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THE ECONOMICS OF BAS-FOND RICE PRODUCTION IN THE EASTERN REGION OF UPPER VOLTA: A WHOLE FARM APPROACH

by

Pascal Tagne Fotzo

A DISSERTATION

Submitted to
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ABSTRACT

THE ECONOMICS OF BAS-FOND RICE PRODUCTION
IN THE EASTERN REGION OF UPPER VOLTA:
A WHOLE FARM APPROACH

By

Pascal Tagne Fotzo

Little is known about the costs and returns of current bas-fond (saucer swamp) rice production techniques in Eastern Upper Volta, and the possibilities for expanded production. This study gathered detailed input/output data on four major bas-fond rice production systems, differing in degree of water control, in the Eastern Region of Upper Volta. The multiple-visit activity approach was used; 116 farmers were interviewed from June, 1980, through February, 1981, at the end of each major field activity (land preparation, weeding, harvesting, etc.).

Financial enterprise budgets for all crops were prepared for each production system. Gross margins and returns to land, family labor and management were computed. Economic costs and returns to the rice enterprises were also analyzed for each production system. In addition, a linear programming model was developed for one representative farm in each production system, to investigate whether and how rice cultivation could be expanded or intensified.

The findings showed that the least cost (and economically profitable) technique for producing rice is traditional cultivation in unimproved swamps. Given current technologies and yield levels, production under improved water control results in negative economic returns. Using financial prices, rice entered the optimal solution in all LP models, at acreage levels which held in each system under a wide range of gross margins per hectare. Seasonal family labor supply was found to be critical in determining the maximum level of total gross margins attainable by the farmer from cropping activities. Although rice is the only feasible rainy-season crop on bas-fond land, this result implies that price policy alone may not stimulate expanded or intensified rice production. However, higher producer prices and a more productive technological package for rice would increase yields and help justify further investment in water control.

The policy recommendations of this study stress the need (1) to de-emphasize major investments in dam irrigation and to give priority to partial water control and rainfed agriculture, (2) to develop a package of improved rice production practices using the Farming Systems Research approach, and (3) to revise the producer price of paddy as an incentive to domestic rice farmers.

In memory of my late Father,

"SOUOP" TAGNE

who taught us basic survival skills

and

to my Mom,

NJIKE

for her support and understanding.

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Turning to the field phase of this research project, I wish to express my immense gratitude to the farmers who willingly sacrificed their time to supply the data for this study. My thanks go also to all the four enumerators and two office assistants who worked to make this research project a successful one. Among my colleagues in the MSU research team in the EORD, a commendation is due to Drs. David Wilcock and Gregory Lassiter and Kifle Negash for their encouragement and help in planning and carrying out this research. Thanks also to all the Upper Volta government officials in the study area and at the central level whose support and assistance was invaluable.

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LIST OF ABBREVIATIONS AND ACRONYMS

ARCOMA = Atelier Regional de Construction des Matériels Agricoles (Regional plant for the manufacture of agricultural tools)

AVV = Autorité des Aménagements des Vallées des Voltas (Volta bottom land Development Authority)

BAEP = Bureau Analyse Economique et Planification

CENATRIN = Centre National pour le Traitement de l'Information (National Center for Data Processing)

CERCI = Centre d'Expérimentation du Riz et des Cultures Irriguées (Research Center on Rice and Irrigated Crops)

COREMMA = Cooperative Régionale de Montage de Matériels Agricoles

CSPPA = Caisse de Stabilisation des Prix des Produits Agricoles

DER = Developpement des Entreprises Rurales

EORD = Eastern ORD

FAO = Food and Agriculture Organization of the United Nations

FSR = Farming Systems Research

GDP = Gross Domestic Product

GNP = Gross National Product

GOUV = Government of Upper Volta

GM = Gross Margin (gross income minus the variable expenses attributable to that enterprise)

IITA = International Institute of Tropical Agriculture

IMF = International Monetary Fund

IRAT = Institut de Recherches Agronomiques Tropicales et de Cultures Vivrières (Research Institute on Tropical and Food Crops)

OFNACER = Office National des Céréales (National Cereals Agency)

ONBI = Office National des Barrages et de l'Irrigation (National Agency for Dams and Irrigation)

ORD = Office Regional de Development (Regional Development Office)

SAED = Société Africaine d'Etudes et du Developpement (Private Research Consulting Firm)

SATEC = Société d'Aide Technique et de Coopération (French Rural Development Agency)

S/M/C = Sorghum/millet/cowpeas

SMIG = Salaire Minimum Interprofessional Guaranti

SOVOLCOM = Société Voltaïque de Commercialisation (Voltaic Marketing Organization)

TAC = Technical Advisory Committee

TGM = Total Gross Margin

USAID = United States Agency for International Development

UV = Upper Volta

Note: Currency unit = CFA (Communauté Financière Africaine)
US $1 = 220 CFA (average exchange rate in 1980)

Weights and Measures: Metric system was used in this study

mm = millimeter
ha = hectare
kg = kilogram
T = ton
km = kilometer
^oC = degree Celsius
km^2 = square kilometer

CHAPTER ONE

INTRODUCTION

The objective of this chapter is three-fold. First, to describe the geographic and socio-economic characteristics of Upper Volta, particularly the Eastern Region, for those who are not familiar with them. Second, to outline the salient features of agriculture in Upper Volta which are pertinent for understanding agricultural problems in the Eastern Region of the country. Third, to present the objectives of the study and the organization of the dissertation.

1. THE COUNTRY

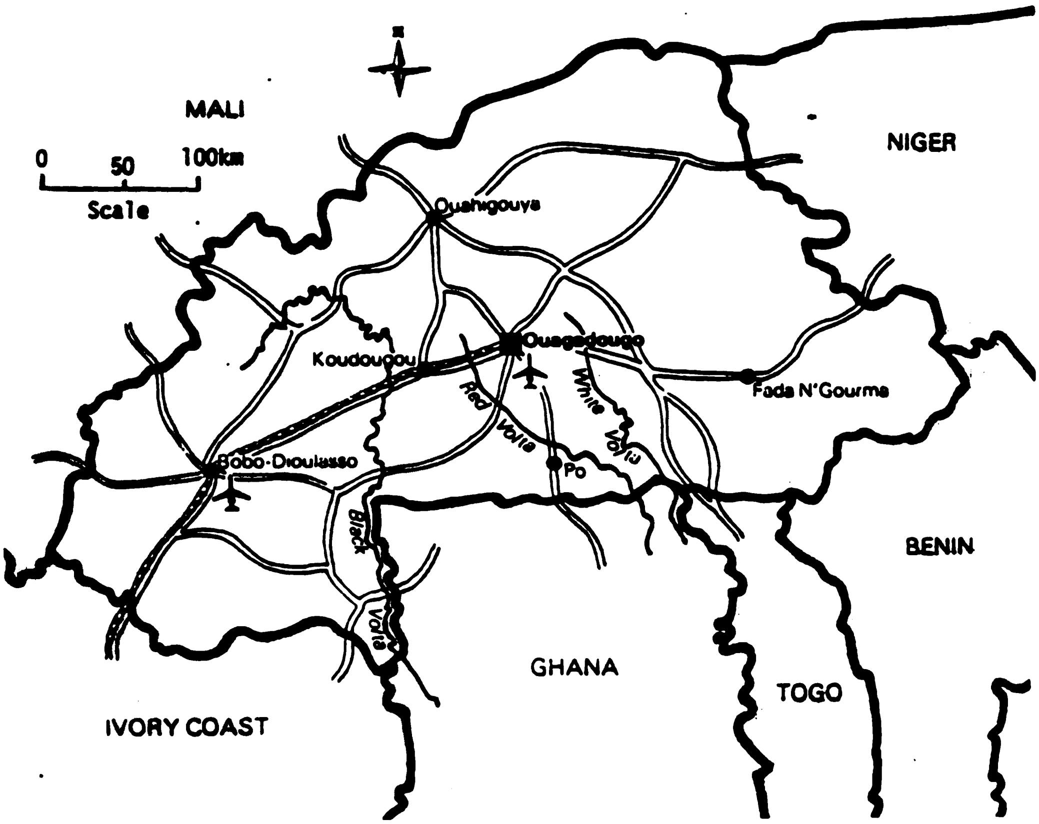
1.1. General Description

Upper Volta is one of the four landlocked Sahelian Countries in West Africa, the other three being Chad, Niger and Mali. Upper Volta is bounded along its northern and western borders by Mali. Niger forms the eastern boundary and the southern boundary is shared by Benin, Togo, Ghana and Ivory Coast(see Map 1.1).

