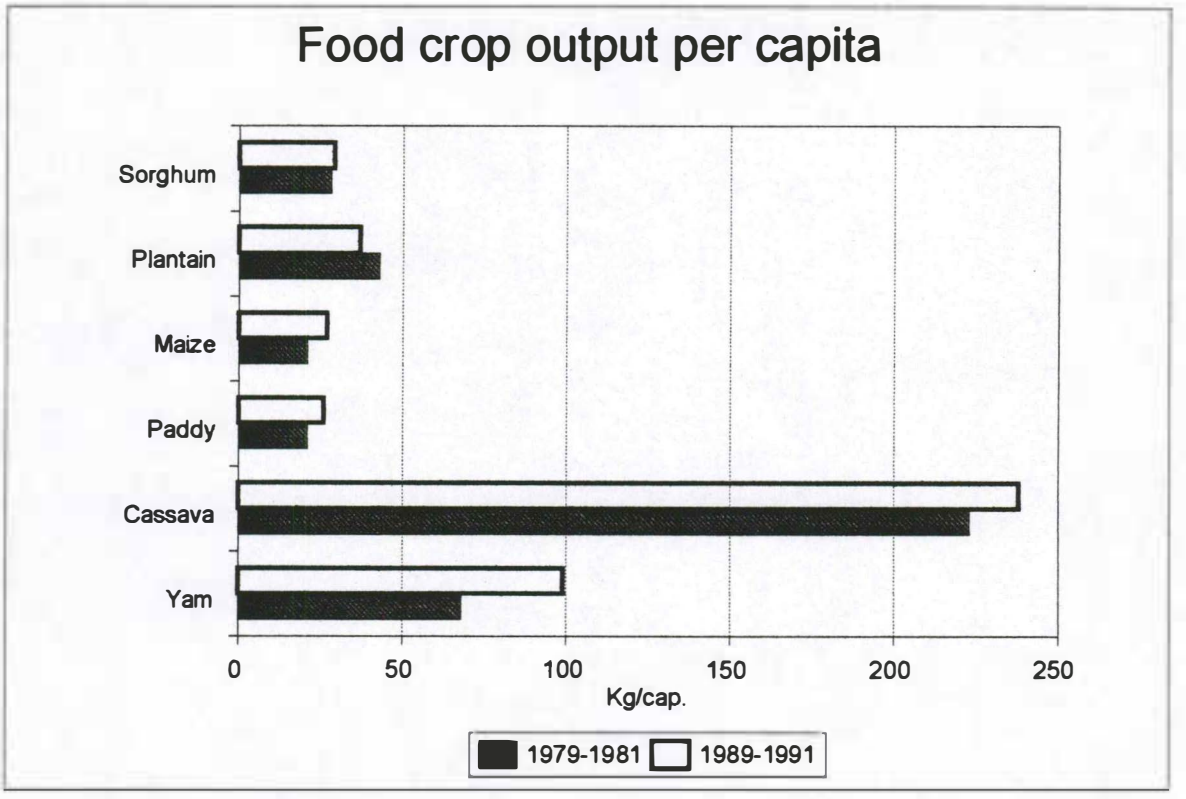
Figures 3 and 4 provide FAO estimates of production of the major food crops of the Region between 1979-81 and 1989-91, on a per capita and per rural inhabitant basis, respectively. The data suggest that overall, per capita production has been rising somewhat over this period, and that there has been even stronger growth per capita of the farm population. The only exception is plantain, which registers a per capita decline, and sorghum, which remains at a constant level per capita. From the individual country data in Tables 8 and 9, one sees that these trends have not been uniform throughout the Region. The strongest performance is registered in Nigeria, for all the food crops. Although it is quite likely that these data overstate the actual performance,[19] it seems clear to many observers within the country that there has been a strong growth dynamics in food production since the mid-1980s. At the other extreme, two countries register substantial declines in both cereals (predominantly paddy) and the root and tubers: Sierra Leone and Liberia. Recent political troubles are surely a factor in the latter country.

The majority of countries registered more moderate changes: among those with positive growth per capita in both the cereals and the root crops are Benin, Ghana, and Zaïre. Overall per capita declines were registered in Cameroon and Guinea (on a per farm population basis, only in Guinea). To the extent that one can place confidence in these trends, they suggest that on average, farmers in most countries in the Region are continuing to expand their output, in order not only to feed themselves, but to feed the growing urban populations.

Nevertheless, the overall per capital data suggest that this growth in many countries is not sufficient to keep up with urban population growth rates. If imports are not available to fill the gap (a problem in many countries in light of the reduced incomes and foreign exchange constraints accompanying the economic crisis), per capita consumption will suffer. For what they are worth, FAO estimates of consumption profiles for 1987-89 showed only four countries (Côte d'Ivoire, Gabon, Cameroon and Liberia) with per capita calorie availability above 2400 cal/day, and three countries (Zaïre, Sierra Leone, and the Central African Republic) with levels

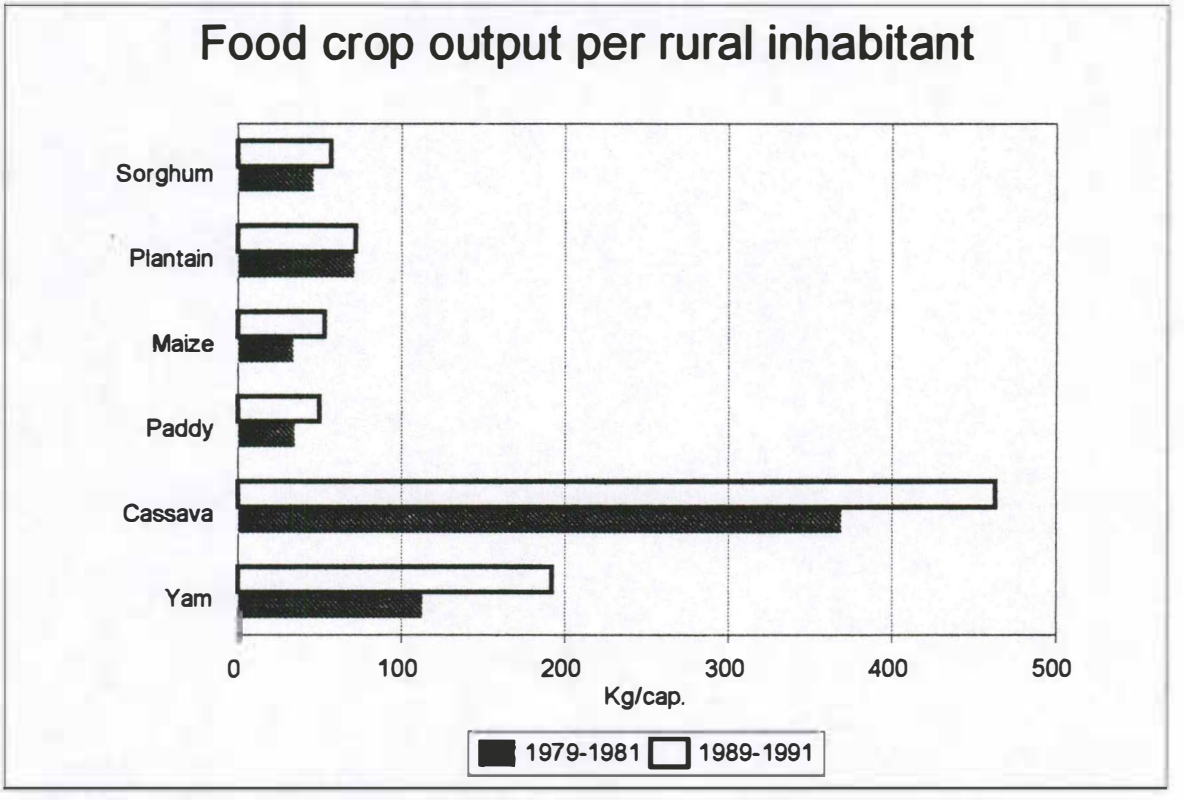
[19] Production estimates are not made independently of population estimates for crops such as these, for which a high proportion is assumed to be produced for subsistence. It is therefore likely that the production estimates will need to be revised downward in line with the downward revision of the census.

Figure 3



Source : Table 8

Figure 4



Source : Table 9

below 2100 cal/day (Table 10). These data suggest that the food situation remains fragile in the Region, despite the relatively favorable position of local production.

Conditions favoring a strong growth dynamics. Looking across the diversity of experiences in the Region over the past few decades, it seems possible to draw some general conclusions concerning the conditions favoring a strong growth dynamics in agriculture. A *sine qua non* has been favorable conditions of sale. Important have been both the level of producer prices and the ease of access to markets. The development and maintenance of transportation infrastructure has been important in this respect (contrast the Côte d'Ivoire and Nigeria, countries having made substantial progress in this area, with Zaïre, Guinea and the Central AfricanRepublic). For certain commodities requiring primary processing before sale (oil palm, rubber, cotton, coffee, rice, cassava,...), the development of processing capacity has been a precondition to growth in output.

The special constraints to a growth dynamics in food crops. For food crops, the expansion of production for the market has had to contend with two types of constraints related to favorable market access: the size of the urban markets (as measured both by the number of people, and their ability to buy), and the heavy burden of transportation costs in moving foods from production areas to these markets. These constraints have limited the ability of food crops to replace the industrial crops as "cash crops". For although the towndwellers of the Region eat local foodstuffs, the urban markets are generally not large enough to accommodate rapid production increases. The experience of Ghana shows that the limits can be attained relatively quickly. In the early 1990s, a maize production boom associated with the Global 2000 project quickly flooded the market in Accra and other urban centers, with the result that the sale price dropped sharply (at which point farmers lost money).

A few cities in this Region (Abidjan, Brazzaville, Douala) appear to have been able to support a strong growth in supply from the local agricultural base in recent years. But the only truly vast market of the Region is Nigeria, whose urban population far surpasses that of the other countries (Table 5). The strong growth dynamics witnessed in Nigeria since the mid-1980s have been linked to satisfying this demand, which had come to rely heavily on imported foods in the decade of the oil boom. The Nigerian market is a potential goldmine for farmers in neighboring countries as well. In the early 1980s, before the restrictions on food imports were imposed by Nigerian authorities, many farmers in Benin, Togo, Niger and Cameroon specialised in production for the Nigerian market. Although this practice has not ceased, it appears to have greatly diminished once border restrictions were introduced. Nigeria's trade policies on foodstuffs are therefore critical for any regional trade initiatives designed to encourage greater regional integration.

For some production areas, the market size constraint is compounded by the transport cost constraint. A good road network can help, but it does not work miracles. Transport costs still impose substantial obstacles to food crop marketing at long distance, and form an important barrier to hooking up the sub-humid savanna zones with the urban markets in the coastal humid zone. Only in Nigeria has this link

been well established, under the combined conditions of good road networks and extremely low fuel costs.[20] In other countries, the transport cost barrier has given a relative edge to farmers in the humid zone itself, permitting them to diversify their sources of cash income.[21] It has also meant that cotton is the mainstay of the cash income base in the savanna zones.

What constitutes an appropriate policy environment for stimulating agricultural growth? There is a tendency in current policy discussions to take a monolithic view of the appropriate policy package for achieving a favorable economic environment for agricultural growth.[22] In particular, the catch-words for the institutional forms being advocated throughout the Region are liberalisation and privatisation. To ensure that producers receive a favorable price, governments are also being discouraged from taxing output, and encouraged to actively use the tool of devaluation. Although it is beyond the scope of this report to provide a detailed analysis of these policy issues, we believe it is important to emphasise that there has been no single formula for achieving favorable growth conditions in the past.

Diverse institutional forms, ranging from fully public to fully private operations, have at times been successful. On the whole, food marketing in this Region has been outside the sphere of direct government control, and producers have received the price the market would pay. In the industrial crops, there has been a greater tendency for intervention, with marketing and processing being at least overseen, if not directly managed, by the public sector, and with guaranteed producer prices. The transition to new institutional forms poses a number of challenges for agricultural growth, to which we return in a later section of the report.

As the experience of cocoa in the Côte d'Ivoire demonstrates, there is no iron-clad rule against the state taxing producers for a share of the world market price: cocoa production in that country increased from under 200,000 tonnes to over 700,000 tonnes between 1970 and 1990, all the while contributing to government revenues. Cocoa also provides the example of the depressing effect on output of

---

[20] In the spring of 1993, a litre of fuel in Nigeria cost approximately US$0.02, while in non-oil-producing countries such as Côte d'Ivoire and Ghana, who tax petroleum imports, the price could run at up to a hundred times that value. Even after the recent 10-fold increase in the Nigerian price (which might be expected to have some effect on transport flows there), the gap with the other countries in the Region remains huge.

[21] For the dynamics in Côte d'Ivoire, see Chaléard (1988), Biarnes and Colin (1987), and Colin (1990).

[22] These are the positions promoted by the World Bank, among others. A well articulated statement of the policy package is provided in World Bank, 1993, A Strategy to Develop Agriculture in Sub-Saharan Africa and a Focus for the World Bank, Agriculture and Rural Development Series No. 2, Technical Dept., Africa Region.

excessive taxation : this is the case of Ghana over the 1970s and early 1980s, where output declined from over 400,000 tonnes to under 200,000 tonnes, in response to high direct taxes on cocoa and a heavy indirect tax because of the overvaluation of the Ghanaian exchange rate (Stryker, 1991).

The issues of direct and indirect taxation of export crops should be seen in the context of the current low world market prices, which are imposing a severe constraint on the scope for producers to receive adequate remuneration from the various industrial crops. In this context, any taxation can be excessive, and the tendency has rather been toward some subsidisation of the producer price in systems which ensure guaranteed prices. The question of direct taxation is less a policy debate than one of finding alternative sources of revenue for governments whose budgets depended on this source (e.g. Ghana, for whom cocoa has remained a mainstay of the revenue base).

Devaluation is promoted in this context because of its potential to permit producers to receive higher shares of the world market price. The mechanism is potentially straightforward: at a new exchange rate, the local value of the product goes up (for a given world price), and producers will receive a higher share of the total as long as other actors in the commodity system (the various intermediaries) are not able to increase their own share. There is a policy debate on this issue both because the extent of the real impact of a devaluation is not certain until after the measure in undertaken, and because different countries in the zone operate under different monetary regimes. The anglophone countries (Nigeria, Ghana, Sierra Leone, Liberia), the lusophone and hispanophone countries (Sao Tome and Eq. Guinea) and two of the francophone countries (Zaïre, Guinea) operate under independent exchange rate regimes, while the countries of the CFA franc zone (in this Region, this includes Côte d'Ivoire, Cameroon, Gabon, Congo, Togo, Benin, CAR) have maintained a constant parity with the French franc since before Independence.

Various countries in the former group lost control of their monetary policy over the late 1970s and early 1980s, with the result of high parallel market rates of exchange. Some that have engaged in major devaluations (Ghana, Nigeria, Guinea) appear to have induced favorable effects on producer incentives. The question on the horizon concerns the potential role of devaluation in the CFA franc zone countries, which many observers consider to be overvalued. One important difference between the situation in these economies and those aforementioned is that the currency has remained convertible at relatively low inflation rates. As a consequence, there may be less scope for increasing farmers' purchasing power through this mechanism in these countries. The hesitancy of the countries of this zone to experiment with devaluation stems from the risks that it would instead generate a rapid rise in inflation, posing difficulties for overall economic management.

Growth dynamics and the organisation of agricultural production. In contrast to the savanna zone, where smallholder agriculture has always dominated, the humid forest zone has been characterised by a dichotomy in the organisation of agriculture, with a **strong role for large-scale plantations in industrial crop agriculture.** During the colonial period, plantations were the basis of commercial

agriculture in the Belgian Congo (oil palm, rubber, coffee, cocoa), and of oil palm and rubber in some other countries (Nigeria, Ghana), side by side with smallholder agriculture (cocoa). Since Independence, there have been continued investments in plantation agriculture. This has especially been so in Côte d'Ivoire (oil palm, rubber, coconut palm and fruits), but substantial investments have also taken place in Nigeria, Ghana, and Cameroon. The post-Independence period has also been marked by a growing emphasis on the smallholder sector. Large-scale plantations in cocoa and coffee have practically disappeared, and smallholder development has been encouraged in the traditional plantation crops in some areas (rubber, oil palm, dessert bananas and pineapple).

In contrast to smallholder growth in coffee and cocoa, which has been of a fairly spontaneous nature (although sometimes promoted through development projects), the development of smallholder involvement in oil palm and rubber has mainly been through closely monitored outgrower schemes, associated to the plantations. Cotton development in the francophone countries has similarly occurred under the guise of tightly run projects, responsible for farmer recruitment, input supply, and output marketing. We will henceforth refer to these projects as belonging to the "CFDT model" after the French-based textile development company[23] which has been associated with them throughout this zone.

Food production in both zones has almost exclusively been the province of the smallholder sector. The exceptions are some investments in state farms (e.g. Nigeria, Ghana in the 1970s) and some isolated cases of large-scale private agriculture (mainly in Nigeria). As we shall see further on, development projects have played an important role in some countries (notably in Nigeria) in the development of the smallholder sector, but these situations could still be considered fairly spontaneous (in the sense of low control of producer behaviour by the project authorities). The only parallel to the tightly run schemes which one finds in the industrial crops is in large-scale irrigated rice in the Sahelian zones of two countries (Nigeria and Cameroon). At some periods, the CFDT projects have also maintained some supervision of food crops produced by participants.

Given these evolutions, the current landscape contains four broad types of farm organisation:

(i) **large-scale plantations**, important in oil palm (Côte d'Ivoire, Nigeria, Ghana), coconut (Côte d'Ivoire), rubber (Liberia, Côte d'Ivoire, Cameroon, Nigeria, Ghana), and fruits destined for export (bananas in Cameroon and Côte d'Ivoire, pineapple in Côte d'Ivoire)

(ii) **smallholders operating in special schemes**, numerically most important in the CFDT cotton zone, but also present in oil palm (Côte d'Ivoire, Nigeria, Ghana), rubber (Côte d'Ivoire, Nigeria, Liberia), and fruits for export (bananas and pineapple in Côte d'Ivoire)

---

[23] Compagnie Française du Développement des Textiles

(iii) **smallholders engaged in relatively "spontaneous" commercial agriculture**, including all of the marketed food crops (staple foods and horticulture), as well as virtually the entire production cocoa, coffee, natural oil palm (especially important in Nigeria, but present throughout the humid zone), and more limited quantities of fruits for export (pineapple in Côte d'Ivoire, Ghana, Guinea)

(iv) **smallholders engaged almost exclusively in subsistence agriculture**, present throughout the Region, but especially concentrated in areas without viable market outlets (large parts of the remoter and sparsely populated areas of the Central African Republic and Zaïre, Congo, as well as areas in the savanna zones of countries such as Cameroon, Côte d'Ivoire where cotton is not present).

These distinctions are important as we consider the role of agricultural research in the development of the Region's agriculture. Overall, the degrees of both research's association with these four types of producers, and its ability to successfully transfer its messages into action, have been closely correlated with the ordering of this list.

III. THE CONTRIBUTION OF RESEARCH TO THE DEVELOPMENT OF THE REGION'S AGRICULTURE

III.1. The institutional context

The history of the Region's agricultural research has also been subject to successive dynamics. The earliest large programs were in the **export crops**, first launched in Belgian Congo (INEAC)[24] in the interwar period, from the 1940s in the anglophone countries as a group (Ghana taking the lead for cocoa, Nigeria for oil palm), and in the former French colonies. Independence led to a number of ruptures: the dissolution of INEAC (some of whose results were retained by transfers to the French system - coffee, cocoa, oil palm), and the breakup of the regional networks of the colonial period into national systems. Although a diversity of crop research programs exists in most countries in the Region, the major post-Independence research programs are in Côte d'Ivoire (all perennials, cotton and fruits), to a lesser extent Cameroon (cocoa, coffee, rubber, cotton) within the francophone zone; Nigeria (all perennials and fruits) and Ghana (cocoa) in the anglophone countries.

Some research on staple foods was undertaken in the colonial period, notably by INEAC within the francophone zone, and at regional centers within the anglophone zone (with Sierra Leone taking the lead for rice). But it has been since Independence that large programs in these areas have been built up. They function to a large extent in association with the two International Agricultural Research Centers, IITA[25] (maize, roots and tubers, plantain) and WARDA[26] (rice), both established in the post-Independence period.

Despite these advances, the scope of food crop research in the Region remains more limited than that for the industrial crops. Nigeria, in association with IITA, has the only major program for the roots and tubers, the main staples of the humid zone. Large programs in plantain, the other staple of the zone, have been launched in the late 1980s both at IITA and in Cameroon, under the auspices of CRBP[27], a research

---

[24] Institut National pour l'Etude Agronomique au Congo. An extremely thorough history of the research strategies and results from this institute's work has recently been published: Drachoussof and others, 1991, Le Développement Rural en Afrique Central, 1908 - 1960/62, Fondation Roi Baudoin, Brussels.

[25] The International Institute for Tropical Agriculture, founded in the late 1960s and headquartered in Ibadan, Nigeria.

[26] The West African Rice Development Authority, which became a member of the CGIAR system in the late 1980s after a long period as a regional association, and whose headquarters have recently moved from Liberia to Bouaké in the savanna zone of Côte d'Ivoire.

[27] Centre de Recherche sur les Bananes Plantains

center intended to have a regional vocation. Maize and rice research programs exist in a number of countries; the Region has also been able to benefit from research in other parts of the world for these crops (CIMMYT, IRRI)[28].