Official estimates indicate a total population of about 6.15 million in 1980, which makes Upper Volta the most densely populated country in the Sahel. The population is unevenly distributed, varying from a density of 10 persons/km^2 in the Volta valleys to 40 persons/km^2 in the

AFRICA

UPPER VOLTA



MAP 1.1 UPPER VOLTA INTERNATIONAL BOUNDARIES

Source: Adapted from Martin Greenwold Associates, Inc., "Maps on File", 1982.

Mossi plateau in Central Upper Volta (IFAD, 1981). An important implication of this variation in population density is the variation in land use intensity throughout the country.

1.2. The Eastern Region

Viewed as a whole, the Eastern Region of Upper Volta is a vast peneplain with the difference between the highest elevation and the lowest elevation being only 101 m. The Eastern Region covers an area of 49,992 km^2 which represents about 18 percent of the total area of the nation (Mehretu and Wilcock, 1979). Because of the flat topography, the drainage system in the Eastern Region is very poor resulting in a large number of saucer swamps, generally called bas-fonds, found along many of the permanent to semi-permanent rivers.

Two main categories of bas-fonds can be distinguished: (i) improved bas-fonds and (ii) traditional bas-fonds. According to Weldring (1979), 224 hectares of the first category and 379 hectares of the second are already under cultivation, but about 2,187 hectares could possibly be put under cultivation. Many organizations are involved in bas-fond land development in the Eastern Region--they include the FAO, the C.T.S. (a Swedish project) and the D.E.R. project (Partnership for Productivity project).

The dominant characteristics of the climate are sustained heat (average temperatures around 33°C can be expected in the hot season) and seasonal rainfall. The alternate north-south movement of the continental air masses, as they follow the annual migration of the sun, bring about sharp periodic differences in rainfall. Two seasons can be distinguished: a short rainy season running from June to September (rains are heaviest

in August) and a long dry season running from October to May. However, December, January and February are relatively cool because of the passage of the harmattan (a seasonal wind from the north). Rainfall varies between 1,000 mm in the southern part of the region to 600 mm in the northern part (Mehretu and Wilcock, 1979). Together with the variation in population density, these climatic characteristics are important determinants of the land use pattern in the Eastern Region.

The population of the Eastern Region of Upper Volta is estimated at about 443,000, which represents only 7 percent of the national population. It is one of the least densely populated areas in the country. The population of the Eastern Region comprises the following ethnic groups: Gourmantché (64 percent), Mossi (28 percent), and Peuhls and Others (8 percent). These groups are differentiated by their traditions, customs, and languages. However, common to all these groups is the fact that they live in small villages made up of several compounds which contain members of a family or close relations (Swanson, 1975).

1.3. The Economy

Upper Volta is recognized as one of the poorest countries in the world. Living standards are very low, as illustrated by an average life expectancy at birth of 39 years and an adult literacy rate of only 5 percent. The 1980 GNP per capita was 210 dollars (World Bank, 1982). Although heavily rural and agricultural, Upper Volta's agricultural production has been declining in real terms over the past decade, -1.2 percent between 1970 and 1979 (World Bank, 1982). According to the World Bank Development Report, 1981, the distribution of GDP in 1980 was as

follows: 40 percent agriculture, 18 percent industry, 13 percent manufacture and 29 percent services. In 1980 the exports of agricultural products accounted for 87 percent of total export earnings. The same World Bank report indicates that capital equipment constituted 29 percent of total import bill while food made up 22 percent of the imports.

The strong trading links between Upper Volta and France have continued since independence. Together with Ivory Cost, France was still the main trading partner of Upper Volta in 1980. The economic bonds between Upper Volta and the other former French colonies in West Africa are very weak, despite a common heritage and common interests. The main exports of Upper Volta are livestock, oil seeds and cotton lint; and on the import side, major trade items include capital equipment, industrial raw materials, foodstuffs and chemicals.

No national accounts have been published since 1975. However, according to IMF estimates, the share of commerce increased from 1975 to 1978 from 15 to 32 percent, while agriculture declined from 45 to 38 percent. Growth of GDP at constant prices has been estimated at 4 percent in 1978 after a 7 percent high in 1977 (World Bank, 1981). The rate of inflation measured on the basis of the price index for an African family in Ouagadougou was estimated at 32.9 percent in 1977 and 30.5 percent in 1980 (IFAD, 1981).

1.4. The Agricultural Sector

Agriculture (including livestock) plays a commanding role in the daily life of the people of Upper Volta and is by far the main element in the country's economy. Although somewhat less than 33 percent of the entire land area is classified as arable, nearly 90 percent of the population is dependent on agriculture as a livelihood (IFAD, 1981).

Upper Volta has a complex geographical structure and a wide variety of climate. Following an IFAD report (1981), Upper Volta can be divided into four regions in terms of its agricultural potential: (i) the southwest with relatively fertile soils, moderate population density and an average rainfall of 900 mm; (ii) the Mossi plateau with poor soils and a high population density (nearly 40 persons per km^2); (iii) the southeastern savannah zone with characteristics similar to those of the southwest zone, but poor road infrastructure; and (iv) the dry northern zone where livestock is the major activity.

Upper Volta is currently in its third five-year development plan (1978-1982).[1] The first priority common to all three development plans is rural development. The main objectives of the government's policy for the rural sector include: (i) to develop rainfed agriculture by promoting improved farm practices, while integrating cropping and livestock activities; (ii) to step-up migration from the densely populated and relatively infertile north-central plateau to areas in the West and Southwest which have low population densities and a good agricultural potential; (iii) gradually to intensify the development of swampland and irrigated agriculture, thus helping to protect the nation against the catastrophe caused by drought; and (iv) to ensure national self-sufficiency

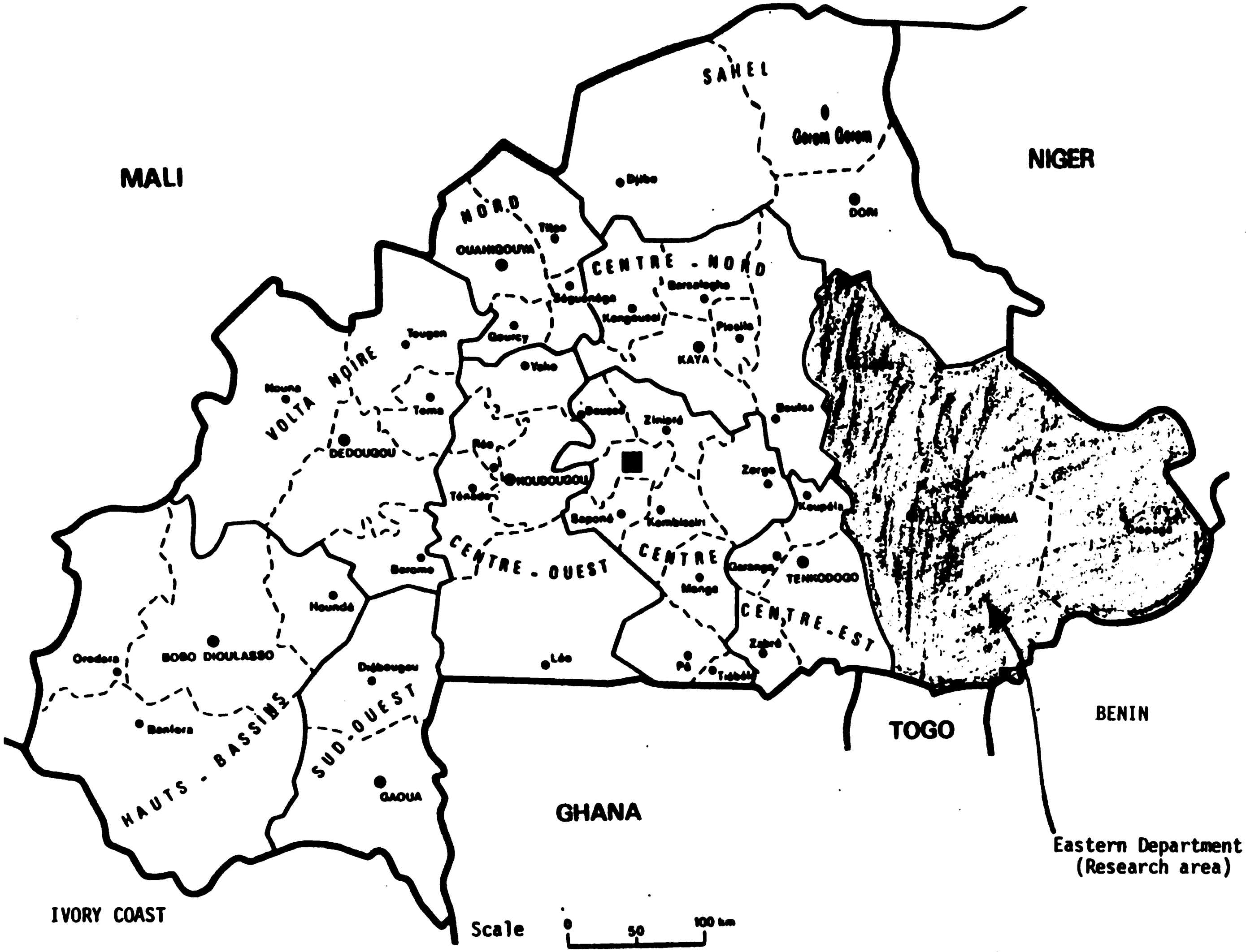
[1] The third five-year plan was not yet officially released as of mid-1980. However, the plan's Avant Projet is generally used as the guideline for development programs.

in food crops, particularly by replacing rice imports (Third five-year Development Plan, 1978). These priorities are pursued by a variety of projects financed by external donors.