Research on crop associations and natural resource management is in its infancy. The vast majority of crop research is concerned with monocultures, implying a radical switch from the typical practice of intercropping in peasant agriculture in the Region. The two main centers of research on crop associations and their applicability in management of natural resources are IITA, and the Nigerian national research system.

Observers of the current problems in the national agricultural research systems (NARS) frequently note the problem of scientific isolation and lack of cross-country linkages. For obvious reasons, the absence of linkages among national systems is most marked across the language barrier, and any efforts to break down this wall will need to take special measures with respect to language skill development.

But there are also problems of linkages among countries within the same language zone. Whatever advantages there may have been in the trend to break up the regional research networks of the colonial period into national systems, one negative consequence has been to isolate the individual national systems. The situation is most pronounced among anglophone countries. In the francophone case, and particularly for the export crops, there has been the possibility to maintain more links among the national systems, owing to the maintenance of large expatriate presence through French overseas institutes (IRCT, IRCC, IRHO, IRCA, IRFA, and IRAT, former institutes now forming part of CIRAD, and ORSTOM)[29]. The progressive withdrawal of these former institutes poses questions for the continuity of such linkages across the countries in the francophone zone.

There is a need to find new ways for the NARS to hook up, through such mechanisms as networks. The principle of networks is not new, and a number of them already exist under different auspices. Indeed, some observers argue for the need to rationalise the network landscape, possibly cutting back to avoid duplication.

---

[28] Centro Internacional de Mejoramiento de Maís y Trigo, the maize and wheat institute headquartered in Mexico City, and the International Rice Research Institute, headquartered in Manila.

[29] Institut de Recherche sur le Coton et les Textiles (cotton), Institut de Recherche sur le Café et le Cacao (coffee and cocoa), Institut de Recherche sur les Huiles et les Oléagineux (oil crops), Institut de Recherche sur le Caoutchouc (natural rubber), Institut de Recherche sur les Fruits et les Agrumes (fruits and citrus), and Institut de Recherche sur l'Agronomie Tropicale (food crops), and Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM). This latter institute covers a range of disciplines, including not only agronomic sciences, but also geological and soil sciences, and geography and demography.

Without wishing to pronounce judgment on such an exercise, we would point out two areas where there seems to be too little, rather than too much, networking.

First, few networks effectively cross the language barrier. For instance, a number of crop-based networks exist in the francophone zone under the auspices of CORAF[30], an organisation linking the African NARS and the French agronomic research institutes. There is an intent to extend participation in CORAF to the anglophone countries in the Region, but this is taking time. On the other side, one must note that despite its efforts, IITA remains a predominantly anglophone organisation, a factor affecting the quality of its outreach to the non-English-speaking NARS. Regional networks coordinated by WARDA on various aspects of rice research may have the best track-record in bridging the gap, perhaps as a result of the long bilingual history of this association.

Across the language barrier, the lack of contacts can be especially important in the cases where the research strength in the Region is highly localised. For instance, the French-speaking world is largely uninformed about the dynamics of cassava improvement occurring in Nigeria. In this case, the language issue also appears to be leading to a duplication of efforts. At the same time that preliminary results are being issued from COSCA[31], a major multi-country study on cassava production and technology adoption being conducted under the auspices of IITA, the CORAF cassava network is in the process of seeking funding to embark on a major study of its own. Although more work in this area may be needed, how much better to benefit from the earlier study before launching a new exercise?

If the language barrier results in duplication of efforts among existing networks, the same cannot be said for the second area of gaps. In both the anglophone and the francophone worlds, existing networks focus almost entirely on food crop issues (specifically, staple foods and groundnuts), leaving researchers in the industrial crop institutes to fend for themselves. The one exception is the CORAF network for cotton, linking up institutes associated with the CFDT-model cotton projects.

From the scientific standpoint, it seems clear that the countries of the Region could gain from some types of collaboration on these crops--whether it involves as little as sharing information on common problems or as much as exchanging genetic material. Yet to the extent that some countries may view each other as potential or actual competitors in these commodities, collaboration may be a more sensitive issue than in the food crops largely destined for the domestic market. Such a view is unfortunate, since in most cases, the real threat of competition comes from other regions in the world: South-East Asia for the perennial crops, Latin America for fruits.

---

[30] Conférence des Responsables de la Recherche Agricole Africaine.

[31] Collaborative Study on Cassava in Africa, under the direction of a Nigerian scientist, Dr. Felix Nweke.

It is our view that the issue is at least worth exploring in the context of the SPAAR regional initiative. For some crops, it might be possible to build on the informal channels that already exist. The most obvious case in point is for the perennial oil crops, where a regional producers' organisation, ADPH,[32] already exists and has expressed an interest in pursuing common research themes. In cocoa, coffee and rubber, the Region's NARS meet each other in the context of world-wide professional organisations (ICCO, IRRDB).[33] For the time being, the interests of such organisations are too broad to be of specific help to the research needs of the Region, but it might be possible to explore some common research themes under a West African sub-group (such a one already exists for rubber, but it is not active). For other crops, such as the various horticultural products, there would be a need to start up the regional exchange process from scratch.

III.2. Overview of research strategies and results

To examine the role research has played in the development of the Region's agriculture, we need to answer a two-part question: what technical solutions has research been able to offer, and which of these results have been adopted? In this section, we explore the first part of this question, by providing a brief overview of the key research issues and the main achievements for the major crops and for systems research. A review of this length is unable to do justice to the full range of individual research themes which have been treated over the years; we would refer readers seeking more scientific details to the various sources in the bibliography.[34]

Overall, it is fair to say that the dominant orientation of research in the Region has been the selection of high-yielding varieties which respond favorably to the

---

[32] Association pour le Développement du Palmier à l'Huile, headquartered in Abidjan.

[33] International Coffee and Cocoa Organisation, and International Rubber Research and Development Board, respectively.

[34] For those seeking slightly lengthier technical overviews of the state of crop research in the Region, we would note the two summary documents prepared for the regional workshop in Abuja, both of which we have drawn on in this review: (1) for the food staples and legumes, IITA, 1992, "Food Crop Improvement and Resource Research: Major Achievements and Challenges for the Future"; and (2) for the various industrial/export crops, CIRAD, 1992, "Technical Notes : Citrus, Pineapple, Bananas and Plantains, Cocoa, Coffee, Coconut Palm, Cotton, Rubber, Oil Palm." Several additional synthesis documents covering research in this Region are Carr (1989), "Technology for Small-scale Farmers in Sub-Saharan Africa: Experiences with Food Crop Production in Five Major Zones," World Bank Technical Paper No. 10; The World Bank's West African Agricultural Research Review (1987), and Memento de l'Agronome, 4th ed. (1991), published by the French Ministry of Cooperation.

application of chemical fertilisers (and to mechanisation in the savanna zones), in monocropping situations. The primary means promulgated for containing pests and disease continues to be via chemical control, but tolerance/resistance has also been an objective of a number of breeding programs, as have, in some cases, other characteristics attractive to growers such as precocity (early-maturing varieties). While the research systems of the Region cannot rest on their laurels, there have been some impressive technical achievements for a number of the Region's crops.

If we hazard a rough hierarchisation, it would appear that the following crop programs have registered the greatest degree of success in producing results: oil and coconut palm, cotton, rubber, maize, cassava and export-quality fruits (banana and pineapple). The programs with some notable, but more limited achievements are in cocoa, robusta coffee, rice, groundnut and sorghum. The most limited progress has occurred in yam and plantain. Research on systems of production and natural resource management falls on the intermediate to low end of the scale. The various vegetable crops (local and "European" species) have been the object of little or no research in this Region.

- **Oil palm**. One species of oil palm is native to this Region (*Elaeis guineensis*), and there is a long tradition of harvesting natural palm trees, not only for oil (both palm oil and palm kernel oil), but also for wine. In the countryside, there are also a variety of uses for the fronds (as fencing and roofing materials) and the by-products of oil processing (shells are used as flooring material, and the ash is used for soap production). There is a tight time constraint in the processing of oil: once harvested, the quality of the oil in unprocessed fresh fruit bunches deteriorates quickly (rise in the fatty acid content), leaving a window of 2-3 days for processing without high losses. Although fairly hardy, the local varieties of this plant (often referred to by the name *dura*) are not very productive, typically yielding well under 1 tonne of oil.

Research efforts have been overwhelmingly focused on how to augment both the productivity of the plant and the processing stage within the framework of agro-industrial plantations producing for export or local industrial uses. These efforts began with the selection of superior strains of the local *dura* population, but already by the end of the 1930s it became evident that the best results could be obtained by crossing these varieties with another local strain (*pisifera*), resulting in the *tenera* hybrid. Successive improvements in the hybrid population have resulted in a dramatically improved yield capacity (3 to 4 tonnes of oil under plantation conditions are not unusual); the improved varieties produce more bunches, whose seeds have a higher oil content than the *dura*. The improved varieties also have a better quality of oil (lower fatty acid content).

The combined effect of these improvements, together with technological progress in the plants themselves, has been relatively high extraction rates in the industrial-scale processing plants (which regularly achieve 20 - 24 % extraction rates). This represents a substantial efficiency gain over the traditional methods of extraction for local use (most often done manually, but in some cases with small-scale partially mechanised units, which at best obtain 10-12%). But the comparison between

traditional and agro-industrial systems is not straightforward. The products are in fact quite different: although the industrial quality oils have much greater stability properties, they do less well on a "taste" scale than the artisanally processed oil, preferred in local cooking. This issue is not important for palm oil products destined for export markets or industrial uses, but we will argue that it is important in considering the future of supply of the local market in food oil.

Other main advantages of the new varieties concern labor costs of harvesting and disease tolerance. The economic life of the new breeds has been lengthened thanks to slower trunk growth, which makes it possible to easily harvest the trees for a longer period of years. There has been some success in breeding tolerance to the main disease affecting oil palm, *fusariosis*, but this work is incomplete. There are questions concerning the degree to which the tolerance achieved in one site can be maintained in other production locations (CIRAD, 1990).

- **coconut palm**. Although this plant also is found in natural state in the Region, it covers a far more limited area than oil palm, being essentially confined to coastal areas. Whereas oil palm products form a basis of the local diet throughout the humid zones of this Region, the main coconut food products (oil and milk) are not widely eaten (in contrast to some tropical areas where the plant is found, as in South-East Asia and Northeastern Brazil). Processing of the coconut can be done over a more flexible time range than oil palm fruits, but the task is exceptionally onerous if done manually, a factor which may have inhibited the spread of coconut harvesting in the Region. The coconut palm appears to does better under higher moisture levels than those which are present in this Region (demanding higher rainfall levels than oil palm).

Research orientations have followed similar lines to those in oil palm, essentially by-passing the traditional sector by aiming at high productivity of oil production in agro-industrial plantations. The results have been similarly impressive. Through a strategy of hybrid breeding, yields have been augmented substantially: hybrids can obtain roughly 2.7 tonnes/ha of coprah, versus roughly 1.5 tonnes/ha of selected local varieties (themselves improved over unselected types found in the wild). Research to build in disease resistance (to MLO, *phytophtora*, St. Paul's Wilt) is underway, but has made only limited progress to date. Drought tolerance is another element of breeding programs currently underway, which has yet to make substantial headway. One might note that the largest collection of genetic materials on coconut palm resides in this Region, at the Marc Delorme station in Côte d'Ivoire.

- **Cotton**. Cotton is a crop well-suited to the climatic conditions of the dryer parts of the sub-humid zone, since its characteristic of multiple-flowering renders it relatively robust to gaps in rainfall during this period. This is a critical point for certain other crops (esp. maize and rice), where crop losses can be high if the rains fail. The plant requires high nutrient levels (and for this reason is known to be a "soil-miner" - see Van der Pol, 1990), and is subject to a number of pests and diseases, which are able to rapidly adapt to phytosanitary treatments.

Like oil palm research, cotton research in this zone has made advances along the entire commodity chain, combining objectives of yield increases (now 2 to 3 tonnes/ha of seed cotton in station), fibre and seed quality improvement, and higher fibre extraction rates (moving from 30 to 40 percent since 1960). Although chemical plant protection remains an integral part of the "package", improved varieties are also less susceptible to a number of insects and diseases (jassides, bacteriosis).

In contrast to either oil or coconut palm, research strategies have been geared to serving the smallholder sector, through the various CFDT-model cotton projects. This orientation has been instrumental in the focus on improving cultivation techniques via animal traction (for plowing, sowing, and weeding). Techniques for chemical phytosanitary treatments have also been developed for smallholder use (Ultra Low Volume sprayers, which are light to carry and substantially reduce the water requirements for the mixtures).

Two by-products of the cotton plant which have their own market value are the meal and oil obtained from cotton seed. In regular cotton varieties, the presence of the gossypol gland renders these products unsuitable for consumption by either humans and mono-gastric animals such as poultry without special treatment. A significant amount of effort in cotton breeding in the Region has aimed to breed varieties without gossypol. "Glandless" cotton is now available in some countries (esp. Côte d'Ivoire), but it exhibits difficulties which limit its advantages in relation to the standard types: there are greater plant protection needs (the gossypol gland serves as a natural protection against some pests), and yield levels are lower.

- **Rubber**. Efforts to promote the growth of rubber, a plant of Brazilian origins, began in the early part of this century, as part of a drive by the industrialists in Europe and the United States to ensure alternative sources of supply to those in South-East Asia, which remains the world's major production zone. The links with the Asian production sources (also under colonial rule at the time) have meant that rubber research in this Region has benefitted from advances in Asia. In relation to Asia, the Western part of the Region does not suffer from any major natural disadvantages for rubber production (as long as specific production zones are well identified). In Central Africa, there is a persistent problem of leaf diseases which considerably tax yields.

Here, as with the palm plants, the focus of research has been on improving productivity in plantation settings. Primary processing of the latex is almost without exception located on site at the plantations, but it should be noted that this is less a technical necessity than in the case of oil palm. For rubber processed into crumb rather than sheets (the two intermediate forms of rubber), it is possible to let the latex coagulate and postpone the industrial processing step.

Some major achievements have been made in yield potential: while yields of roughly 350 kg/ha were considered more than satisfactory in the 1920s, clonal material now available in the Region permits 2 to 3.5 tonnes/ha in station. Basic tapping techniques have also been improved, considerably lowering labor requirements. These techniques can be combined with methods of artificially

stimulating latex production, to radically diminish labor inputs (by reducing the number of times any individual tree needs tapping). Another privileged research theme has been the maintenance of quality consistency, which has been a problem in this Region. Recent changes in the strategies of some of the major industrial users of natural rubber appear to have reduced this constraint; they have apparently adjusted their processing needs to accommodate non-homogenous qualities.

- **Maize.** This crop, of American origin, was introduced into the Region centuries ago, and has become an important secondary staple in a number of "traditional" farming systems. In the humid zones, "green" (undried) maize often serves as a relay crop. In the sub-humid areas, it is becoming an increasingly important alternative to the traditional sorghum. Manual processing of dried maize is onerous, but simple mechanical technologies (small mills) exist which easily handle the task at low cost. A greater natural constraint in the post-production stage may be post-harvest storage losses, estimated at over 10 % of the harvest in Côte d'Ivoire and Cameroon in recent studies (Fusillier, 1991; Conte and others, 1993).

Major efforts have been placed on maize research in this Region. While the orientation has been on smallholder growers, the focus has mainly been on cultivation in single-stand, a practice differing from the norm in peasant agriculture, where maize tends to be associated with a variety of other crops (particularly cassava, plantain, and different legumes). Drawing on new research as well as results obtained elsewhere, a wide range of varieties have been released, corresponding to different levels of intensification, and to different maturities.

Cultivated under optimal conditions (monoculture, with application of chemical fertilisers, with mechanised soil preparation) certain hybrids are able to obtain 5 to 10 tonnes/ha, and a number of more "rustic" improved open pollinated varieties from 3 to 4 tonnes/ha. It should be noted nonetheless that this Region does not have the high performance record in maize of some areas of Eastern and Southern Africa (Kenya, Zimbabwe). On farm conditions, even when farmed intensively, yields rarely achieve these levels in this Region, tending to peak at 2 - 3 tonnes. Average yields (based on USDA data) are estimated at under 1 tonne/ha here, and at 1.2 and 1.5 tonnes/ha in Southern and Eastern Africa, respectively (Gilbert and others, 1993).

Some of the new varieties exhibit tolerance to diseases such as the Msv virus, downy mildew, and *helminthosporiosis* (this has been achieved by crossing local strains with natural resistance to higher yielding varieties). A major plant protection problem which has met with little success, despite considerable research attention, is *striga*, a virulent parasitic plant, which is spreading rapidly throughout the Region, but especially in the areas where soils are heavily depleted. There are considerable debates on the appropriate strategies for attacking the *striga* problem, centering in particular on the possibilities to breed resistance into maize varieties (Gilbert and others, 1993). Given the association of this parasite with degraded ecological conditions, strategies which seek to improve the environment itself, rather than to provide a hardier plant, may be more promising. One such option might be through encouraging maize-legume associations in such areas (since *striga* appears to thrive

most on mono-cropped maize, and certain legumes, such as groundnuts, can block its cycle). *Striga* also affects sorghum in this Region.

- **Cassava**. Cassava, also a plant of American origin, is grown widely in both the humid and sub-humid zones of this Region, and serves a variety of functions within the production systems, depending on the varietal characteristics. Shorter-cycle varieties (12 months) are grown in a variety of associations on new fields, for both home use and marketing, whereas longer-cycle varieties (ready at 18 months, but able to be kept in the ground for much longer) are often left as a last crop on fields which are entering the fallow stage. As long as cassava is left in the ground, it is subject to few storage problems. However, once harvested, it rots within a short space of 2-3 days unless processed. Processing before eating is a requirement for the cassava varieties of the "bitter" type, which contain potentially lethal amounts of cyanide. Some type of fermentation method is used to remove the poison, and the resulting produce is then processed into one of various forms (chips, paste, meal,...) before being prepared as a local dish. "Sweet" varieties can, but do not need to, undergo the fermenting process. In the Central African countries, fermented paste-based dishes are most popular (*chickwangue*, *foufou*), in Nigeria various dishes based on a dried, roasted couscous known as *gari*, and in Côte d'Ivoire, a couscous type dish known as *attiéké*. The leaves of cassava are also highly appreciated as an ingredient in sauce dishes.

Relatively neglected if one takes account of the importance of the crop in this Region, cassava research has nevertheless made some significant progress in both yield increases and disease control. Cassava is a plant which responds well to high input use, and yields of 40 tonnes/ha in intensively farmed plantation conditions are not unreasonable in this zone. In contrast to the majority of crop research programs in the Region, however, cassava research has explicitly taken into account the likelihood that users would be operating under "sub-optimal" conditions, on poor soils, with little or no chemical input use. Several IITA varieties of the "bitter" cassava most commonly consumed in Nigeria and Central Africa generate roughly 75 percent higher yields of fresh cassava than unimproved varieties (an increase from approx. 11 to 19 tonnes/ha on average under low input conditions), are earlier maturing, and exhibit increased tolerance to cassava mosaic disease and cassava bacterial blight. Cassava has also been the beneficiary of a major biological control program against the Cassava Mealy Bug.[35]

Less progress has been made so far in increasing the yield potential of the sweeter varieties more commonly consumed to the West of Nigeria. Little work has been done on the longer-maturing varieties, and there is some debate as to whether this is a useful line of research: is it physiologically possible to develop varieties which do not become more fibrous with longer time spent in the ground?

---

[35] See Kiss and Meermann (1991), for a fascinating account of this research effort.

- **Export quality fruits**. For dessert bananas, research has produced a package of recommendations combining high-yielding varieties with fairly capital-intensive farm management techniques (with high levels of chemical inputs, as well, in most cases, as irrigation and drainage). The improved varieties are better adapted to the Region's agro-climatic conditions, although natural conditions remain more favorable in some other tropical areas (particularly Latin America, where soils are more fertile and rainfall conditions more favorable, such that recourse to irrigation is rarely necessary). Using the combined package of results, plantation-scale producers are able to obtain yields of 30 tonnes/hectare, more than double the level obtained in the 1940s. Research has also been concerned with the downstream aspects of the commodity system. In particular, an important research objective has been to improve the quality conditions under overseas maritime transport. This is done via refrigeration of immature bunches, which are artificially stimulated to ripeness with the aid of hormonal treatments.

Disease and pest problems continue to pose substantial problems for banana production. Although the new varieties are resistant to *fusariosis*, substantial chemical treatments are required against nematodes and other pests. The crop is susceptible to the deadly black sigatoka fungus (*cercosporiose noire*), which has been spreading throughout the Region by way of the plantain. Treatments against this disease are costly and not highly effective.

Pineapple research has made similar progress in raising yield potential, and in achieving quality improvements for the export market. In this case, two key downstream issues have been: (1) control of maturity, to enable producers to target particular seasonal export markets and to maintain steady fruit supply to processing units; and (2) control of size uniformity, to facilitate packaging of the fresh fruits for export and industrial processing.

- **Cocoa**. Cocoa growing in this Region began with the spread of the *amelonado* variety, first introduced in Sao Tomé. Cocoa is a smallholder crop par excellence: it is at one easy to grow (few maintenance requirements once a canopy cover is established), and can undergo the primary processing stage (hulling, fermenting and drying of the beans) on the farm, with few capital costs.