The country is divided into eleven Regional Development Offices (ORDs), one for each préfecture except for the préfecture of the Hauts-Bassins in the Southwest which contains two ORDs (See Map 1.2). The ORDs, which were created in 1967, enjoy some autonomy with respect to project planning and implementation and use of resources within the broad policy guidance of the Plan. The objectives of the ORD structures were defined as promotion of agricultural production, development of rural infrastructure and equipment, and social development.

Agricultural production practices in Upper Volta are characterized by extremely low yields, particularly for the food crops. About 90 percent of the cultivated land in Upper Volta is devoted to cereal crops. Yields achieved in Upper Volta are among the lowest in the world; grain crop yields range from 300 to 800 kg/ha, and yields for cotton are about 500 kg/ha. However, research station cereal yields range upward from 1,000 kg/ha (IRAT, IRCT, 1979). For most food crops, field activities are all done by hand. Chemicals and fertilizers are rarely used on food crops.

The fact that high-yielding varieties of food crops have not been developed to any important degree is a reflection of the neglect of research in this area. The government still does not have an organized research structure. Research responsibilities are still assumed by the French-style vertically organized crop-specific research institutions (IRAT, IRCT, ORSTOM, etc). This applies to virtually all agronomic as well as livestock research. More recently, international research



MAP 1.2 UPPER VOLTA ADMINISTRATIVE DIVISIONS
Source: Institut géographique National

institutes--ICRISAT, IITA and WARDA--are undertaking research on farm production systems, looking both at the cropping and socio-economic aspects of the systems. For more details, see ICRISAT, 1980; IITA/SAFGRAD, 1980; and WARDA, 1979.

Animal traction for land preparation and cultivation is being promoted as a means to increase agricultural production. However, data on the impact of animal traction on the productivity of land suggest that only modest results have been achieved thus far. For more details on animal traction in West Africa, see Kline, et al. (1969); Sargent, et al., 1981; and Barret, et al., 1982.

As a result of food deficits and nutritional problems in Upper Volta, the government initiated a multiplicity of high priority programs and projects aimed towards the recuperation of lowlands. The Fonds de Développement Rural (FDR) and L' Office National pour les Barrages et Périmètres Irrigués (ONBI) are the two main institutions in charge of the above programs, working in close collaboration with the ORDs. One important implication of these programs is that rice, which is the main crop grown in these lowlands or bas-fonds, has seen its domestic production increased in recent years. Although this is an attempt to match the increased local demand estimated at 8 kg/inhabitant/year, rice output has fallen short of required levels (see Table 1.1). Domestic rice production only covers about 65 percent of domestic demand.

2. PROBLEM SETTING AND NEED FOR THE STUDY

As one of its first drought recovery projects in the Sahel, USAID provided substantial material and technical assistance to the Eastern ORD.

TABLE 1.1

HISTORICAL EVOLUTION OF THE RICE SECTOR IN UPPER VOLTA[1]

Year	Paddy Production ('000 mt)	Rice Imports ('000 mt) (milled rice)
1961	31	2.341
1962	30	3.624
1963	45	2.183
1964	25	4.765
1965	34	3.222
1966	36	4.084
1967	34	7.459
1968	44	1.327
1969	40	1.475
1970	34	2.546
1971	34	1.127
1972	37	1.598
1973	30	1.000
1974	32	18.700
1975	39	16.200
1976	40	15.400
1977	41	18.382
1978	28	10.237
1979	47	25.455
1980	29	29.000

[1] Source: FAO, 1965-81a&b.

Michigan State University's contract[2] provided the technical assistance component of the USAID Integrated Rural Development Project in the Eastern ORD. This technical assistance was a combination of program implementation and applied research for improving program design and execution. The project team included a production economist whose task at the beginning of the project (1977-1979) was to organize and coordinate a survey of 480 farmers throughout the EORD, focusing primarily on dryland crop production and use of animal traction. In the course of the implementation of the project, the following concerns emerged as priority activities of the EORD:

1. Increased water control in order to satisfy human consumption and agricultural production needs;
2. As most foodstuffs consist of grains produced under dryland conditions, vagaries of weather often cause shortages. The situation has been particularly serious in the the 7-8 years as a result of the drought that struck the whole Sahelian zone. Hence, it was decided that priority should be given to areas with more reliable water availability, namely the bas-fond areas;
3. Promotion of rice production in the seasonally flooded bas-fond lands.

In Upper Volta, rice still has a marginal share in the average diet of the population. Average per capita consumption is about 8 kg a year.

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[2]Michigan State University's four-year contract to provide the technical assistance component of the USAID Integrated Rural Development Project in the Eastern ORD of Upper Volta was signed and went into effect on May 1, 1977 under the reference number AID/Afr-C-1314.

However, although the staple food is sorghum and millet, rice is of growing concern to the government of Upper Volta (GOUV) because in towns, rice is rapidly replacing sorghum and millet in the diet. This change in food habits of the urban population caused rice imports to soar from 2,341 tons in 1961 to about 29,000 tons in 1980. Although these quantities may seem small, Upper Volta has a large trade deficit, with the value of exports averaging only a third of the value of imports. This provides an incentive for the country to cut imports of foods which it can produce satisfactorily itself (WARDA, 1981). Rice is therefore a high priority investment for the GOUV, the EORD and many donor agencies (USAID, World Bank, SATEC, etc.).

Despite the need to expand rice production in Upper Volta in general and in the Eastern Region of the country in particular, very little is known about the productivity and/or the efficiency of resources committed to bas-fond rice production under alternative cropping systems. Until very recently little was known about the agricultural systems of small farmers in West Africa. In the past decade various organizations and research groups have begun to study these systems, mainly in the coastal countries. Few studies have included the Sahelian countries. But the drought in the early 1970's focused attention on these countries. Before programs aimed at increasing rice production can be proposed or instituted, it is first necessary to understand the existing farming system and at least attempt to predict the reaction of that system to various policies. However, research reports on the economy of bas-fond rice production in Upper Volta are very few.

Two studies by WARDA (1975 and 1979) show that intensive irrigated rice growing was introduced in Upper Volta through technical assistance from Taiwan. Under an agreement signed in 1964 by the governments of Upper Volta and Taiwan, development work was carried out at Boulbi and Louda from 1965 to 1968, downstream of already existing small dams. Yields of 4 to 6 tons of paddy per hectare were obtained in both areas. Unfortunately, the water supply in those areas was inadequate to produce two crops a year. In any case, rice production in the bas-fond areas per se was completely overlooked.

Other rice research reports[3] on different ecological areas in Upper Volta are available, but they emphasize purely agronomic issues (varietal improvement, fertilizer trials, pest control, etc.). Moreover, little empirical study has been done of the bas-fonds areas. How farmers operate in terms of resourse use and production techniques, their cost of production both in absolute and relative terms, and their performance in terms of output and incomes, are questions which have been overlooked. However, it is clear that the production of a staple crop in West Africa will respond not only to the availability of fertilizers and pesticides, but also to price incentives. It is therefore important to examine the relative profitability of different crops, particularly of sorghum and millet and maize relative to rice, in Eastern Upper Volta.

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[3]Angladette, 1966; IRAT, 1980; Mayer and Bonnefond, 1973; and CERCI, 1975–78.

3. OBJECTIVES OF THE STUDY

The general goal of this study then was to provide baseline microeconomic data necessary for regional planning and for suggested improvement in farm practices, with a special focus on the relative position of rice vis-a-vis other major crops in the cropping system of farmers in the bas-fonds areas of the Eastern Region of Upper Volta. This study will serve at least two needs:

1. To provide data for planning purposes and ex-ante agricultural policy evaluation.
2. To provide technical and economic knowledge to researchers, extension services and farmers. It is generally agreed that small farmers use their limited resources and knowledge efficiently in their traditional farming systems. To improve the small farmer's welfare or income, according to this "efficient but poor hypothesis," it is necessary to provide improved technology and better information on market prices and prospects.