The yield improvement strategy fairly quickly began to focus on crossing this material with other varieties (all of American origin). A variety of the resulting hybrid materials have been released since the 1950s; those now available in the principal producing countries of the Region obtain 2 to 3 tonnes per ha. in station (as opposed to under 400 kg/ha obtained with unimproved material in the interwar period). In practice, there are some questions concerning the reliability of the hybrid materials in relation to these results. Lass and Bloomfield (1992) note the tendency of research to use superior trees to classify the whole hybrid population, thereby overestimating the average yield potential.

One clear advantage of the new varieties is that they mature earlier, bearing fruit after only 4 years instead of 7 with the *amelonados*. On the other hand, it

appears that the hybrid materials may die out sooner than the traditional varieties, after 20 or so years instead of up to 40 or even 50 (albeit at post-prime yield levels).

As elsewhere in the world, cocoa production in this Region has always been subject to pest control issues, which have been a primary focus of research since its inception. There have been few successes in genetic work in this area. Although the new materials may exhibit some tolerance to the cocoa swollen shoot virus disease, the mechanisms for resistance to this deadly disease have not yet been established, despite over 40 years of research, and the long-standing recommendation remains to cut down infected trees. To cope with the two other main plant protection problems, capsids (a leaf-eating insect) and the several varieties of the *phytophtora* fungus, the blanket solutions recommended are high levels of chemical control.

There are some debates concerning the appropriate cultural practices for this plant. Young cocoa plants need shade, which is usually provided by associated crops (plantain) in addition to shade trees left in fields after land clearing. Once mature, cocoa can continue to be left under shade, or it can be grown in full sunlight. The debate centers on the advantages and disadvantages of this choice. Unshaded cocoa can produce more, at least over a certain period, and suffers less from the funguses. Fertiliser use is considered an essential ingredient of such a practice. Shade is known to cut down on capsid attacks, and it may prolong the life of the tree. There is a presumption that shaded cocoa leads to less soil degradation, and therefore to fewer problems of replanting when the trees grow old, but this remains a question to be addressed by research. As we will argue, this is one of the major issues for the long-term health of cocoa-growing in this Region.

- **Robusta coffee**. This plant is suitable in many of the same areas as cocoa, but has two main disadvantages in relation to that crop: weeding remains an important maintenance activity throughout the plant cycle, as does regular pruning, and harvest requirements can be onerous. The staggered maturity of the berries makes it necessary to pass through the same fields several times in the season in order to avoid high rates of black (reject quality) beans. Primary processing to remove pulp and skins of the berries is generally done after on-farm drying, and there are both artisanal (manual or small-scale motorised machines) and industrial scale options for the husking.

Coffee research in this Region has made notable progress in varietal improvements raising yields and introducing tolerance to some diseases, but it has been less successful in addressing the labor productivity issues. Varieties now available enable yields of 2 to 3 tonnes of green coffee per ha. in station (as opposed to only 250 kg/ha in the interwar period), exhibit some tolerance to rust, and to drought conditions. For the time being, recommendations concerning labor time appear limited to the identification of a pruning technique known as capping, which makes the berries more accessible (by encouraging the coffee bushes to grow outward rather than upward).

The debates concerning "with" or "without" shade are similar for coffee as for cocoa, although evidence from some areas (e.g. Togo, see Pontié and others, 1984

and Antheaume & Pontié, 1990) suggests there may be fewer difficulties in replanting this crop on old stands.

- **Rice**. Rice growing is traditional in the Western part of the Region, which is considered the genetic home of one rice species (*O. glaberrima*). Thanks to the introduction of other varieties over the centuries, rice farmers in the Region have access to a wide genetic diversity, including the Asian *O. sativa* types. As Leplaideur (1992) has noted, a broad comparison of rice in this Region with rice-growing in Asia permits one to identify two quite different strategies: whereas water management has been the primary characteristic of Asian rice systems, management of varietal diversity to fit different environmental requirements has been the dominant characteristic of their West African counterparts. Traditional rice systems can be differentiated by the water sources they draw on, generally with little or no measures of water control: valley bottom (fed by rains and accumulated runoff water), upland (rainfed) and the lower slopes between the two (fed mainly by rain, but also benefitting from groundwater interflow from upper slopes). The only main exception is the systems fed by the brackish waters of mangrove swamps, in which water control is a necessity.

The predominant research and development effort on rice in this part of the world has concerned a type of system outside the agro-ecological zones of study: large irrigated schemes in the Sahel (including northern Nigeria and Cameroon). Of those efforts within the humid and sub-humid areas, the concentration has been on the upland systems. Research to improve the productivity of these systems has had successes in meeting the combined the objectives of higher yields and tolerance to drought (early-maturing varieties). Breeding work has achieved tolerance to blast rust, the major disease, but this characteristic is not passed down to successive generations. The outstanding constraint to yields in these systems is related to weeds, and which can cut yields in half, and for which there are no technical solutions apart from costly herbicides. The weed problem is a symptom of continuous cultivation; they are far less present when rice is introduced on newly cleared lands.

The valley bottom and lower slope areas have two advantages over the upland systems--less risk of hydric stress and lower weed infestation. Yet there has so far been relatively little attention to these systems, which are only beginning to be studies in depth. For the valley bottom, the main research effort has been varietal selection among varieties initially developed for irrigated rice systems. There has been surprisingly little work on the management of water in these and the lower slope areas, which appears to have the potential to be far lower cost than the large irrigated schemes (e.g. Leplaideur, 1992, for Guinea).

- **Vegetable crops**. Within the Region, there are two axes along which one can distinguish vegetable crop production: according to the supply zones (peri-urban versus counter-season systems located at some distance); and according to the type of species produced (local--mainly leafy--vegetables versus exotic or "European" types--especially tomatoes, onions and cabbage). The implied foreign character of these latter species should not mislead one to think they are minor among vegetables

consumed in the local diets: tomatoes and onions are in fact deficit items in a number of countries in West and Central Africa, and represent a high foreign exchange cost for some countries (e.g. Côte d'Ivoire).

In places where transport cost problems can be surmounted, the natural advantages of producing the European-type crops in certain dryer areas (where there are fewer pest problems) leads to a predominance of the savanna zone in the urban vegetable supply. The case in point is Nigeria, where observers estimate that 70% of the thriving trade in these crops in the large southern cities is produced in the valley bottom and irrigated areas in the dryer sub-humid and semi-arid areas of the North. The leafy vegetables do well in the humid zone, thereby favoring local supply sources.

There is a strong dynamism in vegetable production of both local and European types, despite the lack of major technical inputs from local research. For some of the European species (especially tomatoes and onions, but also okra) as well as local eggplant varieties, some results are available based on research in the dryer areas. But producers of these crops are also able to borrow heavily from European private sector research; seed purchase by mail is quite common. Use of inputs (pesticides and both organic and chemical fertilisers) are also common in these systems.

The majority of the local vegetables types have not been the subject of research. There is the need for very basic inventory work on genetic resources, and basic identification work on potential applied research topics in this area.

- **Yam**. Although concentrated in Nigeria, the largest producer and consumer of yam in the world, the yam eating zone of this Region stretches from western Côte d'Ivoire to Cameroon. This is a plant characterised by a great degree of natural genetic diversity, adapted to a wide range of production conditions within the Region. Yam varieties generally achieve high yields (10 to 20 tonnes/hectare), and many have excellent storage properties, in contrast to cassava. They generally have more stringent growing requirements than cassava, as concerns both soil quality (high potassium levels are needed, favoring recently cleared lands) and cultivation techniques (high labor inputs in soil preparation work, to build mounds, and frequently the need to provide stalking material). Yam growing also has high costs in terms of planting material. Using traditional methods, up to one-third of the harvest must be retained to use as seed-yams.

Yam has been relatively neglected by agricultural research, and to date results raising productivity have been far more limited than for cassava, the other major root crop. In effect, there are a number of technical obstacles to breeding work (among which, "shy flowering," which slows down cross-fertilisation work), and research has yet to develop improved varieties. The major technical achievement has been a more economic method of seed-yam multiplication, known as the "mini-sett" technique. Under this system, much smaller pieces of seed-yam (the "mini" setts) can be used as planting material, enabling substantial reductions in the amount of the crop which

must be retained. Despite initial hopes, there seem to be doubts concerning the widespread receptivity of farmers to the technique (Onweme, 1989): although mini-setts permit an equivalent yield for a smaller amount of planting material, the individual yams it produces are smaller, and less desirable.

Another avenue of innovation has been through varietal screening and introduction from other producing areas in the world (which is found in the Americas as well as in the Pacific).

- **Plantain**. Itself a major staple in the humid zone, plantain plays a key role in crop associations in the humid areas, both as a shade crop in perennial nurseries and as a companion to various food crops, and in some cases adult perennials. As noted, research on this plant has only begun quite recently in this Region. Although plantain shares many characteristics (and susceptibilities) with dessert bananas, the impressive set of research results for those species are not directly transferrable. A major difference in research orientation is necessitated by the fact that smallholder producers of this crop, which is largely destined for subsistence purposes, will not be able to use the degree of chemical inputs which form part of the high-productivity banana packages. Given the local range of the markets for plantain, there is also less need (if any) to refine the conditioning aspects for sale in overseas markets. By contrast, building in genetic resistance to pests is an important issue. The major focus of the breeding work so far has been precisely in this area, and there appear to be promising results in a variety exhibiting resistance to the black sigatoka fungus, now at the testing stage.

- **Systems of production, natural resource management.** Systems research aimed at understanding farmers' behavior has made important contributions in this Region, as elsewhere in Africa. Already since the 1960s, researchers in both anglophone and francophone areas began to better diagnose the reasons for farmers' divergence from recommended practices such as mono-cropping (such as risk management and cutting down on weeding time). Although it has not always been met without resistance, some of this diagnostic work has been able to feed into more upstream research, such as breeding objectives for early-maturing varieties and other "hardy" characteristics (see, e.g. Gilbert and others, 1993, on the influence of systems research on maize breeding in Nigeria).

While this type of systems work is based on diagnosis of farm situations already in existence, there is another whole field of systems research concerned with creating or designing new combinations of crops. This field of research is especially important for soil fertility management, given the low chemical input use by poor smallholders, and the need to complement inorganic fertilizers with organic materials to maintain fertility, even in high input situations. At present, the portfolio of research results concerning crop associations is extremely limited. Probably the best-known type of system proposed by research is IITA's alley cropping technique, designed to associate annual food crops with nitrogen-fixing trees. In savanna areas, some progress has been made in knowledge on introduction of leguminous plants such

as groundnuts into cereals cultivation, as well as on associations of crops with animal raising.

III.3 The record on adoption.

It is more difficult to answer the second part of the question concerning the impact of research. In effect, there has been relatively little work done to examine the adoption of results, and the research system itself is not well aware of the extent to which its results are put to use. Drawing on those studies which do exist, often associated with development projects, it is nevertheless possible to make some overall assessments. One cannot avoid the conclusion that the record on adoption has been far more mixed than the record on research results.

These results are typically proposed to farmers as a package (new varieties to be used following improved practices including chemical fertilisers and pesticides, in single stand, with particular spacing and timing practices). Yet the only systematic cases of across-the-board adoption of packages are found in the large-scale plantations. In smallholder agriculture, the cases of intensification based on a package are few. They are limited mainly to :

(1) **projects for outgrowers of large plantations:** rubber, oil palm in Côte d'Ivoire, Ghana, Nigeria. Smallholders rarely attain the yield levels of the plantations under these schemes (rubber in Côte d'Ivoire seems to be the exception, see Hirsch, 1990b)

(2) **major crop development programmes:** cotton in many of the French-speaking countries following the CFDT model, food crops in some of these same projects, and cassava and maize in the Nigerian Agricultural Development Projects.

Through the cotton projects, average yields in a number of countries (Cameroon, Côte d'Ivoire, Benin, Togo, as well as Mali and Burkina Faso in similar agro-ecological areas) have more than doubled, to 1000 or more kg/ha of seed cotton. There has been widespread adoption of animal traction. Although soil fertility declines lead to the need for periodic fallowing, the production systems have become more sedentarised, in stark contrast to the low-input itinerant cotton-growing practiced in the 1960s. There is an unusually good set of information on adoption in these projects, thanks to their monitoring units and through frequent evaluation missions.

Especially over the past decade, the cotton projects have been successful in encouraging the intensive cultivation of improved maize and sorghum varieties as rotation crops. These crops also benefit from the animal traction techniques.

Information collected by the COSCA study (see the reports by Nweke and others) shows that in Nigeria, by the early 1990s, 90 percent of sample villages surveyed in the cassava growing areas had some farmers growing the improved varieties; adoption occurred on a large scale (more than half of farmers) in 60 percent of the villages. Although one of the breeding objectives was to produce a high yield

response with limited chemical inputs, farmers closely linked to the market also use fertilisers.

Information collected by IITA and for a study of maize impact sponsored by USAID (Brader, 1991; Gilbert and others, 1993) shows a widespread introduction of maize into the northern Guinea savanna of Nigeria. Whereas no farmers in the survey were using improved varieties in 1970, by 1989, all farmers reported adoption (mainly the early-maturing open pollinated varieties, which are tolerant to drought conditions). These same varieties have also been extremely popular in the more humid zones, where they have permitted double cropping, and where they are appreciated because of resistance to lowland rust and blight, two problems in the moister areas. In the savanna areas, the spread of maize has been accompanied by the spread of animal traction. Fertiliser use on maize is widespread in the savanna areas, while it is less important in the humid zone areas.

In smallholder agriculture, there are many more cases of very partial adoption of technical recommendations. The category of research results most interesting to farmers appears to be the **improved genetic material.** This should not be surprising, if one bears in mind the history of spontaneous experimentation with crops in this Region. With the exception of sorghum yam and oil palm, all the major crops in the Region have been introduced over the last few centuries, and farmers have constantly been on the look-out for varieties with interesting properties, which they have exchanged among themselves.

There is evidence of adoption of composite maize, improved rice varieties, cocoa and coffee hybrids, and yam (a Puerto Rican variety, *florido*, brought to Côte d'Ivoire by the research system). In general, such adoption occurs under extensive cultural practices, whereby far lower yields are obtained than under the "package" (250-450 kg./ha. for coffee and cocoa are typical levels in this Region, as against the 2-3 tonnes/ha. on station). In both cocoa and coffee, the adoption rates of pure hybrids is not overwhelmingly high (estimated at roughly 10 per cent in Côte d'Ivoire), but there is also a large population of hybrid descendants, which farmers appear to have preferred in many cases to the traditional varieties.

Improved oil palm varieties appear to be in high demand by small farmers outside of the special outgrower schemes, but their diffusion has largely been limited to the project areas. Rubber varieties also appear to have qualities which would be attractive to small farmers outside of schemes, but their diffusion has similarly been limited so far to the projects.

When used by smallholders, fertilisers are almost universally limited to annual crops, including both some staples and certain vegetables. Farmers recognise the yield-augmenting effect of fertiliser on annuals, and apply it when it is available and affordable, particularly on maize. The effect of fertilisers on perennials is either too long term or not apparent. Even in closely monitored projects, such as the oil palm outgrower schemes, farmers divert fertilisers intended for the perennials

to food crops.[36] The single major exception is coffee in the Moungo Valley of Western Cameroun, where farmers spontaneously developed an intensive cultivation system including chemical fertiliser use, bringing yields from an average under extensive conditions of 300 - 400 kg/ha to 900 kg/ha.

The reluctance of smallholders to apply fertiliser to perennials rejoins a debate concerning the reliability of the research recommendations on this theme. There appear to be unresolved issues concerning the types and levels of nutrient additions needed to achieve high performance with the improved varieties of these plants (see, e.g. CIRAD, 1990 on oil palm).

The only case where there is extensive **chemical pest control** undertaken by farmer initiative is in cotton in the CFDT zone. In cocoa, farmers have practiced spraying against capsids and *phytophtora* on a much less intensive scale than recommended by research, except in certain zones where the spraying has been done by extension services (Ghana and the Central-South of Cameroon for many years). Treatments against scolytes in the intensive coffee system in the Moungo area have also been the responsibility of the plant protection service. In the food crops, there is little evidence of adoption of chemical pest control techniques, except on occasion for storage (maize, groundnuts); chemical treatments of seeds (to protect them from attacks after planting) is also a popular practice for groundnuts and for the coarse grains.

Evidence of **adoption of specific cultural practices recommended by research is extremely scant**. When they are not obliged to do so by special project authorities, farmers pass to mono-cropped systems only under special circumstances: for food crops when purely destined for the market and farmed intensively (some maize and cassava in Nigeria), and for certain perennials (coffee, cocoa, but not oil palm) once sufficient growth has occurred to block light for food crops.

Farmers are often not convinced of recommendations on spacing. Most commonly spacing exceeds research recommendations, although the reverse can also occur, such as cocoa in Ghana (where farmers plant in densities 5-6 times those recommended, to compensate for losses among seedlings and cut down on weeding).

Weeding recommendations rarely attain the levels recommended by research. Farmers recognize the importance of weeding for yield levels; they are limited by labor constraints. This is one of the key attractions of crop associations, which tend to cut down on weeds.

For some crops, the same holds true for harvesting and post-harvest handling. In practice, coffee farmers rarely make more than one passage per field during the harvest season, despite the much higher loss rates. Although labor constraints make it unlikely that farmers would reach recommended levels under any circumstances, the

---

[36] The experience of GOPDC in Ghana is a case in point.

practice of purchasing coffee without quality grades has probably aggravated this practice in countries like Côte d'Ivoire.

Recommendations of research on replanting techniques for coffee and cocoa, demonstrated to be technically efficient on research plots, have generally not been adopted by farmers in the Region, who prefer to let the trees live long past their prime, harvesting a fraction of the peak yields.

III.4. Conditions for the successful adoption of improved technology in the Region by smallholder farmers

There is little mystery in the successful adoption of research results in the case of plantation agriculture; these systems have not been subject to capital constraints for machinery, inputs and labor, and have typically operated under very close links with the research establishment, often receiving management advice from research institutes. It should be noted that high technical efficiency is not necessarily synonymous with economic efficiency in this production mode, however. Often those plantations which operate at high technical efficiency (not uniformly the case, depending on the management quality and the agro-ecological appropriateness of the location) tend to have problems of high production costs in relation to producers outside the Region--a problem competitivity to which we return.

For the future of agriculture in the Region, the more perplexing issue is to identify the conditions for successful adoption in peasant agriculture, and to see to what extent those conditions are reproducible elsewhere.

We begin this inquiry by recalling the general set of constraints to technology adoption in smallholder agriculture in comparison with plantation agriculture. Smallholder farmers face conditions (shortages of manpower and capital, aversion to risk, combined in many cases with a lack of land pressure) which make the adoption of complete technical packages less attractive, if not impossible. Yet the experience of intensification in cotton, maize and cassava shows that these constraints are not insurmountable.

A precondition for successful smallholder intensification is attractive and secure market access. This precondition appears even stronger than for growth of output without intensification, since intensification requires greater risk-taking in cash outlays. The marketing channels need not be official (in the CFDT cotton network they are; in food crop marketing in Nigeria and in urban vegetable marketing more generally, they are not); but they need to be reliable.

For food crops, urban demand may be too limited to constitute a reliable market for intensive production. Intensive maize production in the cotton schemes in Côte d'Ivoire, Mali dropped off dramatically once guaranteed official purchasing was stopped; in effect, the urban demand for the product was limited. The problems encountered with intensive maize production in Ghana under the Global 2000 scheme

reflect the similar phenomenon. Once maize prices plummeted with the rise in output, it became impossible for farmers to repay their seasonal credit.

Secure market access may require access to processing facilities. This is clear in the case of cotton, for which industrial processing facilities have been constructed in tandem with the expansion of output. As the COSCA study has shown, availability in a village of small-scale mechanised facilities for processing *gari*--an intermediate form of cassava which has a long shelf-life and is in high demand by urban consumers--has been a key factor in the expansion of intensive cassava production with the improved varieties in Nigeria.

Intensification also requires favorable conditions "upstream". The cases of successful intensification have in common: chemical input availability at affordable terms (input credit and/or subsidies in the cotton schemes, in Nigerian maize and cassava cases, and in coffee in Moungo), and official drive to distribute improved planting material in all the cases involving annual crops.

This same set of preconditions, both upstream and downstream, are found to the extreme in the case of outgrowers associated with plantations.

The cases where there has been widespread adoption are marked by a close link between the research system and the producers, parallel to the conditions of research linked to the large-scale plantations. Cotton research in the CFDT zone has been highly integrated into the development programs, providing new material and updating recommendations for extension services at frequent intervals. The cassava success story in Nigeria results from close interaction between international and national research and the various development projects responsible for diffusion of genetic material and the provision of extension advice (including extensive conduct of on-farm demonstrations). The same could also be said for maize in Nigeria, though with less pressing technical constraints to getting the genetic material out to farmers, since multiplication rates are more rapid.

Too often, research has failed to make the transition from identifying a technical optimum to calculating the profitability of the packages being recommended. In cases where intensification has failed to take hold, despite the presence of a support infrastructure upstream and favorable marketing conditions (e.g. cocoa throughout the Region, coffee outside of Moungo Valley area), the reason may lie in lack of profitability of the package being recommended. Are fertiliser applications profitable on perennials ? What are the cost:benefit ratios for treatments with pesticides and fungicides ?

IV. KEY ECONOMIC AND TECHNICAL CHALLENGES FACING THE REGION'S AGRICULTURE IN THE YEARS AHEAD

The identification of regional research priorities needs to take into account not only the past record of successes and failures in the development and transfer of technology, but also the key challenges of an economic and technical nature which will face the Region in the years ahead. We identify two issues of short to medium term urgency, and a third of medium to longer term concern.

(1) **Competitivity of the Region's export and food crops.** Especially in their export markets, producers in the Region face major challenges from competing sources of supply, and a situation of low world market prices which threatens the viability of these activities as sources of income and foreign exchange. In real terms, world market prices for virtually every major agricultural export from the Region are at their lowest levels in the post-war period. (See the price graphs in the statistical appendix). Ironically, the exception is tropical timber, which countries are being asked to avoid exploiting for environmental reasons. Price projections, while uncertain, suggest that the Region should not count on any major turnaround in these markets over the next 5 to 10 years. The Region's food crops similarly face strong competition from low-cost international sources of rice, and to a more limited extent wheat, meat and dairy products. To meet this competition, efforts will need to be undertaken at the stages of production, processing, and the organisation of the commodity systems subsectors in order to lower costs and/or raise quality. In many cases, this exercise will need to begin by conducting in-depth analyses of the domestic cost structure to identify weak points within the sub-sectors.

(2) **The changing institutional context within the agricultural sector.** In the context of structural adjustment reforms underway in the Region since the mid and especially the late 1980s, the agricultural sector has been undergoing major institutional changes, characterised in most cases by a retreat of the parastatal input supply and marketing organisations, by the disappearance of agricultural credit, and by a withdrawal of subsidies on chemical inputs. Oftentimes these parastatal organisations had high fixed costs, and had difficulty reducing their operating margins. Nevertheless, the result of their withdrawal has been, at least temporarily, an institutional void, as private sector operators have been unable or unwilling to replace all of their functions. In many cases, the responsibilities for various activities (input supply, marketing,...) are falling on relatively unorganised farmers' groups, which have little experience in dealing with these problems, and no financial cushion to withstand the management risks they impose (the tendency in the cotton zone, for example, see Mercoiret and Berthomé, 1993).

The institutional void is most marked in the areas of credit and input supply. Under unsubsidised conditions, demand for inputs has dropped dramatically (e.g. to one-third its previous level in Ghana), and few private sector dealers are willing to bear the risk of dealing in this area. The only exception to the general drop in the use of inputs seems to be in Nigeria, which has maintained its subsidy program.

The combined result of these institutional changes, the fall in world market output prices and the removal of subsidies has been to jeopardise the conditions for agricultural intensification. Intensive coffee growing in Cameroon has been abandoned, leading to a halving of output since 1990. There has been a 20 percent decline in cotton yields in the CFDT zone, despite the fact that the governments have maintained subsidies on the output price since the last big decline in the world price in 1991.

The contours of a new institutional landscape are as yet uncertain. Under a policy of market pricing of inputs and outputs, there is little that governments can do to shield producers from the sometimes rapid shifts in profitability of input use. If governments are no longer to assure markets for output, however, one response which can help insulate producers from excessive risk would be to search for techniques/technologies which are more robust in a less certain institutional environment.

This is an issue which particularly concerns the choice of processing technologies, themselves critical to the nature of the marketing system. Within the Region, the investment choices have typically favored large-scale industrial techniques, rather than artisanal methods (coffee, rice, oil palm, cassava,....). This presents a marked contrast with the developments in South-East Asian agricultural sectors, which have left much more room for artisanal techniques. The principle of seeking more robust techniques under institutional uncertainty implies moving toward processing systems which permit multiple locations for processing (closer to the various production sites), less dependent on high imported content for their operations, and therefore smaller scale than the installations often chosen in the past.

Moving toward such systems will often be needed from the competitivity perspective as well, whether for cost-cutting or for raising quality. Artisanal units, although achieving lower technical efficiency (as measured by extraction or loss rates), can often be run at substantially lower operating costs under local management conditions. As Bricas and his colleagues have argued (1992), consumers frequently exhibit a quality preference for artisanally processed food products (true not only for palm oil, but also for cassava, yam, and even cereals to the extent that this ensures greater freshness). In many cases, there may be room for increasing the technical efficiency of artisanal processing methods, which in general have received very little attention by the research system. Such research hardly needs to start from scratch. A first step in such research should be to see what techniques can be borrowed (perhaps with modifications) from Latin America and Asia. There may also be scope for simple modifications of existing techniques employed in the Region.

(3) The third issue of medium to long term urgency is to find **technical solutions to deal with impending situations of land pressure in the countryside.** Soil fertility is a major agro-ecological constraint in the Region, and in areas of high population density, farmers will need alternatives to their earlier practices of planting on virgin land when existing soils are exhausted. Research on these issues is still at a very early stage. In the humid zone, it is clear that solutions will need to be found

in some forms of agro-forestry, i.e. of associating tree crops with annual agriculture.

In light of these three challenges, here are some of the issues at stake for the development of the Region's major crops :

Oil palm is one of the crops in which the Region has clearly lost a natural advantage: over the past 20 years, South East Asian countries have been able to capitalise on their yield advantage, and have rapidly displaced West Africa as the major world market supplier. These developments are largely responsible for the fall in the world market price, which should be considered a structural feature of this market rather than a temporary phenomenon (unit production costs of ivoirian palm oil, whose plantations are highly efficient by regional standards, run at nearly double the world market price).

The future of this crop in the Region will depend on its ability to make a successful transition to supplying the domestic market at a competitive price with imports. Such a task will be easier for countries whose production is already primarily consumed locally than for the Côte d'Ivoire, the bulk of whose production is geared for the export market. The issue should not just be one of relying on high import barriers to keep out the lower priced products (this is a key element of the Nigerian strategy for protecting its local palm industry)--such a strategy is costly to the poor consumers who buy the product.

Rather, it will be important to reexamine the strategies for development between the plantation sector (which has higher technical achievements, but higher imported content and fixed costs as well), and the smallholder sector which has largely been left outside of the scope of development efforts (not the outgrowers associated with plantations, whose costs per unit tend to be quite high).[37] There would appear to be substantial scope for low-cost supply of the local market using improved material under smallholder conditions, provided small-scale mechanised processing units were available. There already appears to be a strong consumer demand for artisanally processed oil, and it should be possible to deal with issues of stability through simple improvements in techniques. Research at NIFOR, the Nigerian oil palm research institute, has some interesting applications in this direction.

Robusta coffee, produced by many countries in the Region, has been facing a generalised crisis situation in world markets over the past several years, under which no producing countries have been able to cover all costs. The position of robusta has deteriorated in relation to arabica varieties, whose price advantage has widened during the crisis. African producers appear in a worse position compared with South East

---

[37] Although little serious work has been done to compare these sectors, World Bank estimates of domestic cost ratios found the small-scale sector to have a high degree of comparative advantage (low costs in relation to the value of the output), and the agro-industrial plantations to have a comparative disadvantage (World Bank, 1989).

Asian competitors because of much higher intermediation costs (including transportation, processing and marketing costs). In the absence of a substantial reduction in these costs (here too, African producers have been less successful in this task than their Asian counterparts since the drop in prices in 1986), the future of this crop in the Region will depend on the continuance of the recent modest rise in the world price.

Cotton similarly is facing an acute crisis on world markets, and all the world's major producers are heavily subsidised (e.g. U.S. growers receive 50 percent over the world price, Uzbekistan is selling at a large discount in order to earn scarce foreign exchange). In contrast to the situation in coffee, producers in this Region have undertaken deliberate and successful cost-cutting measures both at the production and intermediation stages since the mid-1980s; in most cases, there is little additional room for manoeuvre, and the future of the crop will depend on a rise in the international price.

For **cocoa,** this Region is the largest producing area, and in contrast to oil palm, it appears to be well-placed in terms of costs of production and quality in relation to other major production zones. There are two big uncertainties for the Region's ability to maintain this position in the future. In the medium term, the issue is the degree to which the spread of the virulent fungus strain, *phytophtora megakarya* can be contained, and to which it can be controlled in infested areas at reasonable cost. This fungus, widely present in Cameroon and Nigeria, but with recent sitings in the West (Togo and Ghana), extracts yield loss rates of 80 to 90 % if left untreated. Under Cameroonian conditions, the multiple treatments needed are only cost-effective on relatively high-yielding plots (Petithuguenin, 1993).

The longer term issue concerns the conditions for replanting as the existing cocoa farms age; the dynamics of growth in this crop have been based on planting on virgin forest, a source of fertile land which is rapidly running out, and there appear to be constraints to replanting on old stands - at the least higher investment costs, at the worst substantially lower yield conditions. Research is needed to clarify the extent to which technical constraints are the main barrier, as distinct from socio-economic factors such as the age of planters, many of whose children (schooled on cocoa proceeds) are unwilling to take over the farms.

Rubber production in the Region does not appear to suffer from natural disadvantages, either, in relation to South East Asia, although there are higher management costs under local conditions. The Region is a marginal supplier (6 percent of world supply), a factor which leads to some marketing handicaps. New market opportunities seem to be opening up for the wood from the rubber tree, which is beginning to be used in mass-produced furniture.

This crop has some favorable properties with respect to soil fertility which suggest that it might be usefully explored as a diversification crop in smallholder (not outgrower) agro-forestry systems. Such a development would presuppose the existence of industrial capacity to process crumb, and a purchasing network for rubber balls (primary processing done by farmers); under such a system, there is no need for

smallholders to be located right near the factory as is the case in the plantation-outgrower schemes. Such a decentralised system already exists in Nigeria in the Benin City area.

- Since **coconut palm** faces even more acute international competition from Asian producers than does oil palm, its potential as an export crop appears extremely weak. Unlike oil palm, whose products are in high demand in the Region, there seem to be few reasons to expect a rapid growth in this crop in local diets. However, from the perspective of crop associations, the coconut palm has interesting properties which may merit exploring. Coconut is, for example, a beneficial shade crop for cocoa in Malaysia. Its successful integration into agro-forestry systems in this Region would depend not only on the biological factors, but also on the ability of this plant to find its niche in the local consumption habits.

Cassava is already a staple food in much of the humid zone of the Region, and has been spreading to the Nigerian savanna in the form of gari. The key issues for the further expansion of this crop on a commercial basis concern the ability to spread the conditions for the Nigerian success to other countries. One part of the equation concerns the improved varieties: will farmers (and consumers) accept the bitter Nigerian varieties, or will it be necessary to make further advances in the "sweet" cassavas for adoption in countries where these are preferred ? A second part concerns the availability of mechanical processing to increase storage capability, reduce transport costs, and enhance the convenience for consumers. In the Nigerian south, processed products such as *gari* have been estimated to have high income elasticity even among wealthier urban dwellers (Nweke, 1988).

The questions on the horizon for **yam** concern its ability to defend its position as a basic food item in the western part of the Region, given its relatively high production costs as compared with other staples for equivalent caloric value. In its favor is the fact that it is given some margin by consumer preferences: Certain of the most popular types (white varieties) are considered "preferred staples", for which consumers are willing to pay a higher price than substitutes like cassava and coarse grains. However, if means to lower production costs are not found, yam risks to maintain its preferred position by becoming a luxury item, purchased for special rather than everyday occasions. In Nigeria, relative price movements between yam and some of the other staples are suggestive of this phenomenon. At the same time, the market pull of yam has been pushing commercial production further and further north into the sub-humid zone.

Maize is often considered to have great potential as an answer to the Region's food needs, in large part because of high technical potential with available improved varieties. Yet an important constraint to its expansion as a commercial crop will be market size. There appear to be important differences within the Region concerning the acceptability of maize as a staple food in areas with large population concentrations.

The traditional maize-eating areas of the coast are those in the non-forest zone: Benin, Togo, and the Accra region of Ghana. Maize has also shown its ability to spread as a staple food throughout the savanna areas of Nigeria where diets were traditionally based on sorghums and millets.

Maize has had much more limited success so far in breaking into the cities in traditional rice and root and tuber-eating areas (Abidjan, the cities of the Nigerian south, and most of the other coastal cities in the humid zone). In these areas, the consumption of maize is mainly limited to agro-industrial uses (a small market for animal feed and in some cases as an input at breweries) and to green maize when in season. An exception seems to be Cameroon, where there is a stronger maize-eating tradition in the more humid areas thanks to its long-standing insertion in the traditional intensive agricultural systems in the Moungo area. In general, the humid zone consumers will need to be convinced to switch over to maize, and that will only happen if the relative price drops considerably: that is, maize will need to become more productive (lower cost) than it currently is in relation to the other staples.

Rice faces serious problems of competition from lower priced imports, despite its long-standing role in the traditional farming systems in the West of the Region. Many of the traditional rice-growing areas are subsistence-based, while the towns are mainly supplied by imports. Although it seems unlikely that the upland rice systems can be competitive with imports, given the high toll of weeds under current technologies, there is insufficient knowledge about the better-watered types of traditional systems to establish whether output can be expanded to serve the market at low production costs. In addition, in some cases (Côte d'Ivoire in particular), the organisation of processing in large-scale industrial complexes has dramatically increased costs over what they would be with artisanal hulling machines.

Plantain, a staple in the humid zone, also suffers from a lack of knowledge about production systems. In addition, the demand aspects of this crop (including the marketing flows) are poorly understood. Agronomic research on plantain (as distinct from dessert bananas) has begun only recently in this Region, and it would be beneficial if a region-wide study on demand and supply issues were undertaken, along the lines of the COSCA study for cassava. Although it is difficult to place great confidence in the aggregate statistics, it is interesting to note the apparent correlation with the lack of research results on this crop: plantain is the only crop which registers a per capita decline over the past decade on the Regional level.

Commercial fruit crops such as banana, mango and pineapple are often signalled as a potential channel for export diversification, since their external market conditions appear less unfavorable. Within the Region, the only large-scale producers of these crops for export are Côte d'Ivoire (all three fruits) and Cameroun (banana); other countries (Guinée, Ghana) promoting this strategy have smaller sectors (under 10,000 tonnes), currently limited to air transport. While there may be potential in this direction, it is important to note the considerable challenges for successfully commercialising these highly perishable products - especially when passing to large-scale production which can be handled by boat and therefore sold at lower cost. Nor can all countries can expand to fit the same niche (for instance, the market for air-

shipped pineapples in Europe is mainly confined to the Christmas holiday season; bananas fetch a high price only in the context of current protection accorded by the EEC, a situation which may change). It is therefore unlikely that such diversification crops can be seen as a replacement for export earnings on some of the more traditional primary commodity exports, at least into the foreseeable future.

V. THE SPECIFIC CHALLENGES FOR AGRICULTURAL RESEARCH

Looking ahead, we identify four specific challenges for agricultural research, of which three thematic and one organisational:

(1) Research on the profitability of technical messages. This approach needs to be systematically integrated into the applied research process.

- To start with, there needs to be a systematic effort to understand the cost:benefit relationship of existing research recommendations on elements of the "package", particular on fertiliser and pesticide use.

- This can help to guide research on the next stage, of finding ways to cut down on the purchased input and labor costs of the recommendations. Progress in this area has already been made in the CFDT cotton zone, and has begun in coffee for both treatments and harvesting techniques. It is in this spirit that IITA noted the need to find ways to halve the nitrogen fertiliser needs of maize (IITA, 1992). This needs to become a generalised approach.

- A medium to long term goal of such a focus is to be able to provide more nuanced recommendations to farmers, depending on the specific conditions at hand (effects of annual rainfall variation on planting and fertiliser recommendations; variations within a country on the amount needed of phytosanitary treatments, ...)

This approach will imply a revolution in the type of messages given by extension services, which currently tend to be uniform and insensitive to changing profitability conditions. The difficulties experienced by cotton extension in Côte d'Ivoire with "decision matrices" are instructive in this respect.[38]

Although cotton research is unusual for its relatively high degree of specificity of recommendations by production region, recommendations within an area were standardised for all producers. In an effort to cut down on input waste, the outreach services attempted to provide extension agents with a means for tailoring input use recommendations to the requirements of individual farmers within an area, according to their time of planting.[39] The extension agents were provided with "decision matrices" to help them calculate the individual fertiliser needs. In the event, there proved to be extreme farmer resistance to this innovation, and the experience has been written off as a failure. Responsibility lies at least partly in a problem of communication: the matrix was widely interpreted as a tool to sanction for farmers who planted late. This highlights the need for carefully conceiving the messages to be conveyed, and for a close working relationship and understanding between research and extension.

---

[38] Information provided by Patrick Bisson, CIRAD-CA.

[39] Late planting reduces the effectiveness of the "optimal" doses of fertilisers based on timely planting schedules.

(2) Research which takes into account the constraints in peasant farming systems: labor constraints, capital shortages, and risk aversion. To more effectively serve its smallholder clients, research needs to continue its move away from a "productivist" approach concerned with raising yields under high input conditions, to an approach concerned with raising yields under constraints likely to be faced by farmers. Through interdisciplinary work, including breeding, agronomy, and plant protection, there is a need to tackle objectives of:

- **resistance to diseases and pests through genetic work and integrated pest management.** There is no doubt unexploited potential for using local plants as part of an IPM strategy. For instance, the *neem* tree has applications as an insecticide which can be sprayed on fields.

- **other plant characteristics which increase the "rusticity" of the crop under farmer conditions** such as drought tolerance, lower sensitivity to following a strict cultural schedule for various agricultural tasks (planting, weeding, harvesting). There may be particular need for attention to these concerns in the industrial crops which have had impressive breeding programs, but which have traditionally been large-scale plantation oriented.

- **plant characteristics which reduce labor requirements and/or investment costs.** Some successful examples are early-maturing cassava, cocoa, and oil palm varieties; slower growing oil palm trunks which cut down on harvesting costs; improved rubber tapping techniques; and the introduction of animal traction in the savanna zones through the cotton projects. By contrast, there has been too little work on reducing labor inputs into coffee harvesting. This may be as simple as introducing less onerous gathering techniques. For instance, belted harvesting baskets which can be worn at waist level are widely used in Latin America, but have not been introduced to this Region, where farmers continue to bend to the ground to fill their baskets.

Solutions which cut down on weeding needs are required for many crops. It may not be a coincidence that some of the crops which have done best in this Region are those which are able to resist weeds naturally through canopy cover (mature cocoa, rubber, oil palm, cassava).

- To determine the most important objectives in each crop, there will be a need to combine analysis of the important constraints to be tackled and the scientific possibilities to do so.

- In many cases tradeoffs will exist between the choice to focus on characteristics for market-oriented or subsistence-oriented farmers. Given the strong links between innovation and the market, and the high diversity of the needs in subsistence-oriented systems (IITA's "population-driven" systems, see Smith and Weber, forthcoming), there is probably more to be gained by focusing efforts on the characteristics enhancing conditions of crops destined for the market.

(3) Research to tackle problems related to sustainability of the agricultural systems. The search for modes of intensification which are not highly

capital intensive (and therefore affordable by the Region's farmers) is mainly a challenge for agronomic research involving crop associations, and, where possible, the association of livestock with crop systems.

In the humid zone, there will be a clear need to develop recommendations on viable ways to restore fertility through organic-inorganic fertiliser combinations, most particularly through crop associations incorporating perennials, given the crucial role of trees in preventing soil erosion and nutrient depletion in this Region (Nair, 1990). At present, the state of knowledge on fertility issues is both incomplete and disparate.

An important first step in pushing forward the frontiers of knowledge on fertility issues could be to pull together the research results touching various aspects of the problem into a "state of the art" review, as has been done for the savanna zones (Piéri, 1989). Such a study could help identify the data gaps that need to be filled in order to provide farmers with viable advice.

Two lines of past research would warrant particular attention in such a review. The first is **agronomic work on fertilisation** of perennial crops. In some cases (rubber, oil palm) opinions on the effects of fertilisation diverge. In others (coffee, cocoa) farmers' practices contradict the recommendations of research. Such an exercise could draw on long-term data from research stations and large-scale plantations to identify the technical issues at stake, and compare this information with that issuing from monitoring and evaluation work on the reasons underlying smallholder practices.

The second area is the **role of intercropping on soil fertility maintenance.** To date, the major system promoted for associations of annuals and perennials, IITA's alley cropping, has hardly been adopted after a decade of on-farm testing. This may be because farmers in the Region are not yet under sufficient land pressure, given the high labor costs of adopting the alley farming system. But perhaps successful adoption will require the consideration of associations with a wider range of trees, which themselves have an economic value (CGIAR-TAC, 1990).

The preoccupation with introducing leguminous trees into the system may have precluded the consideration of integrating some perennials with economic value (rubber, oil palm, rubber, various local trees with medicinal and food values). Although non-leguminous, these other trees can have value in certain aspects of soil fertility retention (at the least in preventing leaching). Although this area has not received adequate attention, there have been some studies of intercropping of food and perennial crops at the beginning of the growth cycle (e.g. Leduc in the South of Côte d'Ivoire), of introducing oil palms into alley-cropping systems (IITA in association with NIFOR), of intercropping oil palm or coconut and cocoa (NIFOR and CRIN in Nigeria; CRIG in Ghana).

Further experimental work on crop associations incorporating economically interesting perennials is an imperative for the Region; a synthesis of existing findings can provide a useful starting point. One obstacle to research in this area has been

institutional: the separation of perennial crop research from the research on food crop systems, and frequently the separation among researchers working on various perennial crops and other trees.

Given the long time lags which will be involved in generating results by traditional experimentation methods for these long-lived crops, it might be fruitful to explore more unconventional "on-farm" experimentation in this area, compiling performance data from actual associations being practiced. There is a need to gather information on both the biological[40] and economic[41] compatibility of the various possible associations.