This study analyzes data collected from a sample of 116 farmers in four different bas-fonds production systems. Four representative farms, one in each production system, are developed for more detailed analysis of production, labor use and income.

More precisely, the objectives of this study are:

1. To diagnose the problems and constraints on bas-fonds rice production in the Eastern ORD. Information from this diagnostic stage can be used to guide experiment station research such as the development of new technological components,

particularly varieties and water control methods. The diagnostic effort can also uncover constraints at the farm level which are the result of policy decisions or problems in policy implementation (e.g., problems of input availability, product marketing, management of water at the dam sites, etc.).

2. To determine the profitability of rice growing relative to other crops in the farming system. In assessing the relative profitability of different crops, two elements must be considered: relative input and output prices and relative yields. Simple enterprise budgets are developed for this purpose.

3. To determine the relative labor requirements of different enterprises both in terms of total labor use and labor profile throughout the cropping season.

4. To evaluate existing cropping enterprises within a whole-farm framework through the development of linear programming models for the four representative farms. Optimal farm plans for each of the four representative farms are obtained under several alternative combinations of resource levels, resource requirements, and objective function coefficients. The shadow prices of different resources and constraints are also analyzed for the four production systems.

5. To discuss the policy implications of the analysis for future programs in the bas-fonds areas of the Eastern Region in particular and of Upper Volta in general.

4. ORGANIZATION OF THE DISSERTATION

The research approach and data collection methods are presented in Chapter Two. A descriptive profile of agricultural production systems in the Eastern Region is presented in Chapter Three. Chapter Four contains the analysis of crop enterprise budgets for the four production systems, both from the financial and the economic point of view. An overview of the whole-farm analytical model is presented in Chapter Five. In Chapter Six the evaluation of the basic model, the presentation of results, and the sensitivity analysis are given. And finally, in Chapter Seven, policy implications of the findings are discussed.

CHAPTER TWO

RESEARCH APPROACH AND DATA COLLECTION METHODS

As noted in Section 2 in Chapter One, the farm level survey of agricultural production in representative bas-fonds was requested by the EORD in order to complement the 1978-79 farm survey, which focused primarily on dryland crop production. The growing interest of the EORD in promoting bas-fond rice production was motivated by the large amount of potentially highly productive land of this type, only a small portion of which was currently being cultivated. The 1980-81 survey carried out in this study was intended to fill important gaps in the present knowledge of the economics of bas-fond production in the Eastern Region.

1. SCOPE OF THE STUDY

Primary emphasis was given to cropping activities on fields located in the bas-fonds areas, rice being the chief crop grown. In order to understand the potential for increasing bas-fond production, it was also necessary to devote attention to household fields outside the bas-fonds, and to other important household activities such as those involving livestock and off-farm employment. However, detailed input/output data were not collected for these activities.

Input-output and sales data were collected for all fields in the sample. Information was also obtained on the full-range of income-earning activities other than crop production. The role of non-cropping activities in terms of labor time and earnings was ascertained in order to assess the potential for expansion or/and intensification of bas-fond production.

2. RESEARCH APPROACH

Three sources of information on farmer circumstances were used:

1. Background information on the farmer's environment from secondary sources (research institutes, government reports, meetings, etc.).
2. Field surveys involving structured interviews with farmers by enumerators.
3. Personal interviewing and observations in farmers' fields and their surroundings to obtain information on the agricultural production processes.

The author arrived in Upper Volta on May 26, 1980. In-country orientation consisted of meetings in Ouagadougou with officials from USAID, Agricultural Services in the Ministry of Rural Development, SOVOLCOM, the Department of External Trade of the Ministry of Commerce and the Upper Volta Rural Development Fund. The objective of these contacts was to gather information on quantifiable parameters likely to affect farmer decision making such as price trends, production trends, and import trends of rice since 1961, and also to gather information on national rice marketing and price policy. This secondary information was considered useful for drawing policy implications from the analysis of farm level data. Orientation in the EORD itself took place in the form of:

1. Meetings with the EORD personnel including the director and the heads of the Bureaus of Economic Analysis/Planning Agricultural Production, and Rural Works.
2. Attendance at monthly ORD sector chief meetings.
3. Extensive travel to major bas-fond production areas to develop familiarity with their salient agronomic features and to initiate contact with farmers with significant bottom-land production in these zones.

The main objective of data collection was to provide information on the inputs and outputs of the agricultural production processes at work in the research area. The inputs include all labor, land, capital and technology. Technology was understood here in the broad sense of the timing and nature of operations, as well as the implements used. Data on the outputs include total yield of the major crops grown as well as the disposition of these crops. An effort was also made to ascertain the role of livestock and non-farm activities in terms of labor time, other costs and earnings in order to assess the potential for expansion or intensification of the cropping enterprises studied. In brief, the study was seeking to obtain all the data necessary for calculation of the factor requirements for each output under a given technology, the returns to factors in different enterprises, and the opportunity cost of resources used.

3. THE FIELD RESEARCH SITES

This section deals with the choice of research sites, their characteristics and population. From an administrative standpoint, the EORD covers the whole Eastern Department with its headquarters being Fada N'gourma. The EORD itself is divided into eight sectors, and the sectors are in turn divided into 24 sub-sectors.

The major bas-fond areas in the EORD were visited by the author accompanied by Dr. Wilcock, MSU field team leader and Mr. Lompo, Chief of Section, Aménagements Hydro-Agricoles, EORD, during the first two weeks of June, 1980. After interviewing senior ORD personnel in Fada N'gourma, the author consulted production maps and tables as well as available literature, e.g., the reports by J. R. Weldring (1979) on watershed management projects for agricultural purposes in the EORD and the report by D. Wilcock and A. Mehretu (1979) on Planning Regional Development for the EORD of Upper Volta. The following areas were then visited:

— Zanre, Dianga, Tamosgo and Lantaogo in the Diabo sector;
— Komboari, Panpangou I and Panpangou II in the Fada sector;
— Sampieri, Sambalgou, Botou, Gangana, Koyenga and Boudieri in the Kantchari sector;
— Tapoa, Mordeni, Tanla, Logobou, Kouakouli, Kalbouli, Bomoandi and Dangou in the Diapaga sector.

These areas were visited in order to develop familiarity with the salient features of the bas-fonds and the farmers involved in these bas-fonds. During the visits, the following information was collected:

- estimated number of farmers involved in each bas-fond;
- degree of mastery of water in each bas-fond;
- method of land preparation; and
- use of manure and/or fertilizer.

At the end of the reconnaissance survey, five basic criteria were used to select the villages or areas to be studied. First the location chosen had to present great potential in terms of bas-fond development and to be representative of either traditional bas-fonds or improved bas-fonds. The basic objective was to select an area with characteristics such that rice activity reflects a choice between viable enterprises (millet, sorghum and possibly some grain legumes or cotton) as opposed to an area where rice represents the only way to earn cash. Second, the area chosen needed to be in a region that was of interest for future policy intervention since the purpose of the exercise was to be of use in such planning. For this reason, areas for possible consideration were confined to the areas where there were already extension agents involved in bas-fonds development. Third, in the location chosen, there had to be at least 30 farmers engaged in rice growing activity in the bas-fonds during the cropping season 1980/1981. Fourth, the research site had to be accessible to a fairly good road leading to a major consumption center. This restriction was made to ensure that the farming system studied had an outlet for food grains and cash crops. This restriction was also imposed in order to facilitate the supervision of the enumerators by the principal investigator. Fifth, farmers in the research site chosen had to be willing to cooperate in order to aid in the successful completion of the study.

On the basis of these criteria, the following areas were selected as the research sites:

- Zanre in the Diabo sector;

- Komboari, Panpangou I and II in the Fada sector;
- Kalbouli and Kouakouli in the Diapaga sector; and
- Tapoa in the Diapaga sector.

(See Map 2.1 for the location of these research sites.)