In the subhumid zone, if the diagnosis of the problem in these zones seems clear, there are challenges concerning solutions which will increase the attractiveness of fertility-restoring practices. Concerning the introduction of organic fertilisers into the soils, research needed to expand the range of options available: how to increase biomass recycled by animals; what legume crops to introduce? The rich assortment of plants available in the sub-humid zones and the economic worth of certain local tree species suggests that not all the possibilities have been adequately explored. The same applies to non-tree legumes, which are more likely to be introduced into crop cycles if they have their own economic value. This line of research may imply some basic genetic work on the individual legumes (such as groundnuts and cowpeas, for which little recent research has been done concerning these agro-ecological zones).

Future research and technology should also attempt to better exploit the understanding one has achieved of the role of fallow in fertility restoration, to see to what extent it can be mimicked by agricultural activities. The issue here is to encourage the two dynamic thrusts of the "live phase" of the soils, rooting and biological activity. The development of the root system and the global root mass should be favoured in order to ensure uninterrupted biological activity related to humification and mineralisation. This means that research orientations should give greater attention to this biological dimension: varietal selection that improves the root mass, intercropping trees and crops that have complementary root systems, etc.

- The nature of devising systems solutions is more complex than agronomic work in monocrop situations, and **will need to involve substantial on-farm trials** to understand the functioning of the associations and devise modifications. Such on-farm research should receive a high priority (examples are initiatives in this direction

---

[40] Root systems and nutritional needs, canopy cover, production and reproduction cycles,...

[41] Production periods and labor calendars, investment requirements and delays of entry into production, life cycle of the plantations, life cycle of farmers and inheritance issues,...

through the TRIPS[42] and COMBS[43] networks associating national researchers and IITA).

(4) To ensure that they are focusing on the right problems, research systems need to establish closer links with producers. This has been a natural part of the development process in plantation agriculture, where the producers are in a position to articulate their concerns and needs. The challenge ahead for research looking for solutions to peasant agriculture is to find ways to integrate these farmers into the research process: through contacts with farmers' associations where they exist, through joint work with extension services, through on-farm trials,.... To become full partners in this process, farmers' groups may need special support.

[42] Collaborative Group on Root and Tuber Improvement and Systems Research

[43] Collaborative Group on Maize-Based Systems Research

VI. COMPLEMENTARY ACTIONS NECESSARY FOR TECHNICAL PROGRESS IN THE REGION'S AGRICULTURE

In the current climate of liberalisation and the retreat of the state from many of its service roles in the agricultural sector, there are nevertheless some areas where public support is likely to remain a prerequisite for agricultural innovation. At a minimum, we identify two areas:

(1) Support in the diffusion of genetic material. Special conditions in the supply of improved genetic material (hybridisation, cloning, slow multiplication processes for some crops) suggest that there is a public sector role to be played in getting genetic material out to small farmers. In some cases, improved material already exists, but its use is limited by supply constraints (oil palm, cocoa, rubber, cassava outside of Nigeria). The Nigerian cassava example shows the importance of support to diffusion in such cases. Private sector suppliers are unlikely to step in on the scale warranted, given the risks involved (fragility of seedlings, uncertain demand under commercial conditions). This is less of a problem in the cereals, which are predominantly open pollinated varieties, and which have rapid multiplication rates.

(2) Support in the diffusion of artisanal processing technologies. Actions appear warranted in two respects: the location of techniques from elsewhere (esp. Asia) which can be used (adapted in some cases by research), and support to establishment of distribution networks for machines which are suitable (already the case for cassava, oil palm, rice, coffee). This may require subsidised credit, support to cooperatives, etc. in order to make the initial investments possible.

Beyond this minimum, **the experience of successful innovation also suggests cause to reexamine the policies of taxing petroleum products, and of eliminating all subsidies on inputs.** Although petrol taxes are an important source of revenue in non-producing countries, the constraints on agricultural development posed by high transport costs in this zone (particularly between the savanna zones and the southern consumption centers) suggest that alternative tax bases may be needed (such as VATs). This is not an easy issue at this time when commodity prices are so low as to preclude their use in the tax base, but the Nigerian example of integrated agricultural trade makes the question worth posing.

Input subsidies elimination should be reconsidered, even if one agrees that input subsidies are a poor means of lowering the costs of production. Given the role of subsidy in the reduction of risk, subsidies on inputs (fertiliser in particular) can encourage farmers to innovate, and to sedentarise their production systems. Here the Asian experience, where input subsidies continue to be the rule, should not be forgotten, nor should the fact that the only "Green revolution" occurring in the Region in food crops is in Nigeria, where the subsidies have continued. It is also the case that in Africa, the "market" price of inputs is extremely high, with landed costs often at double the world market price, even before adding upland transport costs. It is true that governments do not have the resources under the current crisis conditions. But this may be an area meriting support by donors as a development tool.

BIBLIOGRAPHY

The physical environment and soil fertility issues

Berger M., Belem P.C., Dakouo D., Hien V., 1987. Le maintien de la fertilité des sols dans l'ouest du Burkina Faso et la nécessité de l'association agriculture élevage. Coton et Fibres Tropicales, 1987, vol. XVII, Fasc. 3.

Elemo K.A., Kumar V., Olukosi J.O., Ogungbile A.O., 1990. Review of research work on mixed cropping in the nigerian savanna. Samaru Miscellaneous Paper 127, IAR, Samaru, Ahmadu Bello University, Nigeria, 130 pages.

Gigou J., 1987. L'adaptation des cultures dans le centre de la Côte d'Ivoire. L'agronomie tropicale, 1987, 42-1 : 1-12.

Hien V., Belem P.C., Berger M., Richard L., 1984. Aspects général de l'évolution de la fertilité des sols burkinabé en culture continue. Notes et documents burkinabé, 15 (4) : 18-24.

IITA, 1992. Resource and crop management program. Annual report 1991, Highlights of scientific findings. IITA Ibadan, Nigeria, 35 pages.

Kalms, J.M., Forest, F., 1982. Une approche agronomique du déterminisme du rendement du riz pluvial. Cas de la région centre de Côte d'Ivoire. Bouaké-Montpellier, IDESSA-IRAT, 17 p.

Labrousse, 1992. Typologie des problèmes spécifiques à la zone inter-tropicale humide. CFD, BDPA-SCETAGRI, Réseau zone inter-tropicale humide. Document de travail n° 1, Octobre 1992.

Labrousse, 1992. Typologie des systèmes agraires. CFD, BDPA-SCETAGRI, Réseau zone inter-tropicale humide. Document de travail n° 2, Janvier 1993.

Lal R., Okigbo B., 1990. Assessment of soil degradation in the southern states of Nigeria. World bank, Environment working paper n° 39, September 1990, 58 pages.

Leduc B., 1984. Liaison Recherche-Développement, recherche de systèmes stables de cultures vivrières en zone forestière. Premier bilan 1971-1982. IDESSA, Côte d'Ivoire, 164 pages.

Nair P.E.R., 1990. The prospects and promises of agro-forestry in the tropics. Washington, D.C., World Bank.

Pichot J., Sedogo M.P., Poulain J.F., Arrivets J., 1981. Evolution de la fertilité d'un sol ferrugineux tropical sous l'influence de fumures minérales et organiques. Agronomie Tropicale, 1981, XXXVI, pp 122-133.

Piéri C., 1985. Management of acid tropical soils from Africa and Madagascar. In : Atelier de travail inaugural du réseau sols acides, Brasilia, Brésil, 1er mai 1985, 34 p.

Piéri C., 1989. Fertilité des terres de savanes. Bilan de trente ans de recherche et de développement agricoles au sud du Sahara. CIRAD, Ministère de la Coopération et du Développement, 444 p.

Smith J., Weber G.K., s.d.. Strategic research in heterogeneous mandate areas : an example from the west african savanna. IITA. Forthcoming as chapter 30 in Agricultural Technology Policy Issues for the International Community, 21 p.

Van der Pol F., 1990. L'épuisement des terres, une source de revenus pour les paysans de Mali-sud. In Savanes d'Afrique, terres fertiles ? Actes des rencontres internationales, Montpellier 10-14 Septembre 1990, Collection "Focal Coop", Ministère de la Coopération et du Développement, CIRAD, pp 403-418.

The socio-economic and institutional environment

BAD-OCDE, 1993. Perspectives à long terme en Afrique de l'ouest : population, espace et développement. Projet CINERGIE. Document de synthèse à l'issue de la première phase des travaux, 124 pages + annexes.

Banque mondiale, 1987. Inventaire de la recherche agricole en Afrique de l'Ouest, 1985-1986. Département des projets d'Afrique de l'Ouest. Banque Mondiale, 420 pages.

Berthomé J., Mercoiret M.R., 1993. Les organisations paysannes face au désengagement de l'Etat : les ambiguités de la période. CIRAD-CIEPAC, Montpellier, processed.

Brader L., 1991. IITA : recent achievements and future outlook. Text of presentation at International centers week, Washington D.C., October 1991, 27 pages.

Carr S.J., 1989. Technology for small scale farmers in Sub-Saharan Africa. Experience with food crop production in five major ecological zones. World bank technical paper number 109.

CGIAR, 1993. Report of the third external program and management review of the West africa rice development association.

CGIAR, 1993. Investment in rice research in the CGIAR : a global perspective. report of the inter-centre review of rice.

CGIAR-TAC, 1990. Report of the third external programme review of the International Institute of Tropical Agriculture. Octobre 1990, 85 pages + annexes.

Chauveau J.P., 1993. L'innovation cacaoyère : stratégies d'acteurs, institutions et contextes locaux. La diffusion comparée de la cacaoculture en Afrique de l'Ouest. *In* L'innovation en milieu rural II, Chauveau J.P., Cormier-Salem M.C., Mollard E. Ed., ORSTOM, Laboratoire d'études agraires, Montpellier, pp. 135-165.

CIRAD, 1992. Technical notes : citrus, pineapple, bananas and plantains, cocoa, coffee, coconut palm, cotton rubber, oil palm. Document présenté à Abuja, Nigeria, SPAAR.

CIRAD, 1993. Propositions pour l'élaboration d'un dispositif de recherche-action en zone tropicale humide d'Afrique. CIRAD, Direction Scientifique, processed, 25 p.

Cleaver K., Schreiber G., 1992. The population, agriculture and environment nexus in sub-saharan Africa. Agriculture and rural development series n° 1, Technical department, Africa region. World Bank, 206 pages.

Colin J.P., Losch B., 1990. "Touche pas à mon planteur". Réflexions sur les "encadrements" paysans à partir de quelques exemples ivoiriens. Politique Africaine N° 40, Décembre 1990, pages 83-99.

Coulter J.K., Population pressures, deforestation, and land in the wet tropical forest zones : the techical dimension.

Drachoussof V., Focan A., Hecq J., 1991. Le développement rural en Afrique Centrale. 1908-1960/62. Fondation Roi Baudoin, Bruxelles, Belgique. 621 pages.

Freud C., 1988. Quelle coopération ? Un bilan de l'aide au développement. Khartala.

Gavira J., Bindlish V., Lele U., 1989. The rural road question and Nigeria's agricultural developemnt. MADIA discussion paper 10, The world bank, Washington, 35 pages.

IITA, 1992. Food crop improvment and resource research : major achievements and challenges for the future. SPAAR, Abuja, Nigeria, October 1992.

IITA, Humid forest systems group, 1992. A mid-term strategy for cropping systems research with special reference to the african humid tropical zone (Off-station), Third draft, 34 pages.

Losch B., 1992. Les filières café au Cameroun et en Côte d'Ivoire : vers la fin du mode de régulation étatique. Restitution de l'exposé présenté le 3/7/92 dans

le cadre du séminaire de Chantilly sur la compétitivité des cafés africains organisé par le Ministère de la Coopération et du développement. CIRAD-SAR, multigr. 12 pages.

Ministère de la Coopération et du Développement, 1991. Mémento de l'agronome. Quatrième édition. Paris, France, 1635 pages.

Ministère de la Coopération et du Développement, 1993. La compétitivité des bois d'oeuvre africains.

Riverson J., Gavira J., Thriscutt S., 1991. Rural roads in Sub-Saharan Africa. Lessons from World Bank experience. World Bank technical paper number 141, Africa technical department, 48 pages.

Sautter G., 1958. De l'Atlantique au fleuve Congo. Mouton, Paris.

SPAAR, INSAH, 1992. Revitalizing agricultural research in the Sahel. A proposed framework for action, multigr. 88 pages.

Stryker, D., 1991. "Ghana" in Krueger A., Schiff M., Valdes A., ed., The Political Economy of Agricultural Pricing Policy, Johns Hopkins Press for the World Bank.

Swift M.J., Mutsaers H.J.W., 1992. IITA research for the humid forest zone, Humid forest program, IITA, Ibadan, Nigeria.

World bank, 1989. Nigeria. Strategy for agricultural growth. Washington D.C.

World bank, 1989. Staff appraisal report. Nigeria. Tree crop project. Western Africa Department, Agriculture Operation division. February 28, 1989, 101 pages.

World bank, 1992. Market outlook for major primary commodities. Vol II : Agr. prod., fertilizers and tropical timber.

World Bank, 1993. A strategy to develop agriculture in Sub-Saharan Africa and a focus for the World Bank. Technical department, Africa region, Agriculture and rural developement series n°2, 133 pages.

Rubber

CIRAD, 1991. Rapport de la première revue externe de l'Institut de recherches sur le caoutchouc, IRCA. CIRAD, Paris, 152 pages.

Compagnon P., 1986. Le caoutchouc naturel. Editions Maisonneuve et Larose, 595 pages.

De la Serve M., Sainte Beuve J., 1990. L'hévéaculture paysanne au Libéria et la réponse des producteurs aux variations de prix du caoutchouc. ***In*** Economie des filières en régions chaudes. Actes du Xème séminaire d'économie et de sociologie, 11-15 septembre 1989, Montpellier, CIRAD, pp. 767-784.

Hirsch R., 1990a. Etude comparative des coûts de production de caoutchouc dans les grandes plantations en Afrique et en Asie. Tome II : Rapport principal. Caisse centrale de coopération économique, Département des politiques et des études, 107 pages.

Hirsch R., 1990b. Evaluation rétrospective du premier projet de développement de l'hévéaculture villageoise dans le sud-est ivoirien (PVSE1) Tome 1, CCCE, Paris, juillet 1990.

Losch B., 1990. La filière caoutchouc naturel en Côte d'Ivoire, originalité et enjeux. In Economie des filières en régions chaudes. Actes du Xème séminaire d'économie et de sociologie, 11-15 septembre 1989, Montpellier, CIRAD, pp. 785-804.

Sérier J.B., 1993. Histoire du caoutchouc. Editions Desjonquières, Paris, 273 pages.

Cotton

Boutiller J.L., Conesa A.P., 1984. Evaluation de la recherche sur le coton en RCA. Ministère des relations extérieures, Coopération et développement, Série Evaluations.

Bigot Y., Raymond G., 1991. Traction animale et motorisation en zone cotonnière d'Afrique de l'ouest. Burkina Faso, Côte d'Ivoire, Mali. Collection "Documents Systèmes Agraires" N° 14, CIRAD, Montpellier, 95 pages.

Faure G., 1990. Pression foncière, monétarisation et individualisation des systèmes de production en zone cotonnière au Togo. CIRAD-IRCT, thèse de doctorat soutenue à l'ENSA. Montpellier en mai 1990, 480 pages.

Funel J.M., Raymond C., Schulmann J.P., Schwartz A., 1983. Evaluation économique de l'activité coton au Togo. Ministère des relations extérieures, Coopération et développement, série Evaluations.

Le Roy X., 1993. Innovation et culture cotonnière. Le cas de la Côte d'Ivoire septentrionale. Communication au séminaire CIRAD INRA ORSTOM "Innovations et sociétés", Montpellier, Septembre 1993.

Ministère de la Coopération et du Développement, 1991. Le coton en Afrique de l'ouest et du centre. Situation et perspectives. groupe de travail Coopération française, 353 pages.

Peltre-Wurtz J., Steck B., 1991. Les charrues de la Bagoué. Gestion paysanne d'une opération cotonnière en Côte d'Ivoire. ORSTOM Paris, Collection "A travers champs", 303 pages.

Raymond G., Beauval V., 1991. Perspectives d'évolution à moyen terme des superficies de coton et de la production de coton graine au Bénin. Rapport définitif. République du Bénin, Ministère du développement rural et de l'action coopérative, Juillet 1991. 136 pages + annexes.

Yung J.M., 1989. Aperçus sur les comportements des producteurs de coton en RCA. SEDES, Paris, 159 pages.

Maize

Conte S., Fusillier J.L., Iloga L., Nkouenkeu T., Voufo P., 1993. Analyse économique de la filière maïs au Cameroun. Ministère de l'agriculture, Direction des enquêtes agro-économiques et de la planification agricole, Juillet 1993.

Fusillier J.L., 1990. La filière maïs en Côte d'Ivoire. CIRAD-MES, Montpellier.

Gilbert E., Philips L.C., Roberts W., Sarch M.T., Smale M., Stroud A., Hunting E., 1993. Maize research impact in Africa. The obscured revolution. USAID, June 1993, 184 pages.

Silvestre A., Muchnick J., 1993. La dynamique du maïs au nord Cameroun. Communication au séminaire CIRAD INRA ORSTOM "Innovations et sociétés" , Montpellier, Septembre 1993.

Groundnut

Adoumou G., 1990. Situation de la culture arachidière en république populaire du Bénin. *In* Les acquis de la recherche arachidière et la coordination des programmes en zone à deux saisons des pluies. CORAF, 1990.

Cattan P., Schilling R., 1992. Facteurs techniques d'amélioration de la productivité arachidière en Afrique de l'ouest. In Arachide infos, La lettre du réseau arachide de la CORAF, n°4, décembre 1992.

CORAF, 1990. Les acquis de la recherche arachidière et la coordination des programmes en zone à deux saisons des pluies. CORAF Réseau Arachide, DGRST Congo, Brazzaville, 12-16 Décembre 1989, 85 pages.

Essomba N.L., 1990. Production d'arachide et recherche dans la zone humide du Cameroun. *In* Les acquis de la recherche arachidière et la coordination des programmes en zone à deux saisons des pluies. CORAF, 1990.

Matokot L., 1990. Utilisation de plantes à effets insecticides répulsifs et anti-appétants contre les insectes ravageurs des denrées stockées. Cas de l'arachide. *In* Les acquis de la recherche arachidière et la coordination des programmes en zone à deux saisons des pluies. CORAF, 1990.

Schilling R., 1992. La filière arachide en Afrique : Situation, perspectives et études à entreprendre sur le plan économique. CIRAD-CA, Multigr., Décembre 1992, 8 pages.

Food processing

Bricas N., Bridier B., Fusillier J.L., Sautier D., Thuillier C., 1992. La valorisation des produits vivriers dans les pays d'Afrique humide et sub-humide. Situation et perspectives pour la recherche. CIRAD, Montpellier, Août 1992, 39 pages + Annexes.

Muchnick J. (sous la coordination de), 1993. Alimentation, techniques et innovations dans les régions tropicales. L'Harmattan, Paris, 556 pages.

Requier-Desjardin D., 1989 (?) L'alimentation en Afrique. Manger ce que l'on peut produire. Khartala-PUSAF.

Thuillier C., Hounhouigan J., Devautour H., 1991. Filières courtes et artisanat alimentaire au Bénin. Coordination scientifique Nago M. et Muchnik J., ATP innovations agro-alimentaires et filières courtes des produits vivriers, juin 1991, 120 pages + annexes.

Rice

Adesina A., nd (1992 ?). Economics of rice production in West Africa. State of the arts paper, WARDA, Côte d'Ivoire, 209 pages.

Andriesse W., Fresco L.O., 1991. A characterization of rice growing environments in West Africa. Agriculture, Ecosystems and Environment, 33 (1991) : 377-395.

Carsky R.J., 1992. Rice-based production in inland valleys of West Africa : research review and recommandations. Ressource and crop management research monograph n°8, IITA, 31 pages.

Fresco L. O., 1991. A characterization of rice-growing environments in West Africa. Agriculture, ecosystems and environment, 33, 1991, 377-395.

Harre D. Le riz en Côte d'Ivoire. Origine et performance des secteurs de transformation artisanal et industriel. réseau Stratégies alimentaires, Solagral collection, mars 1992, 87 pages.

Leplaideur A., Forbeau F., Meneux Y., Orrit E., 1990. Quelques premières informations sur l'économie du riz en Guinée Conakry : Labé, Boké, Télimélé, Gaoual, Koundara. DCV, Labo agro-économie n°3, Janvier 1990, 165 pages?

Leplaideur A., 1992. Aménagement des bas-fonds en Guinée. Laboratoire Economie, CIRAD-CA n° 35, octobre 1992, 45 pages.

Louis Berger International, 1990. Etude de la filière riz, rapport final. République de Côte d'Ivoire, DCGTX, 270 pages.

Pearson S.R., Stryker J.D., Humphreys C.P., 1981. Rice in West Africa. Stanford University Press. Cakifornia, USA, 482 pages.

Poisson C., 1989. Amélioration variétale du riz en Afrique de l'Ouest. Communication présentée à la Revue Annuelle de la Riziculture, ADRAO, Bouaké, Côte d'Ivoire, 24 au 26 avril 1989, 19 pages.

Rebuffel P., 1993. La mise en valeur des bas-fonds du nord Ghana. Synthèse Crop research institute/CIRAD 1991-1992.

Coffee-Cocoa

Antheaume B., Pontié G., 1990. Les planteurs-rénovateurs de cacao du Litimé (centre-ouest du Togo). L'innovation technique à marche forcée. Cah. Sci. Hum. 26 (4) : 623-654.