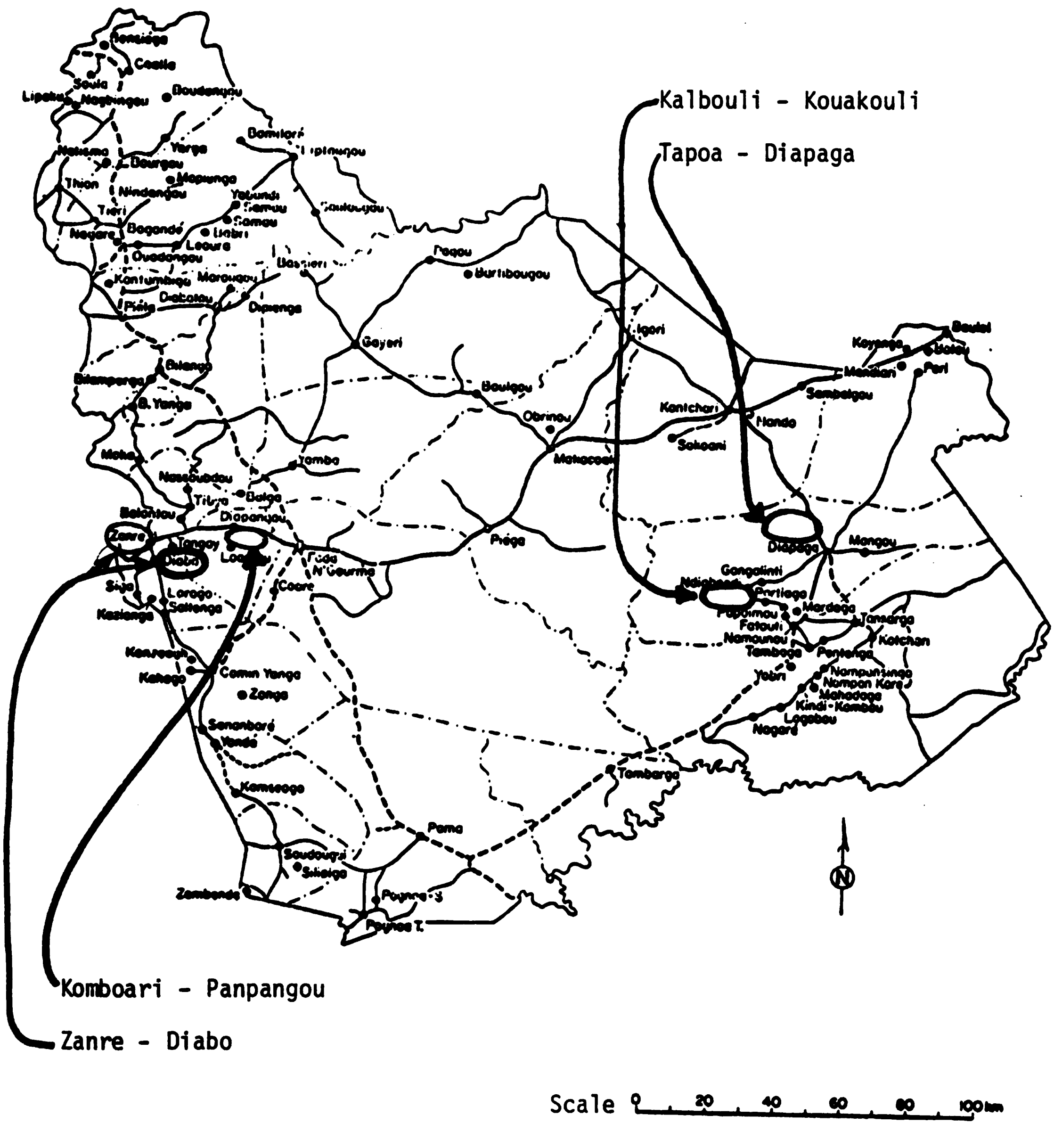
4. SELECTION OF SAMPLE FARMERS

The unit of data collection adopted for this study was the "household," defined here as the aggregate of persons who normally reside together (not necessarily under the same roof), eat together and have common granaries. The members of a household are generally bound by ties of kinship, although a household member may be non-relative as well.

After the selection of research sites, the first task was the selection of sample households. The major concern in household selection was to include households which would provide truthful and complete information, as well as representative data. While random sampling helps ensure obtaining the latter, the first two elements can never be taken for granted. So a two-step approach was adopted for the selection of the households retained for the study.

First, a random sample of 35 to 40 households was selected for each of the production systems to be studied. In the second stage, households were dropped from the final sample for any of the following three reasons:

- lack of cooperation;
- cases where the household was obviously unrepresentative of the population, e.g., village chiefs;



MAP 2.1 LOCATION OF RESEARCH SITES
(all in circles)

Source: BAEP, ORD de L'est, Fada N'gourma

- cases where the information obtained at the inventory stage (household and field inventory) was obviously unreliable.

So, with this procedure, the final sample retained for the survey consisted of:

26 households in Zanre - Diabo - System 1

30 households in Kalbouli - Kouakouli - System 2

30 households in Komboari - Panpangou - System 3

30 households in Tapoa - System 4

116 total households

5. INTERVIEW FREQUENCY

Since it was anticipated that the most important input would be labor, detailed data on labor utilization was collected. And since the amount of labor furnished by each worker may be highly variable over the agricultural season and since the timing of agricultural labor input may be as important as the quantity, it was important to have some form of data collection procedure operating at or around the time the labor is being performed.

The data collection approach usually followed in these cases is the cost route survey which is that of Spencer (1972), Norman (1973) and others who used multiple visits in their production economics research.

Other methods[1] used for collecting micro-level data from farmers include: (i) model or case farm study, (ii) farm account books, and

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[1] For a comprehensive discussion of these methods, see Spencer (1972).

(iii) the farm business survey. The model farm study and the farm account book methods were ruled out in this study because in the first method, farms studied are atypical and therefore cannot be used to represent a given system of production; and the latter method was inappropriate due to the illiteracy of farmers, which means that they cannot and do not keep records. The options remaining for collecting micro-level data were then the farm business and the cost route methods. In the farm business approach, the enumerators visit the farmers once or twice to complete the survey questionnaire. This approach usually covers a large sample of statistically selected farmers, hence minimizing sampling errors. But it was this author's view that this approach could result in high observational errors, mainly with respect to the labor input profile. So, because of the objectives of this study and the type of analyses planned, the cost route method was chosen.

Critics of the cost route survey have raised the issue of its cost effectiveness, and the issue of the sustained interest of the farmer during repeated interviews. The cost route method has been widely used in farm management and production economic studies carried out in Africa and has been modified over the years. More precisely, the frequency with which the farmers are formally interviewed depends on the researcher's confidence in the ability of farmers to remember the required details of their past operations.

In an attempt to incorporate the best features of farm business surveys and cost route surveys, our approach to data collection, later on referred to as activity approach,[2] employed less intensive methods of family labor data collection. We shifted from weekly or bi-weekly interviews of sample farmers to interviewing them once for each of the major field activities (land preparation, planting, weeding, etc.) on a plot by plot basis. Since it was felt that sample farmers would be able to remember the details, particularly of labor input for periods longer than one week, it was decided that they would be visited at weekly intervals but that actual recording of labor input would only take place at the end of each major field activity. However, weekly visits without any recording involved did help in terms of establishing a strong rapport between the enumerator and the sample farmers while increasing the chance for accurate information to be collected. These visits were also very helpful in deepening the author's understanding of the production processes and of farmers' goals and priorities.

For hired labor and for expenditures on and use of purchased non-labor inputs, monthly interviews were considered adequate. In contrast to flow data, stock variables are susceptible to measurement by "one shot" interview, at least in theory. Examples pertinent to this study are land holdings, farm implements, and livestock ownership. Although some of this information may be sensitive, these data can be gathered with accuracy in one or two interviews. In addition to flow and stock questionnaires, an additional questionnaire was administered by the author himself through personal interviewing. This questionnaire tried

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[2]While the activity approach is promising, it may not reduce survey costs unless there is detailed information available on the cropping calendar of sample farmers. But data processing costs are reduced and the researchers can benefit from insights gained through informal interviewing.

to get at attitudes, objectives, the relative importance of various enterprises, and reasons underlying particular production practices. One or two interviews were conducted per household on a sub-sample of farmers (five farmers per research zone). It was anticipated that this questionnaire would provide an essential context for interpreting the quantitative survey data and fill in gaps which the stock and flow questionnaires do not or cannot cover. Table 2.1 gives the details about farm recording schemes used in this study.

During the reconnaissance survey, it was noted that if there were two or three wives or an adult son in a household, each responsible for a plot, there were then as many as five decision makers within the same production unit: each wife as a maternal head of her family and as independent manager of her plot, and the household head or the sample farmer making overall "policy" decisions over the land in general, the main sorghum/millet field, and some or all of the individual plots. The practical significance of this for data collection was that reliable data on labor use or cropping practices could only be obtained from the household member who actually did the work or who was in charge of the plot. So in this study, efforts were made to interview directly the household member responsible for the plot under consideration.