Bateman M.J., Meeraus A., Newbery D.M., Okyere W.A., O'Mara G.T., 1990. Ghana's cocoa pricing policy. World bank, Agricultural policies.

Bloomfield E. M., 1993. Cocoa : costs of production in various producing countries. Cocoa growers bulletin, n°17, September : 23-33.

Bloomfield E. M., Lass R.A., 1992. Impact of structural adjustment and adoption of technology on competitiveness of major cocoa producing countries. OECD, Paris, April 1992, 90 pages.

CIRAD, Ministère de la Coopération et du développement, 1990. Compétitivité du cacao africain. Analyse du marché mondial et des principaux producteurs. Rapport d'étude, septembre 1990, 279 pages.

CIRAD, SOFRECO, 1992. Relance régionalisée de la production paysanne de café et de cacao au Cameroun. Etude de faisabilité. Phase 1, cadre général de la relance.

CRIN (Cocoa Research Institute of Nigeria), 1989. Progress in Tree Crop Research. Cocoa Research Institute of Nigeria, Ibadan, Nigéria, Second edition, 224 pages.

Daviron B., Fousse W., 1993. Compétitivité des cafés africains. Ministère de la Coopération.

Dorosh P., Akanji B., 1987. Impacts of exchange rate changes on the cocoa-food crop farming systems of southwest Nigeria. IITA, Ibadan, Nigeria, 53 pages.

Freud C., Hanak Freud E., 1993. Les cafés robusta africains peuvent ils encore être compétitifs. CIRAD, UR Economie des filières, n°2.

IRCC, 1991. L'agronomie du cacaoyer à l'IRCC. IRCC-CIRAD, 44 pages.

Jarrige F., Ruf F., 1990. Comprendre la crise du cacao. Café cacao thé, vol.XXXIV, n°3, juil-sept. 1990 : 213-222.

Losch B., Fusillier J.L., Dupraz P., 1991. Stratégies des producteurs en zone caféière et cacaoyère du Cameroun. Quelles adaptations à la crise. Collection "Documents Systèmes Agraires" N° 12, CIRAD, Montpellier, 252 pages.

Losch B., 1992. Côte d'Ivoire, Note 8. Texte présenté au séminaire de Chantilly "L'avenir du café en Afrique, conditions de compétitivité des cafés africains", 2 et 3 juillet 1992, 29 pages + annexes.

Losch B., 1992. La relève incertaine de la régulation étatique dans les filières café et cacao en Côte d'Ivoire. Communication présentée à la table ronde de Bingerville (30/11 au 2/12/92) organisée par le groupement Interdisciplinaire enSciences sociales (GIDIS) de Côte d'Ivoire, multigr., 16 pages.

Petithuguenin Ph., 1993. Bilan diagnostic de la recherche agronomique café/cacao. Quels acquis pour le développement dans le contexte actuel ? Relance régionalisée de la production paysanne de café et de cacao au Cameroun. CIRAD-CP, Montpellier, Février 1993, 46 pages.

Pontié G., Raymond C., Ruf T., Funel J.M., 1984. Evaluation a posteriori de la rénovation de la caféière et de la cacaoyère du Togo. Ministère de la coopération et du développement, Série "Evaluations".

Ruf F., 1987. Eléments pour une théorie sur l'agriculture des régions tropicales humides. I. De la forêt, rente différentielle, au cacaoyer, capital travail. L'Agronomie tropicale 1987, 42-3 : 218-232.

Ruf, F., Beaussejour O.K., Konan Konan G., Konan N'guessan F., 1992. Après la forêt, quelle stabilisation de l'agriculture de plantation. Le cas du département d'Abengourou, Côte d'Ivoire. Rapport de mission GTZ du 14/11 au 30/11/91 concernant les aspects socio-économiques. CIRAD-SAR 1992/04.

Ruf F., 1992. Les crises cacaoyères, la malédiction des âges d'or. Cahiers d'études africaines, XXXI, 121-122 : 83-134.

Ruf F., 1993. Innovations et gestions paysannes face aux maladies et ennemis du cacaoyer. Communication au colloque de Yamoussoukro, 18-24 juillet 1993, 12 pages.

Ruf F., 1993. Adoption et abandon du cacaoyer cycles d'innovation et ajustements. Contribution au séminaire organisé par le CIRAD, l'INRA et l'ORSTOM sur le thème "Innovations et sociétés". Montpellier 13-16 sept. 1993, 16 pages.

Ruf F., Ruf Th., 1989. Le café et les risques de l'intensification. Cas de la Côte d'Ivoire et du Togo. In Le risque en agriculture, P. Milleville et M. Eldin Ed Paris, France, ORSTOM.

World Bank, 1987. Staff appraisal report. Ghana. Cocoa rehabilitation project. Agriculture Operation division. October 19, 1987.

Cassava

Adamu S.O., 1989. Trends and prospects for cassava in Nigeria. IFPRI, Working paper 5 on cassava. Washington, May 1989, 104 pages.

Agboola S. A., 1968. The introduction and spread of cassva in Western Nigeria. The Nigerian Journal of Economic and Social Studies, p. 369-385.

Fresco L.O., 1986. Cassava in shifting cultivation. A system approach to agricultural technology development in Africa. Royal Tropical Institute. The Netherlands. 240 pages.

IITA, 1990. Le manioc en Afrique. Un manuel de référence. IITA, Ibadan, 190 pages.

Kiss A., Meerman F., 1991. Integrated pest management and african agriculture. World Bank technical paper number 142, Africa technical department, 122 pages.

Muchnick J., Vinck D., 1984. La transformation du manioc. Technologies autochtones. PUF, ACCT, Collection techniques vivantes, 172 pages.

Naire D.L., Alari P., Leplaideur A., Yung J.M., 1992. Démographie des populations, systèmes de cultures et modes de commercialisation des produits agricoles dans les "villages-centres du district de Mindouli au Congo (Région du Pool). Premiers éléments d'une étude sur les sytèmes de cultures à base de manioc. CIRAD-IRAT, Laboratoire d'agro-économie, N° 25, Montpellier, janvier 1992, 95 pages.

Nweke F.I., 1988. COSCA project description. COSCA, Collaborative Study of Cassava in Africa. Working paper n° 1. IITA Ibadan, Nigeria.

Nweke F.I., Ezumah H.C., Spencer D.S.C., 1988. Cropping systems and agroeconomic performance of improved cassava in a humid forest ecosystem. Ressource and crop management research monograph n°2, IITA, 45 pages.

Nweke F.I., Okorji E.C., Njoku J.E., King D.J., 1992. Elasticities of demand for major food items in a root and tuber based food system. Emphasis on yam and cassava in southeastern Nigeria. Ressource and crop management research monograph n°11, IITA, 21 pages.

Nweke F.I., Ogwu B.O., Dixon A.G.O., 1992. The spread and performance of improved cassava varieties in Nigeria : an assessment of adoption. COSCA, Collaborative Study of Cassava in Africa. Working paper n° 15, First draft, December 1992, IITA Ibadan, Nigeria.

Nweke F.I., Polson R., Strauss J., 1992. Cassava production trends in Africa. COSCA, Collaborative Study of Cassava in Africa. Working paper n° 13, First draft, December 1992, IITA Ibadan, Nigeria.

Nweke F.I., 1992. Commercialization of cassava production : potential for production growth in Africa. COSCA, Collaborative Study of Cassava in Africa. Working paper n° 14, First draft, December 1992, IITA Ibadan, Nigeria.

Nweke F.I., 1992. Processing potentials for cassava production growth in Africa. COSCA, Collaborative Study of Cassava in Africa. Working paper n° 11, First draft, December 1992, IITA Ibadan, Nigeria.

Nweke F.I., 1992. Cassava distribution in Africa. COSCA, Collaborative Study of Cassava in Africa. Working paper n° 12, First draft, December 1992, IITA Ibadan, Nigeria.

Nweke F.I., Dixon A.G.O., Asiedu R., Folayan S.A., 1993. Cassava varietal needs of farmers and potential for production and growth in Africa. COSCA, Collaborative Study of Cassava in Africa. Working paper n° 10, Second draft, January 1993, IITA Ibadan, Nigeria.

Tari M., Touya J.C., 1983. Le complexe industriel de Mantsoumba et la filière manioc au Congo. Ministère de la coopération et du développement, Série "Evaluations".

Trèche S., Muchnick J., 1993. Changement technique et alimentation urbaine. Identification et diagnostic des systèmes techniques de transformation du manioc en chikwangue à Brazzaville. *In* L'innovation en milieu rural II, Chauveau J.P., Cormier-Salem M.C., Mollard E. Ed., ORSTOM, Laboratoire d'études agraires, Montpellier, 221 pages.

Tshikala B. Tshibaka, 1989. Food production in a land-surplus, labor-scarce economy : the zairian basin. IFPRI, Washington research report, 74, June 1989.

Yam

Chaléard J.L., 1988. Croissance urbaine et dynamisme rural : l'igname des Lobi (Côte d'Ivoire). *In* Dynamique des systèmes agraires, La dimension économique, ORSTOM, Collection Colloques et séminaires, 246 pages, pp 129-147.

Doumbia S., 1989. L'adaptation des producteurs aux exigences de la demande commerciale : le cas de l'igname en Côte d'Ivoire. In Economie des filières en régions chaudes. Actes du Xème séminaire d'économie et de sociologie, 11-15 septembre 1989, Montpellier, CIRAD, pp.

Olorunda A. O., 1989. Etude de cas : l'industrie de transformation de l'igname au Nigéria. *In* Racines, tubercules et légumineuses. Potentiels et problèmes pour résoudre les problèmes alimentaires en Afrique. Agro Action Allemande. Fondation allemande pour le développement international (DSE). Centre de développement pour l'alimentation et l'agriculture, pp. 126-141.

Onweme I. C., 1989. Etude de cas : une analyse critique de la technique du mini-boutturage de l'igname et de son adoption par les agriculteurs au Nigéria. *In* Racines, tubercules et légumineuses. Potentiels et problèmes pour résoudre les problèmes alimentaires en Afrique. Agro Action Allemande. Fondation allemande pour le développement international (DSE). Centre de développement pour l'alimentation et l'agriculture, pp. 116-126.

Pouzet D., 1986. Propositions pour le développement de la filière igname. IRAT, Montpellier, multigr., 16 pages.

Ruf F., 1993. Adoption et abandon du cacaoyer cycles d'innovation et ajustements. Contribution au séminaire organisé par le CIRAD, l'INRA et l'ORSTOM sur le thème "Innovations et sociétés". Montpellier 13-16 sept. 1993, 16 pages.

SCET-AGRI, 1987. Etude de la filière igname. 209 pages.

Oil and coconut palm

BUROTROP, 1991. Les contraintes de développement du palmier à huile en Afrique : intérêt et rôle d'un réseau de recherche et développement. Compte rendu du séminaire organisé du 10 au 15 juin 1991 à Abidjan par l'Association africaine pour le développement du palmier à huile et BUROTROP, 68 pages.

BUROTROP, 1991. Working towards a better future for the african coconut farmer. Proceedings of the first african coconut seminar, 4th - 8th February 1991 Arusha / Dar es Salaam, Tanzania, 81 pages.

CIRAD, 1990. Rapport de la première revue externe de l'Institut de recherches pour les huiles et oléagineux, IRHO, département du CIRAD. CIRAD, Paris, 135 pages et annexes.

Green A.H. ed., 1991. Coconut production. Present status and priorities for research. World Bank technical paper number 136, 150 pages.

Hirsch R., Benhamou J.F., 1989. Etude comparative des conditions techniques et économiques de production de l'huile de palme en Afrique et en Asie. Caisse centrale de coopération économique.

ILO, nd. Palm oil processing. Technologies for rural women. Ghana. Technical manual n° 1. International labour office, Geneva ; National council on women and development, Accra.

ISNAR, 1988. Review of the nigerian institute for oil palm research (NIFOR), report to the Ministry of Science and Technology of the Federal Republic of Nigeria, 168 pages.

Onwubuya I. I., Eneh F. K., Ofoh M.C., Irusota A. O., Odigie E. E., 1989. Development of mixed oil palm and food crops farming systems research in Nigeria : a response to population pressure and smallholder agriculture. Paper presented at the International Conference on Palms and Palm products, 21-25 November 1989, Benin City, Nigeria, doc. multigr. 33 p.

World Bank, 1990. Staff appraisal report. Ghana Diversification Project. Agriculture operation division.

Fruits and vegetables

Ameganvi F.K., 1991. L'expérimentation maraîchère à Agricongo : propositions pour une meilleure réponse aux besoins des maraîchers de Brazzaville (Congo). Mémoire présenté pour l'obtention du diplôme d'Ingénieur en Agronomie Tropicale. CNEARC-ESAT, AGRICONGO, 82 pages + annexes.

Berton S., 1991. Quelques éléments sur l'évolution des systèmes culturaux à Brazzaville. *In* Filières maraîchères à Brazzaville. Premiers éléments. Leplaideur A. (Sous la direction scientifique de), 1991, pp 45-49.

Borrell B., Yang M., 1992. EC bananarama 1992. The Developing Economies, Vol. XXX, n° 3, September 1992.

Deshayes Ph., 1993. Les filières légumes, fruits et produits de cueillette de la région de Ziguinchor. PAARZ-CIEPAC, Ziguinchor, Montpellier, Juin 1993.

Islam N., 1990. Horticultural exports of developing countries : past performances, future prospects, and policy issues. IFPRI, research report 80, April 1990, 121 pages.

Leplaideur A. (Sous la direction scientifique de), 1991. Filières maraîchères à Brazzaville. Premiers éléments. Programme de recherche CIRAD-IRAT/AGRICONGO, avec la participation de la DGRST Congo. CIRAD, AGRICONGO, 231 pages.

Moustier P., 1990. Les filières maraîchères à Bangui. Compte rendu de mission exploratoire IRAT/AFVP. DCV/Labo agro-économie, n°6, programme maraîcher, 57 pages.

Moustier P., 1992. Is the urban vegetable supply performant in Africa. Some evidence from Congo, Central African Republic and Madagascar. Paper presented at the XIIth symposium on Horticultural Economics, Montpellier, France, 7-11 September 1992, 17 pages

Moustier P., 1993. Note sur la collaboration AGRICONGO/CIRAD-CA en sciences sociales. Document interne CIRAD-CA, multigr. 15 pages.

Ofoueme Y., Kassa L.G., Ali-Gaye, 1991. L'approvisionnment de Brazzaville en produits maraîchers, étude des filières : production et commercialisation. *In* Filières maraîchères à Brazzaville. Premiers éléments. Leplaideur A. (Sous la direction scientifique de), 1991, pp 185-213.

Richard J., Agel C., Perez de Arce D., 1985. Projet maraîchage et pisciculture à Kinshasa.Ministère de la coopération et du développement, Série "Evaluations".

Schilter C., 1991. L'agriculture urbaine à Lomé. IUED-Khartala, 334 pages.

SOFRECO, 1990. Etude de la filière banane en Côte d'Ivoire. Rapport définitif, tome I, première partie, synthèse du diagnostic et des recommandations, 160 pages.

SODETEG, 1990. Etude du marché et de la commercialisation de l'ananas de Côte d'Ivoire. Volume I : Stratégies et orientation. Ministère de l'agriculture, DCGTX, Mars 1990.

SODETEG, 1990. Etude du marché et de la commercialisation de l'ananas de Côte d'Ivoire. Volume V : Etude économique de la filière. Ministère de l'agriculture, DCGTX, Mars 1990.

Tezenas du Montcel H., 1985. Le bananier plantain. Maisonneuve et Larose.

Farming systems case studies (general)

Biarnes A., Colin J.P., 1987. Production vivrière et accès à la terre dans un village de basse Côte d'Ivoire. Cah. Sci. Hum., 23 (3-4) 1987 : 455-470.

Chaléard J.L., 1988. La place des cultures vivrières dans les systèmes de culture en agriculture de plantation : le cas du département d'Agboville (Côte d'Ivoire). Cah. Sci. Hum., 24 (1) 1988 : 35-49.

Colin J.P., 1990. La dynamique des systèmes productifs agricoles en basse Côte d'Ivoire. *In* Dynamique des systèmes agraires, La dimension économique, ORSTOM, Collection Colloques et séminaires, 246 pages, pp 165-190.

Freud C., Amselle J.L., Bulteau P., Hanak E., Toure A., 1991. Evaluation du programme soja. CIRAD, Ministère de l'agriculture, décembre 1991, 236 pages.

Roesch M., 1990. Une expérience de recherche-développement dans la province du Zou (Bénin). Collection "Documents Systèmes Agraires" N° 11, CIRAD, Montpellier, 105 pages.

STATISTICAL APPENDIX

Table 1 : Population and area data for the Region, 1990

Country	Total population (1000 inhabitants)	Total area (1000 Ha)	Population density (inhabitants/km²)	Urbanisation rate (1)
Benin	4 776	11 062	43	0,38
Cameroon	12 239	46 540	26	0,41
Central Afr. Rp.	3 127	62 298	5	0,43
Congo	2 346	34 150	7	0,63*
Côte d'Ivoire	12 462	31 800	39	0,49
Sierra Leone	4 260	7 162	60	0,30
Togo	3 643	5 439	67	0,29
Zaïre	36 728	226 760	16	0.50*
Equatorial Guinea	360	2 805	13	-
Gabon	1 211	25 767	5	0,69*
Ghana	15 524	23 002	67	0,32
Guinea	5 934	24 586	24	0,28
Liberia	2 659	9 675	27	0,22
Nigeria	90 000	91 077	98	0,56

Sources : FAO. Production Yearbook 1991
(1) CINERGIE project / BAD-OCDE, 1993
* ILTA

Table 2 : Population and area data, by density groupings

	Population		area	
	1000 inhab.	%	1000 inhab.	%
Countries with high population density (≥ 100 inhab./Km²) Nigeria	90 000	46	91 077	15
Countries with intermediate high population density (between 40 et and 70 inhab./ km²) Benin, Côte d'Ivoire, Togo, Sierra Leone, Ghana	40 665	21	78 465	13
Countries with low-intermediate population density (between 20 and 30 inhab./ km²) Cameroon, Guinea, Liberia	20 832	11	80 711	13,5
Countries with low population density (below in 20 inhab./km²) Zaïre, Congo, Equatorial Guinea, Central African Republic	43 772	22	351 780	58,5
TOTAL	195 269	100	602 033	100

Sources : Table 1

Table 3 : Land use estimates in the Region

Country	Total Area ('000 ha)	Annual crops		Perenial crops		Pasture and prairie		Forests		Others	
			%		%		%		%		%
Benin	11 062	1 410	13	450	4	442	4	3 470	31	5 290	48
Cameroon	46 540	5 940	13	1 068	3	8 300	18	24 540	53	6 692	13
Central Afr. Rp.	62 298	1 920	3	86	-	3 000	4,8	35 800	58	21 492	34
Congo	34 150	144	0,5	24	-	10 000	29,5	21 160	62	2 822	8
Côte d'Ivoire	31 800	2 430	8	1 260	4	13 000	41	7 380	23	7 730	24
Sierra Leone	7 162	500	7	150	2	2 204	30	2 060	29	2 248	31
Togo	5 439	600	11	69	1	1 790	33	1 600	29	1 380	25
Zaïre	226 760	7 250	3	610	-	15 000	7	174 310	77	29 590	13
Equatorial Guinea	2 805	130	5	100	4	104	4	1 295	46	1 176	42
Gabon	25 767	295	1	162	0,5	4 700	18,5	20 000	77	610	2
Ghana	23 002	1 140	5	1 580	7	5 000	22	8 070	35	7 212	31
Guinea	24 586	610	2,5	118	0,5	6 150	25	14 580	59	3 128	13
Liberia	9 675	128	1,5	245	2,5	5 700	59	1 740	18	1 862	19
Nigeria	91 077	29 765	33	2 535	3	40 000	44	11 900	13	6 877	7

Sources : FAO, Production Yearbook 1991
and CINERGIE project / BAD-OCDE for Nigeria

Table 4 : Evolution of land area under cultivation ('000 hectares)

Country	Area 1980			Area 1990			Annual growth rate (%)		
	Annual crops	Perennial crops	All crops	Annual crops	Perennial crops	All crops	Annual crops	Perennial crops	All crops
Nigeria	27 850	2 535	30 385	29 765	2 535	32 300	0.67	0.00	0.61
Benin	1 350	446	1 795	1 410	460	1 860	0.44	0.11	0.36
Côte d'Ivoire	1 955	1 140	3 095	2 430	1 260	3 690	2.20	1.01	1.77
Sierra Leone	450	135	585	500	150	650	1.06	1.06	1.06
Togo	555	65	620	600	69	669	0.78	0.60	0.76
Ghana	1 090	1 710	2 800	1 140	1 580	2 720	0.45	-O.79	-0.29
Cameroon	5 910	1 020	6 930	5 940	1 068	7 008	0.05	0.46	0.11
Guinea	590	112	702	610	118	728	0.33	0.52	0.36
Liberia	126	245	371	128	245	373	0.16	0.00	0.05
Central African Republic	1 870	75	1 945	1 920	86	2 006	0.26	1.38	0.31
Congo	134	14	148	144	24	168	0.72	5.54	1.28
Equitorial Guinea	130	100	230	130	100	230	0.00	0.00	0.00
Gabon	290	62	352	295	162	457	0.17	10.08	2.64
Zaïre	7 050	550	7 600	7 250	610	7 860	0.28	1.04	0.34
Total for the region	49 350	8 208	57 558	52 262	8 457	60 719	0.57	0.30	0.54

Sources : FAO Production yearbook, 1991

Table 5 : Evolution of urban and rural population

Country	Population		Urbanisation rate		Urban population		Rural population		Population increase rate		
	1980	1990	1980	1990	1980	1990	1980	1990	Rural	Urban	Total
Nigeria	70 390	88 500	0.47	0.56	33 083	49 560	37 307	38 940	0.43	4.12	2.32
Benin	3 459	4 630	0.27	0.38	934	1 759	2 525	2 871	1.29	6.54	2.96
Côte d'Ivoire	8 194	11 997	0.41	0.49	3 360	5 879	4 834	6 118	2.38	5.75	3.89
Sierra Leone	2 271	4 151	0.24	0.32	546	1 328	1 726	2 823	5.04	9.92	6.22
Togo	2 615	3 531	0.24	0.30	628	1 059	1 987	2 472	2.20	5.37	3.05
Ghana	10 736	15 028	0.30	0.29	3 221	4 358	7 515	10 670	3.57	3.07	3.42
Cameroon	8 653	11 833	0.29	0.41	2 509	4 852	6 144	6 981	1.29	6.81	3.18
Guinea	4 461	5 755	0.25	0.28	1 115	1 611	3 346	4 144	2.16	3.75	2.58
Liberia	1 876	2 575	0.18	0.22	338	567	1 538	2 009	2.70	5.31	3.22
Cent. Afr. Rep.	2 320	3 039	0.39	0.43	905	1 307	1 415	1 732	2.04	3.74	2.74
Congo	1 669	2 271	0.53	0.63	885	1 431	784	840	0.69	4.93	3.13
Equ. Guinea	217	352	0.54	0.62	117	218	100	134	2.97	6.42	4.96
Gabon	806	1 172	0.36	0.69	290	809	516	363	-3.44	10.79	3.81
Zaïre	26 225	35 568	0.34	0.50	8 917	17 784	17 309	17 784	0.27	7.15	3.09
Region	143 892	190 402	0.40	0.49	66 846	92 522	87 046	97 880	1.18	4.99	2.84

Source : FAO production yearbook, 1991 except for Nigeria and urbanisation rates : BAD-OCDE, 1993 CINERGIE project and urbanisation rate for Congo, Eq. Guinea, Gabon and Zaïre and urbanisation rate 1990 for Eq. Guinea (World bank,1989)

Table 6 : Evolution of the production of industrial crops in the Region ('000 tonnes)

Annual average 1969-71

Country	Unshelled Groundnut	Seed Cotton	Coprah	Palm Oil	Coffee	Rubber	Cocoa
Nigeria	1 602	186	9	587	4	63	261
Benin	46	36	3	28	2	0	0
Côte d'Ivoire	42	36	6	46	243	11	195
Sierra Leone	20	0	0	46	8	0	5
Togo	20	7	3	16	11	0	27
Ghana	88	0	10	19	6	7	430
Cameroon	206	67	1	67	90	13	127
Guinea	75	0	2	44	12	0	2
Liberia	2	0	0	15	5	78	2
Central African Republic	68	52	0	2	10	1	0
Congo	17	0	0	14	1	1	1
Equitorial Guinea	-	-	-	4	7	0	28
Gabon	3	0	0	2	1	0	5
Zaïre	265	63	0	233	71	43	6
Total for the Region	2 455	447	34	1 123	471	216	1 090

Source : FAO Production Yearbook

Table 6 : Evolution of the production of industrial crops in the Region ('000 tonnes)

Annual average 1979-81

Country	Unshelled Groundnut	Seed Cotton	Coprah	Palm Oil	Coffee	Rubber	Cocoa
Nigeria	466	92	10	667	4	49	169
Benin	60	19	3	30	0	0	0
Côte d'Ivoire	73	131	23	158	298	21	427
Sierra Leone	12	0	0	47	11	0	9
Togo	25	19	2	20	8	0	14
Ghana	125	7	7	21	2	10	268
Cameroon	187	81	1	77	108	17	120
Guinea	83	0	2	41	14	0	4
Liberia	3	0	0	26	10	81	5
Central African Republic	123	28	0	2	17	1	0
Congo	14	0	0	15	3	2	2
Equitorial Guinea	0	0	0	5	6	0	8
Gabon	7	0	0	2	1	0	4
Zaïre	334	23	0	168	90	21	5
Total for the Region	1 462	400	48	1 277	572	202	1 035

Source : FAO Production Yearbook

Table 6 : Evolution of the production of industrial crops in the Region ('000 tonnes)

Annual average 1989-91

Country	Unshelled Groundnut	Seed Cotton	Coprah	Palm Oil	Coffee	Rubber	Cocoa
Nigeria	1 134	246	13	859	1	102	142
Benin	72	139	3	40	1	0	0
Côte d'Ivoire	133	285	81	197	254	72	728
Sierra Leone	20	0	0	56	26	0	24
Togo	29	86	2	14	11	0	8
Ghana	198	14	9	83	1	4	297
Cameroon	103	107	1	105	82	38	107
Guinea	50	3	2	49	13	0	2
Liberia	3	0	0	32	3	52	3
Central African Republic	105	30	0	2	18	1	0
Congo	26	0	0	17	1	2	1
Equitorial Guinea	0	0	0	5	7	0	7
Gabon	15	0	0	5	2	0	2
Zaïre	28	77	0	180	110	15	5
Total for the Region	2 317	986	111	1 644	530	284	1 326

Source : FAO Production Yearbook

Table 7 : Food Crop Production Estimates ('000 tonnes)

Annual average 1979-81

Country	maize	sorghum	paddy	all cereals	cassava	yam	cocoyam	all roots and tubers	Plantain
Nigeria	599	3284	1027	7480	11500	5187	1967	18926	1128
Benin	289	59	10	366	631	687	3	1363	0
Côte d'Ivoire	352	24	438	856	1067	2079	254	3414	1013
Sierra Leone	13	11	504	542	94	0	20	126	22
Togo	150	87	15	301	404	498	18	922	0
Ghana	380	140	89	726	1894	614	674	3183	793
Cameroon	418	301	48	866	977	203	0	1683	1022
Guinea	87	25	438	678	480	64	30	644	340
Liberia	0	0	254	254	300	15	15	346	31
Central African Republic	40	39	13	103	920	153	32	1106	61
Congo	12	0	3	15	631	12	0	678	51
Equitorial Guinea	0	0	0	0	32	O	0	53	0
Gabon	10	0	1	11	242	80	49	372	165
Zaïre	604	32	236	900	12942	222	31	13595	1555
Total for the Region	2964	4002	3076	13098	32114	9814	3093	46391	6181

Source : FAO Production Yearbook, 1991

Table 7 : Food Crop Production Estimates ('000 tonnes)

Annual average 1989-91

Country	maize	sorghum	paddy	all cereales	cassava	yam	cocoyam	all roots and tubers	Plantain
Nigeria	1955	4605	2996	14365	18156	13078	1300	32835	1424
Benin	228	104	9	550	941	1061	2	2035	0
Côte d'Ivoire	491	26	671	1244	1200	2562	288	4298	1114
Sierra Leone	12	21	469	526	110	0	28	152	28
Togo	269	125	29	499	501	410	13	930	0
Ghana	745	197	102	1166	3215	886	1058	5159	1004
Cameroon	400	364	74	903	1189	69	0	1893	848
Guinea	96	34	15	812	419	102	63	691	396
Liberia	0	0	163	163	317	16	16	367	33
Central African Republic	87	39	15	152	519	195	38	753	67
Congo	25	0	1	26	750	12	0	811	75
Equitorial Guinea	0	0	0	0	45	0	0	77	0
Gabon	20	0	1	21	237	107	63	409	236
Zaïre	874	49	350	1311	17742	282	40	18528	1807
Total for the Region	5201	5564	4896	21738	45341	18780	2910	68938	7032

Source : FAO Production Yearbook, 1991

Table 8 : Food Production Estimates per Capita (Kg/cap.)

Annual average 1979-81

Country	maize	sorghum	paddy	all cereales	cassava	yam	cocoyam	all roots and tubers	Plantain
Nigeria	9	47	15	106	163	74	28	269	16
Benin	84	17	3	106	182	199	1	394	0
Côte d'Ivoire	43	3	53	104	130	254	31	417	124
Sierra Leone	6	5	222	239	41	0	9	55	10
Togo	57	33	6	115	154	190	7	353	0
Ghana	35	13	8	68	176	57	63	296	74
Cameroon	48	35	6	100	113	23	0	192	118
Guinea	20	6	98	152	108	14	7	144	76
Liberia	0	0	135	135	160	8	8	184	17
Central African Republic	17	17	6	44	397	66	14	477	26
Congo	7	0	2	9	378	7	0	406	31
Equitorial Guinea	0	0	0	0	147	0	0	244	0
Gabon	12	0	1	14	300	99	61	462	205
Zaïre	23	1	9	34	493	8	1	518	59
Total for the Region	21	28	21	91	223	66	21	322	43

Source : Table 5 and 7

Table 8 : Food Production Estimates per Capita (kg/cap.)

Annual average 1989-91

Country	maize	sorghum	paddy	all cereals	cassava	yam	cocoyam	all roots and tubers	Plantain
Nigeria	22	52	15	162	205	148	15	371	16
Benin	49	22	3	119	203	229	1	440	0
Côte d'Ivoire	41	2	56	104	100	214	24	358	93
Sierra Leone	3	5	113	127	27	0	7	37	7
Togo	76	36	8	141	142	116	4	263	0
Ghana	50	13	7	78	214	59	70	343	67
Cameroon	34	31	6	76	100	6	0	160	72
Guinea	17	6	3	141	73	18	11	120	69
Liberia	0	0	63	63	123	6	6	142	13
Central African Republic	29	13	5	50	171	64	13	248	22
Congo	11	0	0	11	330	5	0	357	33
Equitorial Guinea	0	0	0	0	128	0	0	218	0
Gabon	17	0	1	18	203	91	54	349	201
Zaïre	25	1	10	37	499	8	1	521	51
Total for the Region	27	29	26	114	238	99	15	362	37

Source : Tables 5 and 7

Table 9 : Food Production Estimates per rural inhabitant (Kg/rural inhabitant)

Annual average 1979-81

Country	maize	sorghum	paddy	all cereales	cassava	yam	cocoyam	all roots and tubers	Plantain
Nigeria	16	88	28	201	308	139	53	507	30
Benin	114	23	4	145	250	272	1	540	0
Côte d'Ivoire	73	5	91	177	221	430	53	706	210
Sierra Leone	8	6	292	314	54	0	12	73	13
Togo	75	44	8	151	203	251	9	464	0
Ghana	51	19	12	97	292	82	90	424	106
Cameroon	68	49	8	141	159	33	0	271	166
Guinea	26	7	131	203	143	19	9	192	102
Liberia	0	0	165	165	195	10	10	225	20
Central African Republic	28	28	9	73	650	108	23	782	43
Congo	15	0	4	19	804	15	0	864	65
Equitorial Guinea	0	0	0	0	321	0	0	531	0
Gabon	19	0	2	21	469	155	95	721	320
Zaïre	35	2	14	52	748	13	2	785	90
Total for the Region									

Source : Tables 5 and 7

Table 9 : Food Production Estimates per rural inhabitant (Kg/rural inhabitant)

Annual average 1989-91

Country	maize	sorghum	paddy	all cereals	cassava	yam	cocoyam	all roots and tubers	Plantain
Nigeria	50	118	77	369	466	336	33	843	37
Benin	79	36	3	192	328	370	1	709	0
Côte d'Ivoire	80	4	110	203	196	419	47	702	182
Sierra Leone	4	7	166	186	39	0	10	54	10
Togo	109	50	12	202	203	166	5	376	0
Ghana	70	18	10	109	301	83	99	484	94
Cameroon	57	62	11	129	170	10	0	271	122
Guinea	23	8	4	196	101	25	15	167	96
Liberia	0	0	81	81	158	8	8	183	16
Central African Republic	50	23	9	88	299	113	22	435	39
Congo	30	0	1	31	892	14	0	966	89
Equitorial Guinea	0	0	0	0	336	0	0	573	0
Gabon	55	0	3	58	653	294	174	1 127	650
Zaïre	49	3	20	74	998	16	2	1 042	102
Total for the Region	53	57	50	222	463	192	30	704	72

Source : Tables 5 and 7

Table 10.

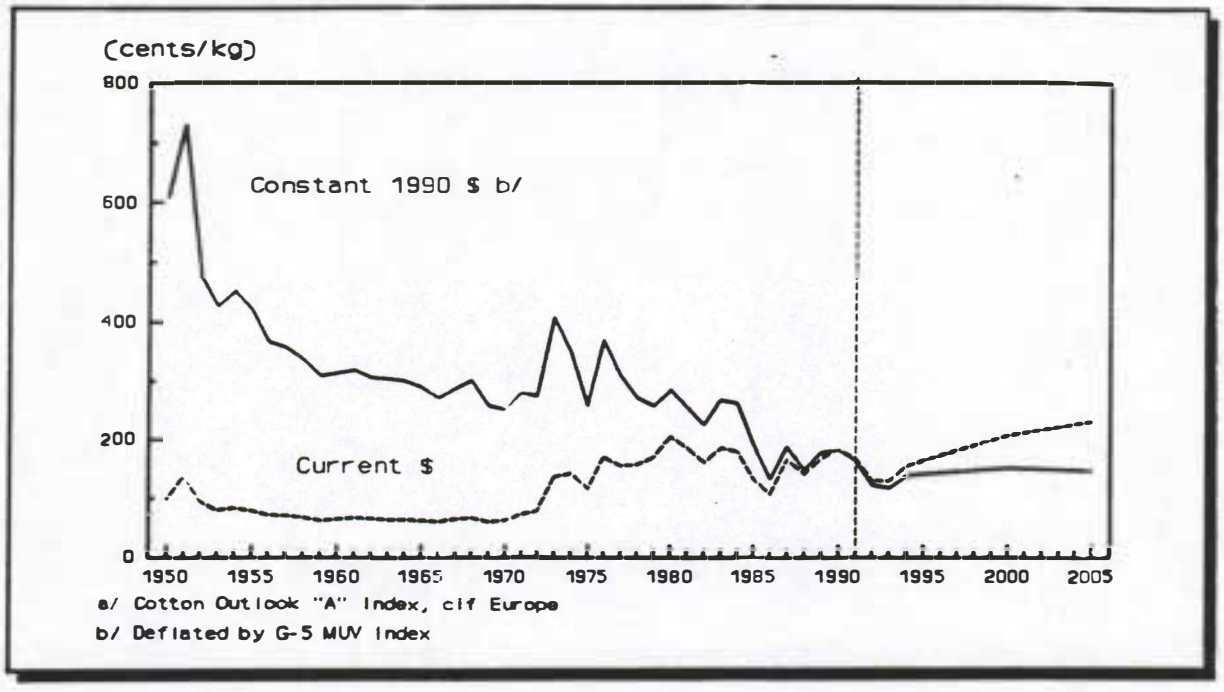
Estimated per capita caloric availability per day

	72-74	75-77	78-80	81-83	84-86	87-89
Bénin	2084	2089	2195	2134	2268	2274
Cameroun	2239	2422	2395	2249	2270	2417
Rép. Centraf.	2278	2196	2091	2036	1932	2008
Congo	2254	2149	2209	2268	2332	2306
Gabon	1889	2345	2378	2413	2510	2473
Ghana	2195	2112	1984	1848	2122	2245
Guinée	1940	2250	2255	2244	2273	2204
Côte d'Ivoire	2331	2320	2549	2668	2654	2597
Libéria	2236	2312	2397	2373	2384	2404
Nigéria	2084	2171	2287	2252	2235	2318
Sierra Leone	1931	2010	2080	2012	1864	1841
Togo	2103	2037	2185	2145	2127	2134
Zaïre	2288	2240	2118	2124	2146	2084

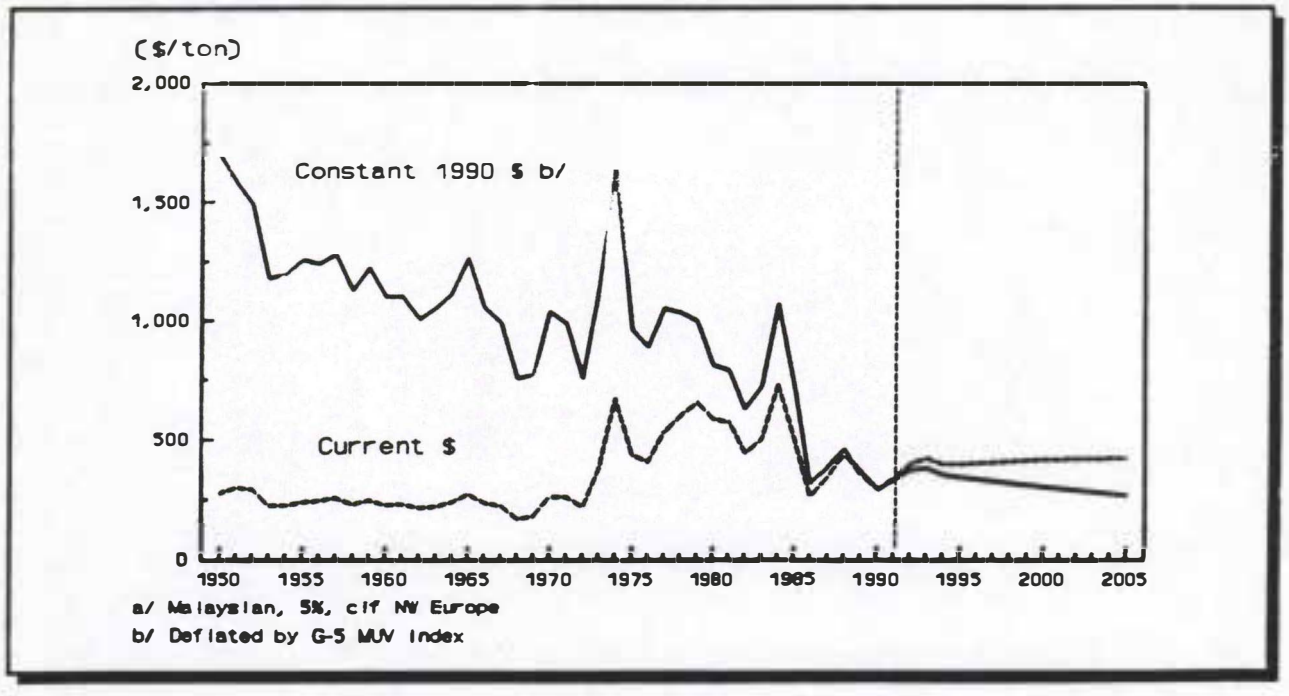
Source : FAO Food Balance Sheets

COMMODITY PRICE HISTORIES AND FORECASTS
Source: World Bank, Market Outlook for Major Primary Commodities, Oct. 1992