6. ENUMERATOR TRAINING AND RESEARCH CALENDAR

Enumerators were recruited from the set who previously served in the 1978-79 farm survey carried out by the MSU team. The four enumerators recruited for the bas-fond study participated in a four-day training course during July, 1980, consisting of instruction in the purpose

TABLE 2.1

DETAILS OF THE SCHEDULES USED FOR COLLECTING
AGRO-ECONOMIC DATA IN THE EORD, 1980-81

Type of Data	Frequency	Remarks
1. Plot inventory	Twice	At the beginning and end of survey
2. Household census	Once	Details about each member in each sample household
3. Family labor	For every field activity	Recorded on a plot by plot basis
4. Non-family labor	Monthly	Plot by plot
5. Non-labor input use	Monthly	Plot by plot
6. Farm implement inventory	Twice	Beginning and end of survey
7. Harvest records	Every 7-14 days	Total off-take recorded on a plot by plot basis
8. Sales records	Monthly	Recorded type and value of every transaction
9. Price information	Every 12-15 days	Price details of major food items transacted by villagers in their village
10. Area measurement	Once	At the end of survey
11. Non-farm activities	Once	For all members of sample households, recorded actual activities during agricultural season
12. Livestock	Once	Type of livestock, labor requirement, investment and returns
13. General information (qualitative data)	Once	On a sub-sample towards the end of the survey

of the study and its objectives, definition of survey terms, interviewing techniques, how to approach the farmer, delineation of enumerator's responsibility, and practice using the different survey forms. At the end of the training, one enumerator was assigned to each research zone. The number of sample farmers per research zone varied between 26 and 30.

Actual data collection began in July, 1980, with the collection of plot and household inventory data. Resource utilization was obtained according to the schedule indicated in Table 2.1. The enumerators interviewed farmers from July, 1980, through January, 1981. Towards the middle of the harvesting period, a mobile team of two BAEP staff was sent to the research sites to measure sample farmers' fields in collaboration with the enumerator already established in the area.

Because of the importance of close supervision throughout the cropping season, during the months of July-November, a major activity of the author was to visit the enumerators as often as possible. Because of the dispersion of the research sites, great distances and poor roads, this proved to be a time-consuming and often arduous task. On the average, each enumerator was visited on site every 12 days for the first three months (July-September), and every 18 days for the last four months (October-January). The main activities during the author's supervision tours were to:

- ensure that enumerators were on schedule;
- check over completed forms;
- deliver instructions and explanations, and provide guidance;
- ensure a prompt and coordinated delivery of materials;
- help the enumerators in organizing a work schedule; and
- conduct personal interviewing.

In general, individual performance for all the four enumerators during the survey was very satisfactory. Perhaps the single most important factor in successful data collection is staff morale. The author spared no effort in this respect and feels strongly that the investment was justified in terms of the results.

7. DATA PREPARATION AND ANALYSIS

Organizing and editing completed survey forms started as early as in August, 1980, and ran through the month of January, 1981. For each of the 116 sample farmers surveyed, approximately 2,200 completed survey forms had to be sorted, organized and accounted for at the end of the cropping season. Completed survey forms were checked, noting data errors, inconsistencies, and illegible or incomplete responses.

Since the questionnaires used in this survey were not precoded, this necessitated setting up an adequate coding system as each type of survey form was being completed in the field. Two options with respect to data processing were available to the author:

- use of local computer facilities (Centre National de Traitement de l'Information [CENATRIN]); or
- use of Michigan State University (MSU) computer facilities.

The lack of a pool of clerks combined with the fact that CENATRIN was over-committed and therefore not dependable ruled out the first option. Furthermore, the fact that during the processing of the 1978-79 MSU survey data, it was necessary to switch from CENATRIN to the MSU computer facilities with further "conversion" problems and attendant delays was not a precedent to be followed.

With the second option being the only feasible one, all the survey forms were transferred to MSU where all the coding, keypunching and file creation took place. Files were "cleaned" by a combination of computer validation routines, rejection of sample observations and judgments by the author to remove obvious contradictions.

Data analysis began with calculation of means, variance, frequency distributions and modes for the major parameters. This provided a quick impression of variability and extreme values.

The next step was to prepare a set of crop enterprise budgets, which involved computing the following input, output, and productivity measures:

- average yields of major crops produced per hectare (kg/ha);
- per hectare labor requirement per activity for major crops;
- per hectare farm budgets for each major enterprise or group of enterprises containing the following items:
  - a) technical data
    - (1) yield in kilograms
    - (2) kilogram seed rate
    - (3) fertilizer used
      - (a) percent farmers using
      - (b) application rate
    - (4) total labor use
    - (5) average hourly wage for hired labor
    - (6) price per kilogram of major crops
  - b) costs and returns
    - (1) value of output
    - (2) variable costs

(a) seed

(b) fertilizer

(c) non-family labor

(3) gross margin

(4) depreciation on farm implements

(5) net margin to family labor and management

(6) net margin per hour of family labor

A comparison was made of the performances of the crop enterprises, both across the four systems of production being studied, and also with respect to data from IRAT and AVV. This analysis of the relative profitability of the crop enterprises in the different systems was a necessary first step in identifying the major production constraints and possibilities for improved productivity.

The final step in the data analysis consisted of looking at the implications of re-allocating farmers' resources using the linear programming (LP) technique. LP allows all the constraints and revenue considerations affecting agricultural production in the EORD to be incorporated in a simultaneous framework. The underlying hypothesis is that the optimizing framework of LP can help explain why farmers typically engage in some activities more than others, given the resource constraints they face, the particular desires they may have concerning production (such as on-farm self-sufficiency in sorghum/millet), and the desire to make the most of what they have.

8. DATA LIMITATIONS

In a study of the economics of rice production in the bas-fonds of the EORD, many factors are likely to affect the quality of data collected and thus the inferences that can be drawn from such data. Among these factors are:

- the cross-sectional analysis problem;
- the representativeness of the systems studied;
- the reliability of farmers' responses;
- the problem of estimating labor time; and
- the problem of estimating quantities of other outputs and inputs.

8.1. Cross-Sectional Analysis Problem

Because only one season's data was used in the analysis, the findings must be interpreted accordingly, taking into consideration specific conditions (e.g., rainfall) that prevailed during the survey period. Coupled with this problem is the fact that the study looked at the use of bas-fonds only during the rainy season. A longitudinal analysis where data are collected from the same observational unit at successive points in time would have been desirable to enable us to take into consideration changes over time in the farmers' environment. However, this was not possible in this study.

8.2. Representativeness of the Rice Production Systems Studied

No statistical procedures were employed to choose the systems studied. Since our main objective was not to estimate response functions, but rather to illustrate the costs and returns of alternative techniques of producing rice currently existing in the EORD, a purposive choice of the systems to study was appropriate.

8.3. Reliability of Sample Farmers' Responses

Despite the fact that the objectives of the study were clearly explained to the farmers and that at the onset of the study they all agreed to cooperate throughout the study, from time to time certain farmers were reluctant to give out the information requested. Their main allegations were that "prior investigations have yielded no visible fruit." When this problem occurred in an area, the enumerator in that area would report the case to the author. In all the four cases reported, the author, with some persuasion, was able to re-convince the farmers of the value of their continued cooperation. Frequent informal visits to sample farmers involving no recording coupled with personal interviewing by the author were believed to be very helpful in this process.

8.4. Problem of Estimating Labor Time

To measure field labor use, data were collected separately for family, hired, and social labor on the basis of age-sex category (men, women, children) and activity. Field hours represent the time actually spent by the farmer on the field, not including travel time to and from the field. Because it was not possible to estimate the time the farmer spent in eating or resting when the sun gets very hot or the time gone from a farm operation briefly to set a trap for animals or for other reasons, the time stated as spent on farm work tends to be overestimated. For non-family labor, information on total expenditures, non-wage payments and the wage rates (case of hired labor only) were obtained in addition to field hours.

Work rates may be affected by the age and sex of the worker as well as by the task being performed. Some researchers have used complicated weighting procedures for aggregating the different categories of labor (Spencer, 1972). It is doubtful whether such elaborate weighting procedures are necessary for the following reasons:

- dividing the sample into different age classes may involve substantial errors; the ages often have to be estimated because farmers cannot tell their ages in years with precision;
- from survey results and as Spencer (1972) pointed out, in many parts of Africa, women and children rarely participate in activities in which they are less efficient than adult males. Where they are commonly employed (seeding, weeding, harvesting), women and children are as efficient as men.

Because of the above reasons, coupled with my interactions with sample farmers regarding this issue of relative productivity of different categories of labor, actual field-hours were used in the analysis, i.e., the work productivity indices for all age-sex categories were assumed to all be equal to one regardless of task performed.

8.5. Problem of Estimating Quantities of Other Inputs and Outputs

To estimate farm size, 965 plots were measured towards the end of the harvesting period using tapes and field compasses.[3] The quantity of output was estimated by recording (generally on a weekly basis) the

[3]For description of various techniques of field measurement, see Collinson (1972).

number of units of product leaving the farm and their intended disposal. Most of the containers used to carry the output to the storage were local measures, i.e., baskets, tins, bags, etc. Local measures were also used to collect quantities of inputs such as seeds and fertilizers. For each research site, the amount represented by each local measure was weighed for various products. For each type of container and for each crop, six to eight measurements were taken and the average weight in kg was used to convert all the quantities into kilograms.

9. SUMMARY

The purpose of the field survey was to obtain farm level data in order to estimate the financial costs and returns of the major rice production systems currently existing in the bas-fond areas of the EORD. The multiple-visit activity approach was used to collect input-output data on the major crops from 116 farmers during the 1980-81 crop season. Information was also obtained on the full range of income-earning activities other than crop production, using a single-visit survey technique.

Enumerators were recruited from those who previously served in the 1978-79 farm survey carried out by the MSU research team in the EORD. The four enumerators recruited participated in a four-day training course consisting of instruction in the purpose of the study and its objectives, definition of survey terms, interviewing techniques, how to approach farmers, and practice of using the different survey forms. Enumerators were required to visit farmers weekly but to collect field records only at the end of each major field activity. Field data were periodically cross-checked for completeness and consistency.

Labor utilization data were collected on an activity by activity basis, for both family and non-family labor. Data were recorded in terms of field hours. For non-family labor (hired and social labor), information regarding wage rates, total labor expenditures and the estimated value of payments in kind was also collected. Total production estimates were determined by counting on a weekly basis the number of units of product leaving the field and their intended disposal. Quantities in local measures were converted to kilograms. To estimate farm size, 965 plots were measured toward the end of the harvesting period using tapes and field compasses.

CHAPTER THREE

DESCRIPTIVE PROFILE OF THE AGRICULTURAL PRODUCTION SYSTEMS IN THE EASTERN REGION OF UPPER VOLTA

The purpose of this chapter is to present the organization of agricultural production in the EORD and the problems that it faces, and to look at the profile of sample farmers and rice production systems studied.

1. CROPS GROWN AND DEGREE OF MIXED CROPPING

A total of 22 crops were grown in the EORD, sorghum and millet accounting for about 31 percent of the total number of fields under cultivation in 1980-81, and rice for another 27 percent. Maize and peanuts make up 27 percent (13 and 14 percent, respectively), while soybeans, tubers, bambera nuts, and vegetables account for the remainder. In terms of acreage, sorghum and millet fields account for about 45 percent of the total area under cultivation and rice only accounts for about 19 percent.

Rice was generally grown in pure stands (less than 1 percent of the total area under rice was mixed either with sorghum or millet around the edges of the bas-fonds). Sorghum and millet themselves were either grown in pure stands (about 13 percent of total area under cultivation) or mixed with cowpeas and okra (32 percent of total area under cultivation). Maize accounts for 7 percent of total area under cultivation and is either grown in pure stands or mixed with some banana trees and some vegetables.

Peanuts account for 6 percent of total area under cultivation. Peanuts are either grown in pure stands or mixed with tubers or sesame. Soybeans, tubers and cowpeas grown in pure stands account for the remainder of total area under cultivation.

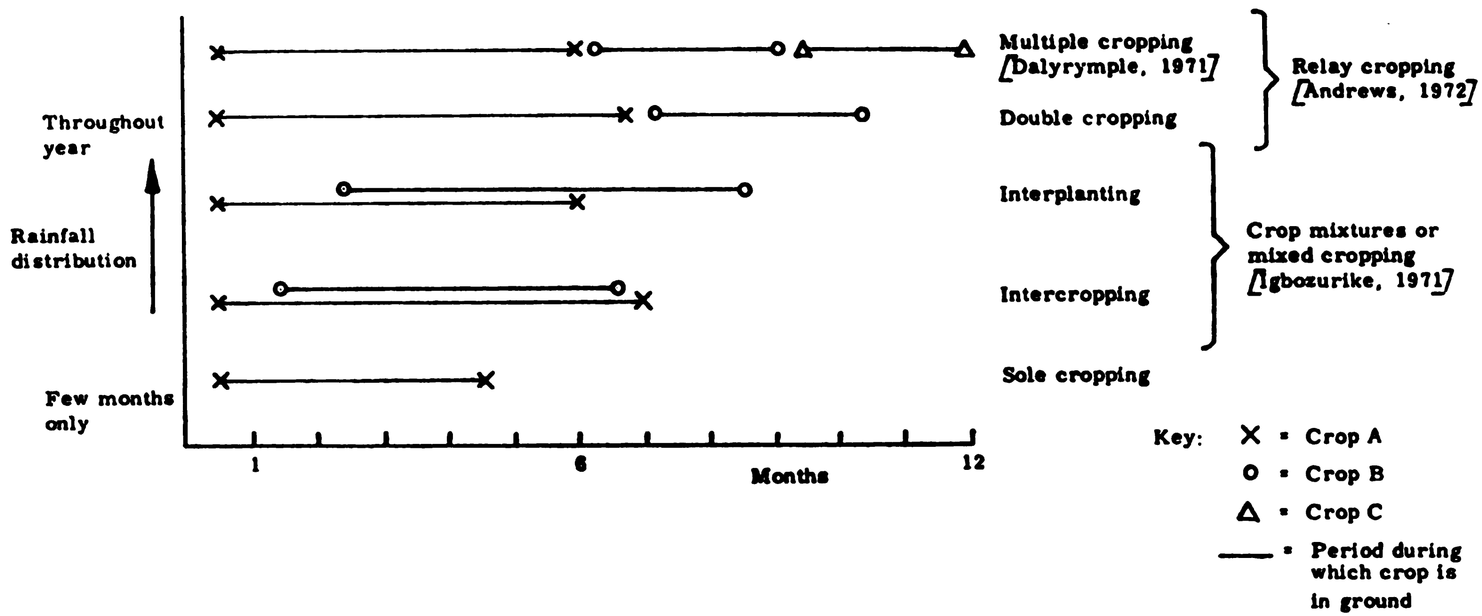
On the average, 57 percent of the cultivated land was sole cropped. The remaining land cultivated was primarily devoted to crop mixtures, i.e., two or more crops grown on a given piece of land at the same time. It should be noted here that the different crops may be together for a short or long time. For the purpose of this thesis, any degree of overlapping in terms of time was considered to be mixed cropping. As Norman (1974) pointed out, confusion exists in the literature concerning the use of the terms mixed cropping, interplanting, intercropping, etc. (For more clarification of the terminology, see Figure 3.1.) The major crop mixtures found in the EORD were: millet/sorghum, sorghum/cowpeas or millet/cowpeas, millet/sorghum/cowpeas, millet/sorghum/cowpeas/okra, maize/sorghum, and maize/cowpeas. The mixtures consisting of two crops were the most common although occasionally as many as four crops were found. See Table 3.1 for all details about crop mixtures.

2. SOME AGRICULTURAL CONSTRAINTS IN THE EASTERN REGION

Five major categories of agricultural constraints can be distinguished in the Eastern Region of Upper Volta. They are: (i) land tenure, (ii) marketing and processing, (iii) water control, (iv) research and technological problems and (v) extension problems.

FIGURE 3.1

INCORPORATION OF THE TIME DIMENSION INTO CROPPING PATTERNS UNDER INDIGENOUS CONDITIONS[a]



[a]This is a simplistic schematic presentation. It is of course appreciated that combinations and variations of the patterns are possible. For example, in double or multiple cropping there may be slight overlapping of the crops while where three or more crops are grown in a mixture elements of both interplanting and intercropping may be present. Also, of course, sole crops are not necessarily confined to areas of seasonally distributed rainfall, and in fact may take a longer period to grow than shown. These definitions could apply to different varieties of the same species as well as different species.

Source: Norman, 1974.

TABLE 3.1

HECTARES OF CROPS GROWN AND PERCENTAGE GROWN AS SOLE CROPS AND IN DIFFERENT CROP MIXTURE CLASSES, 1980-81

Crop Class	Name of Major Crop on the Plot	Total Hectares Grown[1]	Percent of Total Ha. Grown			
			Sole Crops	Crop Mixtures		
				Two	Three	Four or More
Cereal	Rice	87.0	89.1	10.1	.8	
	Sorghum (Red and White)	153.6	34.2	43.7	19.6	2.5
	Millet	58.7	4.2	45.6	49.6	.6
	Maize	39.7	37.7	50.7	11.6	
Grains	Groundnuts	54.2	48.9	50.5	.6	
Legumes	Cowpeas	2.4	100			
	Soybeans	12.4	98.2	1.8		
Roots and Tubers	Cassava	5.3	94.8	5.2		
	Yams	.5	100			
Vegetables[2]		2.6	60	40		
Non-Food[3]		1.3	100			

[1]In calculating the total ha. of crops, all the hectarage was affected to the major crop grown on the plot.