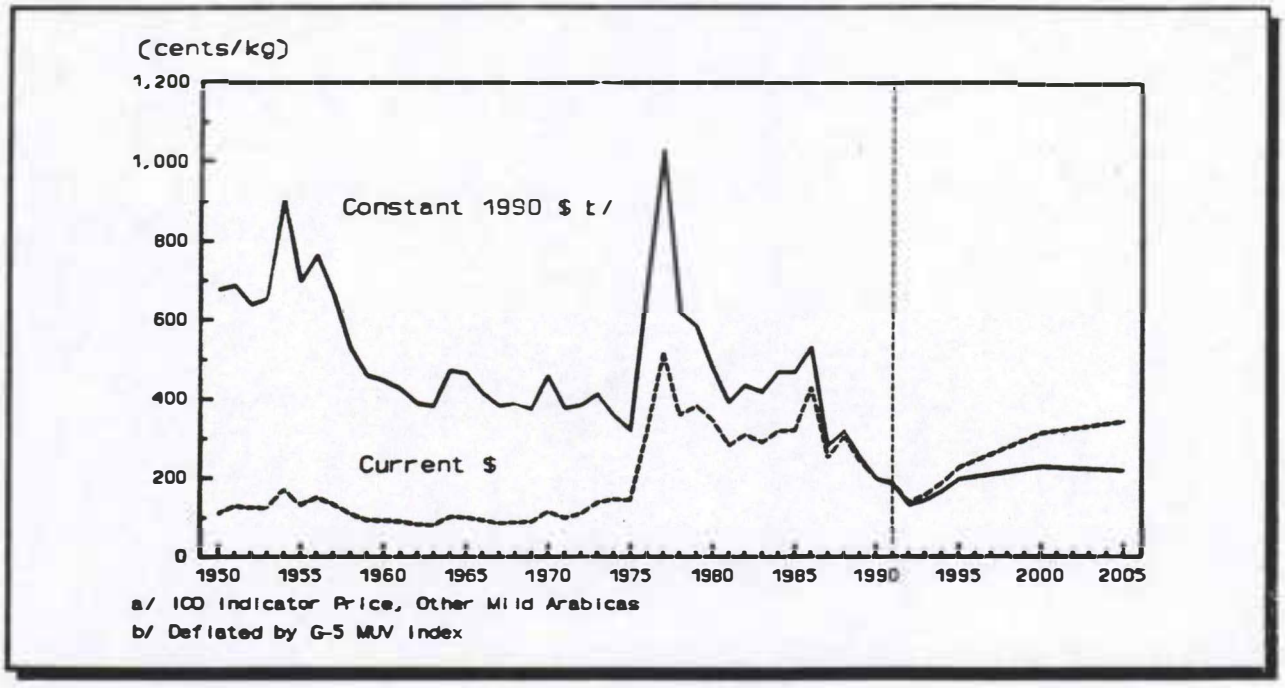
Cotton Prices a/, 1950-2005



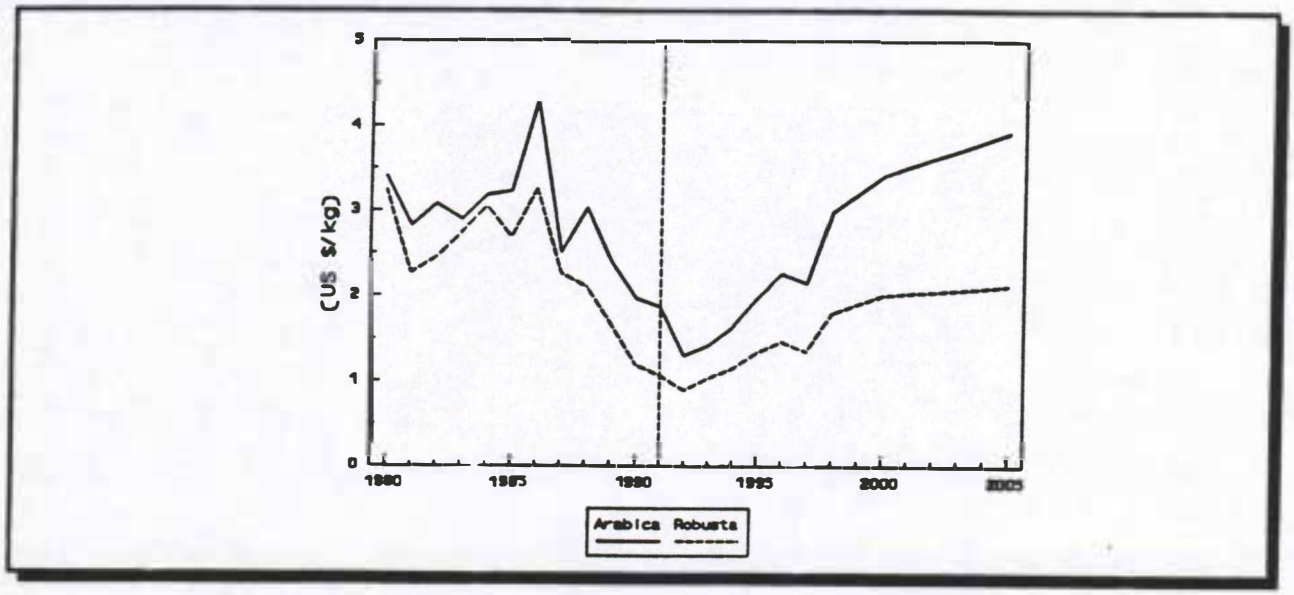
Palm Oil Prices a/, 1950-2005



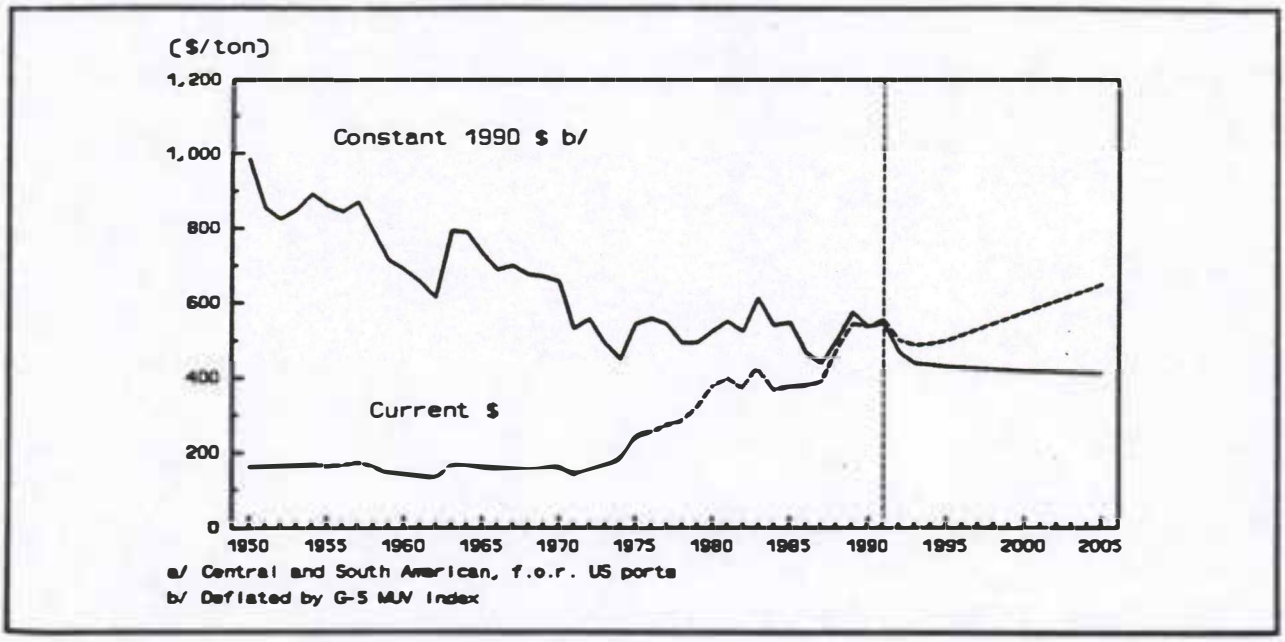
Coffee Prices a/, 1950-2005



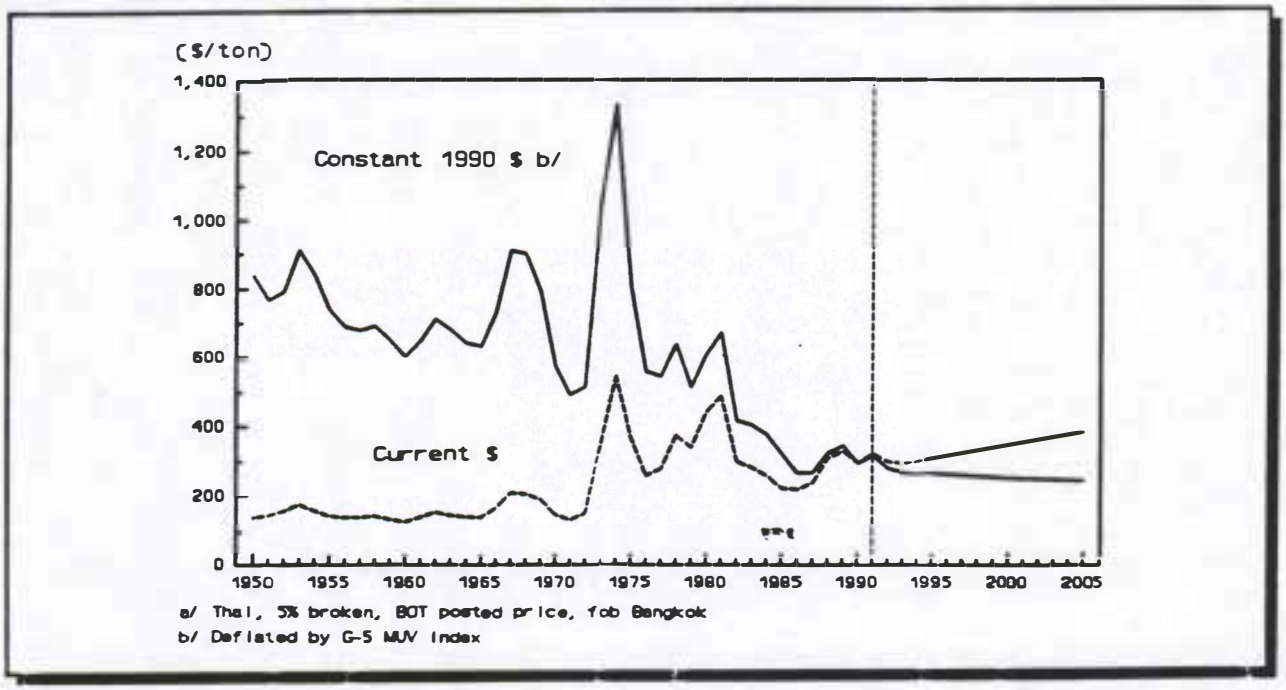
Arabica and Robusta Prices, 1980-2005 (Current Dollars)



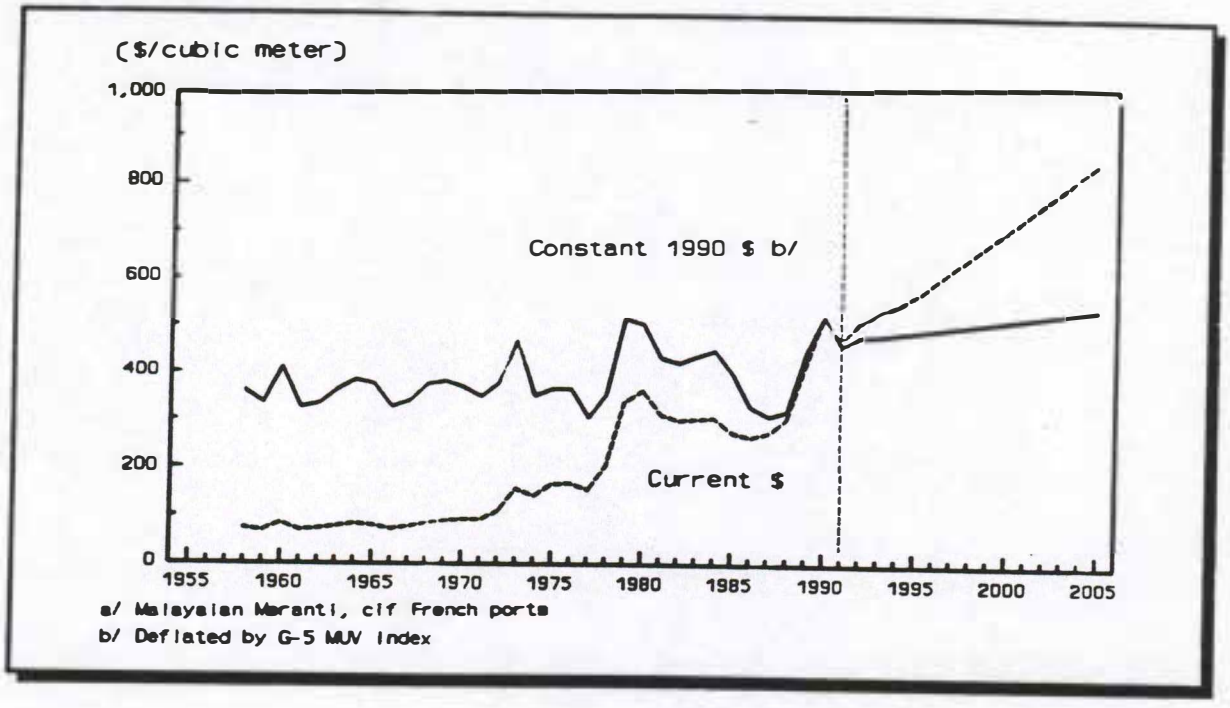
Banana Prices a/, 1950-2005



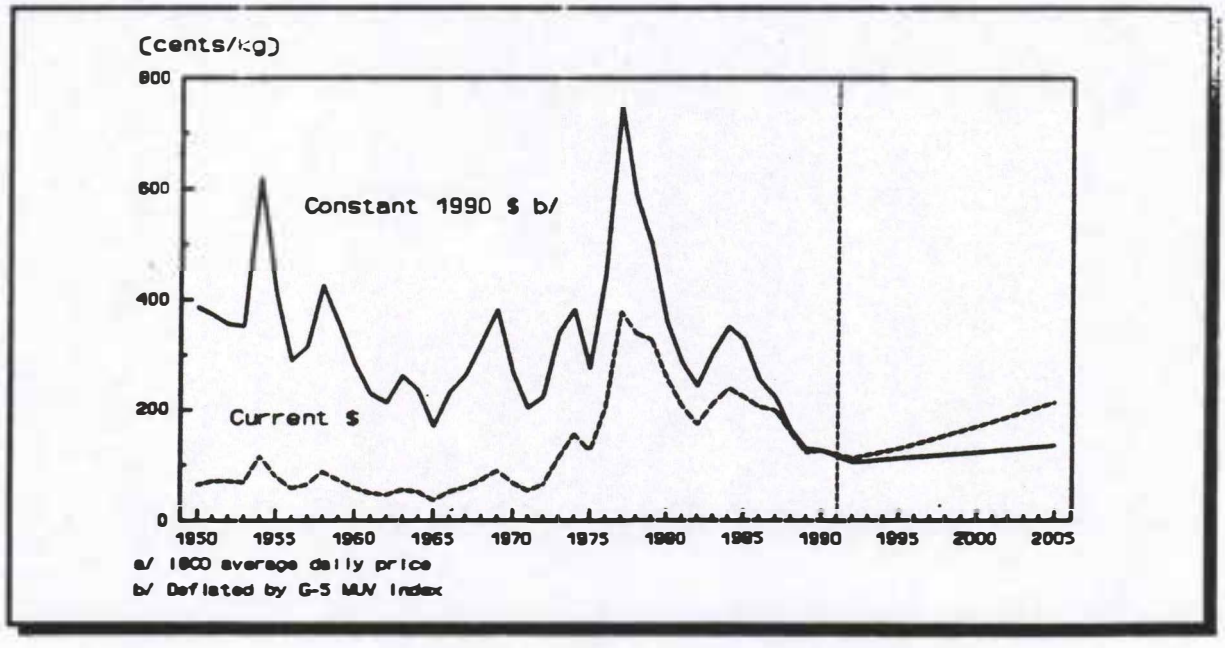
Rice Prices a/, 1950-2005



Sawnwood Prices a/, 1955-2005

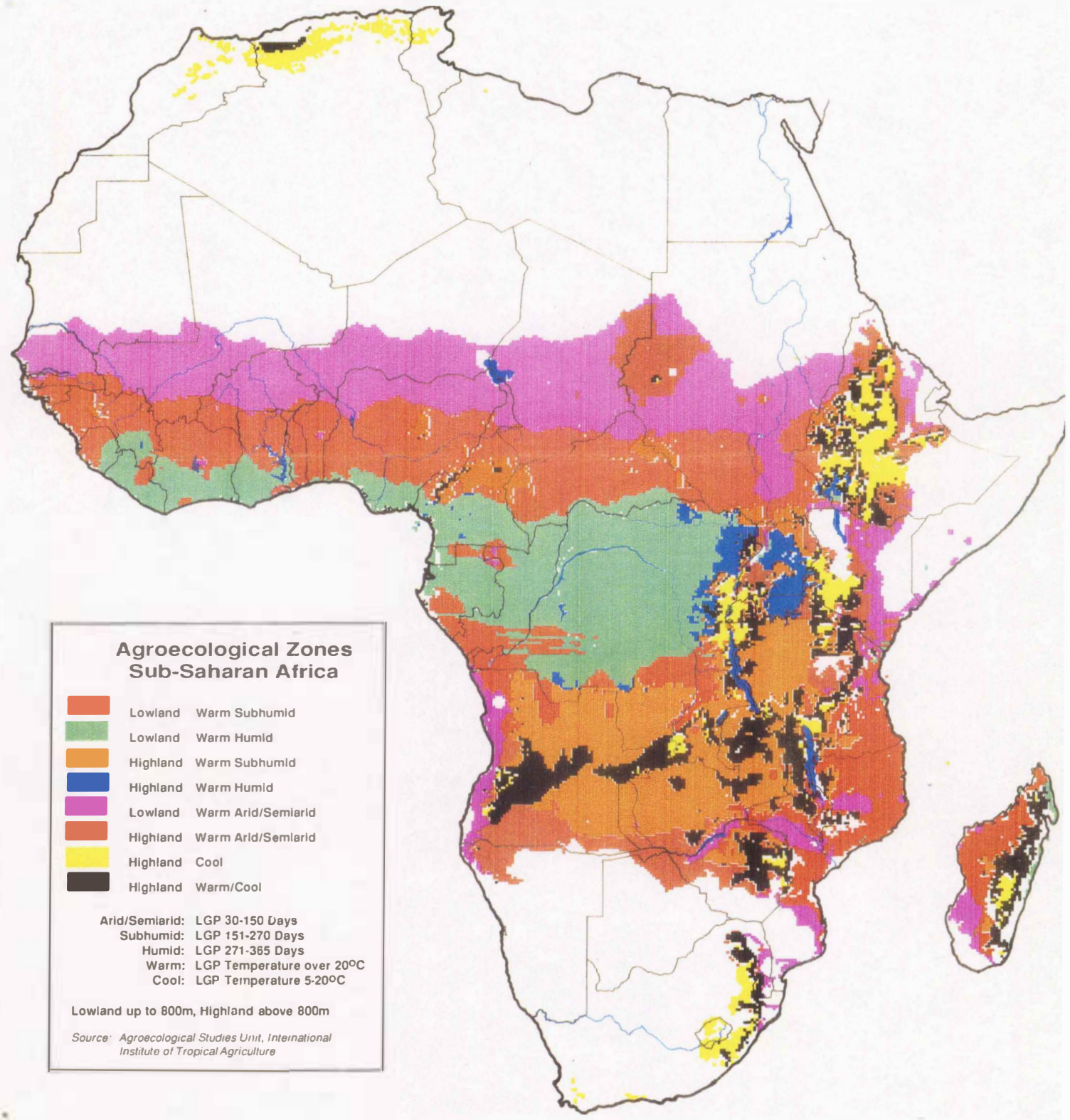


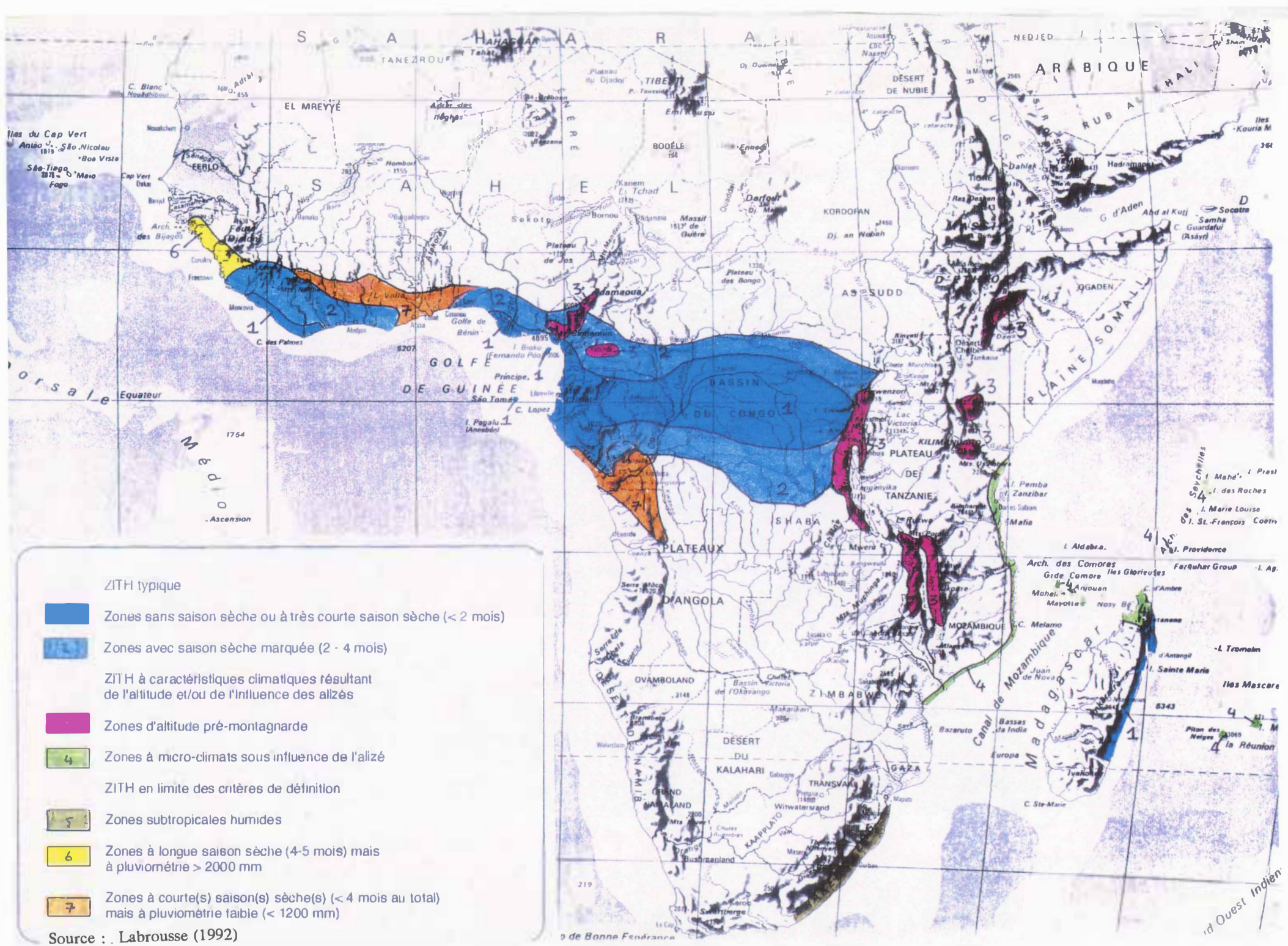
Cocoa Prices a/, 1950-2005



MAPS

Agroecological Zones in Africa





Source : . Labrousse (1992)