[2]Includes okra, pepper, tomatoes and onions.

[3]Includes cotton and tobacco

Source: Survey data, 1980.

2.1. Land Tenure

Shifting cultivation has probably been the dominant agricultural pattern of Gourtmantche farmers for centuries. In this system of cultivation, a farmer will cultivate a piece of land, and, after some time, abandon it to fallow and move on to clear a new piece of land. Nonetheless, as Swanson (1975) pointed out, the low population density in the EORD combined with this practice of shifting cultivation should not obscure the fact that personal and family land rights represent a sensitive issue which is going to become a major problem area in the development of this region. For instance, some farmers today, even though they have never cultivated bas-fonds land, are attempting to lay claim to newly improved bas-fonds by demonstrating that their cultivated fields or fallow land lie adjacent to such bas-fonds and that this land thus represents part of their property, thus raising disputes over ownership of bas-fond lands. However, it should be pointed out that outside currently established villages, there are great portions of yet unclaimed arable land.

2.2. Marketing and Processing

Cereals are marketed by two parastatals and private traders. The two parastatals are OFNACER (National Cereal Agency) and SOVOLCOM (Voltaic Marketing Agency). OFNACER is the governmental agency responsible for marketing all cereals (sorghum, maize and rice). It operates by direct purchases and purchases through licensed buyers, to ensure that farmers receive the official prices[1] for cereals, and also through its retail outlets which act as a buffer stock to make the official consumer prices effective at the retail level. SOVOLCOM, which is 97 percent government owned, operates under the umbrella of the Ministry of Commerce and Industry. It buys locally, imports, and sells a variety of commodities including agricultural goods throughout the country.

Even though OFNACER is responsible for the marketing of all cereals, it was not giving enough attention to rice, which is the main crop grown in the bas-fonds in the EORD. In fact, in 1980, the regional director of OFNACER for the Eastern Region suspended all the paddy buying activities from his program because of inadequate storage and processing facilities. Throughout the whole EORD, only two small processing units (130-160 kg of paddy per hour) were in operation during the survey period. This scarcity of processing units coupled with the fact that batches of paddy were not homogenous resulted in a poor quality of milled rice (60 percent of broken rice), making the imported rice preferred to domestic rice.

2.3. Water Control

Table 3.2 showed that rainfall data in the Eastern Region has a skewed distribution mainly towards the end of the growing season (see

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[1]Prices of agricultural products are set by the government. They are determined in part by the government's policy to promote production. For 1978/80, they were set as follows:

Product	Price (CFA/kg)
White Sorghum	40
Red Sorghum	30
Millet	40
Paddy Rice	63
Groundnuts (unshelled)	37
Cowpeas	45

TABLE 3.2

RAINFALL DATA IN MM IN FADA-NGOURMA, BY PERIOD, 1975-80

Months	Periods (in calendar days)						Monthly Average (mm)	Average Number of Rainy Days
	1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	25 to 30/31		
January	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1
February	0.7	0.0	0.0	0.0	0.0	0.1	0.8	0.2
March	0.0	0.5	0.7	1.3	1.4	2.3	6.2	1.0
April	0.4	2.2	2.0	2.9	5.4	6.3	20.2	2.8
May	7.5	6.2	11.9	10.9	14.3	30.0	80.8	7.2
June	24.3	13.7	23.4	22.2	24.5	17.8	125.9	10.1
July	22.7	26.1	23.8	32.7	26.1	21.0	172.4	12.6
August	37.5	50.6	50.0	61.6	40.3	43.2	283.2	17.6
September	42.5	36.4	31.6	22.7	20.4	16.3	169.9	14.2
October	7.2	3.1	5.7	2.6	7.0	1.3	26.9	3.6
November	0.6	0.3	0.0	0.4	0.0	0.0	1.3	0.5
December	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1
Annual Total							887.7	70.0

Source: FAO, Rapport No. 24/80 DDC-UPV.5, June, 1980.

monthly average column). This will have serious implications both for the screening of short cycle varieties and for the development of improved cultural practices. It also appears from Table 3.2 that, at least as far as the cereals are concerned, the main constraint is not insufficient level of rainfall, but it is the management of available water that is lacking. This was reinforced by the author's personal observations which revealed that some sample farmers suffered from both drought and overflooding during the same cropping season.

Speaking about management of available water, there are two main types of improvement of bas-fonds in the EORD, based on the topography of the area and the availability of a permanent river. The first type of improvement consists of building dikes to retain water longer on the plots than otherwise. Figures 3.2 (a and b) illustrate this system of improvement.

The main problem of this system of improvement is that after heavy rains, the wings of the dikes are wiped out with the consequence that water does not stay on the plot long enough for the investment in building dikes to be worthwhile.

The second system of improvement consists of building a dam in an attempt to fully master the control of water and irrigate the plots downstream at will. Figure 3.3 below illustrates this second system. The main problem with this system is the water losses along the main and secondary canals coupled with the fact that plots are not protected from overflooding by a protection dike.

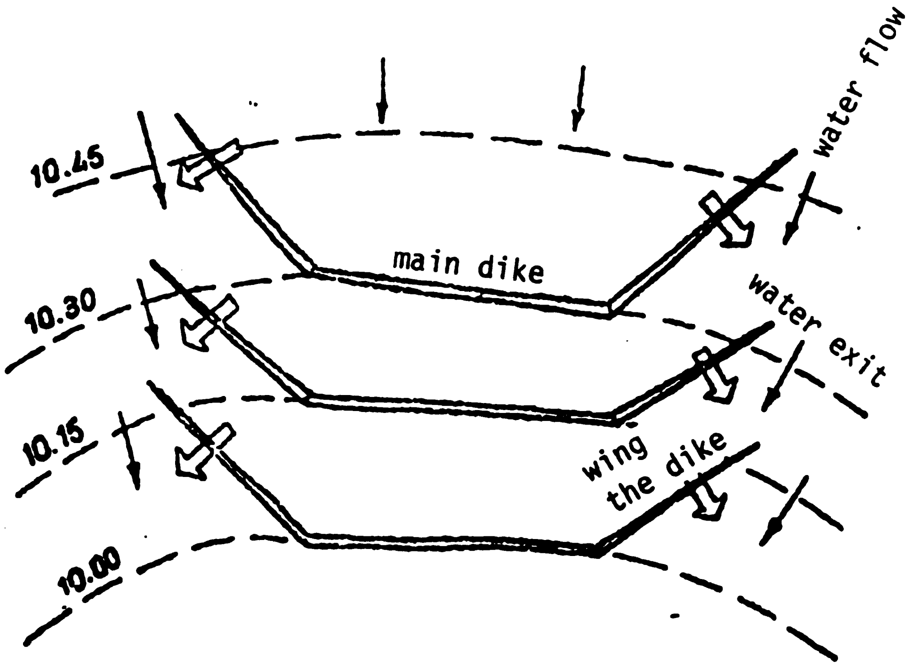

FIGURE 3.2.a

SKETCH OF THE BAS-FOND IMPROVEMENT STRUCTURE,
TYPE 1a: OPENED STRUCTURE

Source: Adapted from Ministry of Rural Development, HER, "Annual report," 1980.

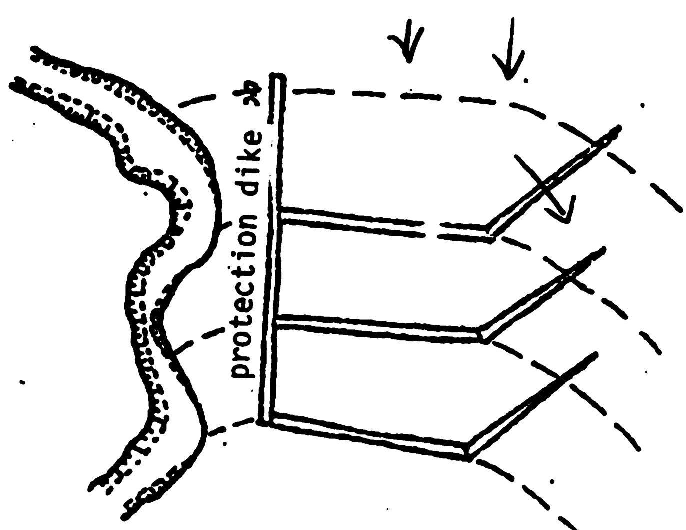

FIGURE 3.2.b

SKETCH OF THE BAS-FOND IMPROVEMENT STRUCTURE,
TYPE 1b: SEMI-OPENED STRUCTURE

Source: Adapted from Ministry of Rural Development, HER, "Annual report," 1980.

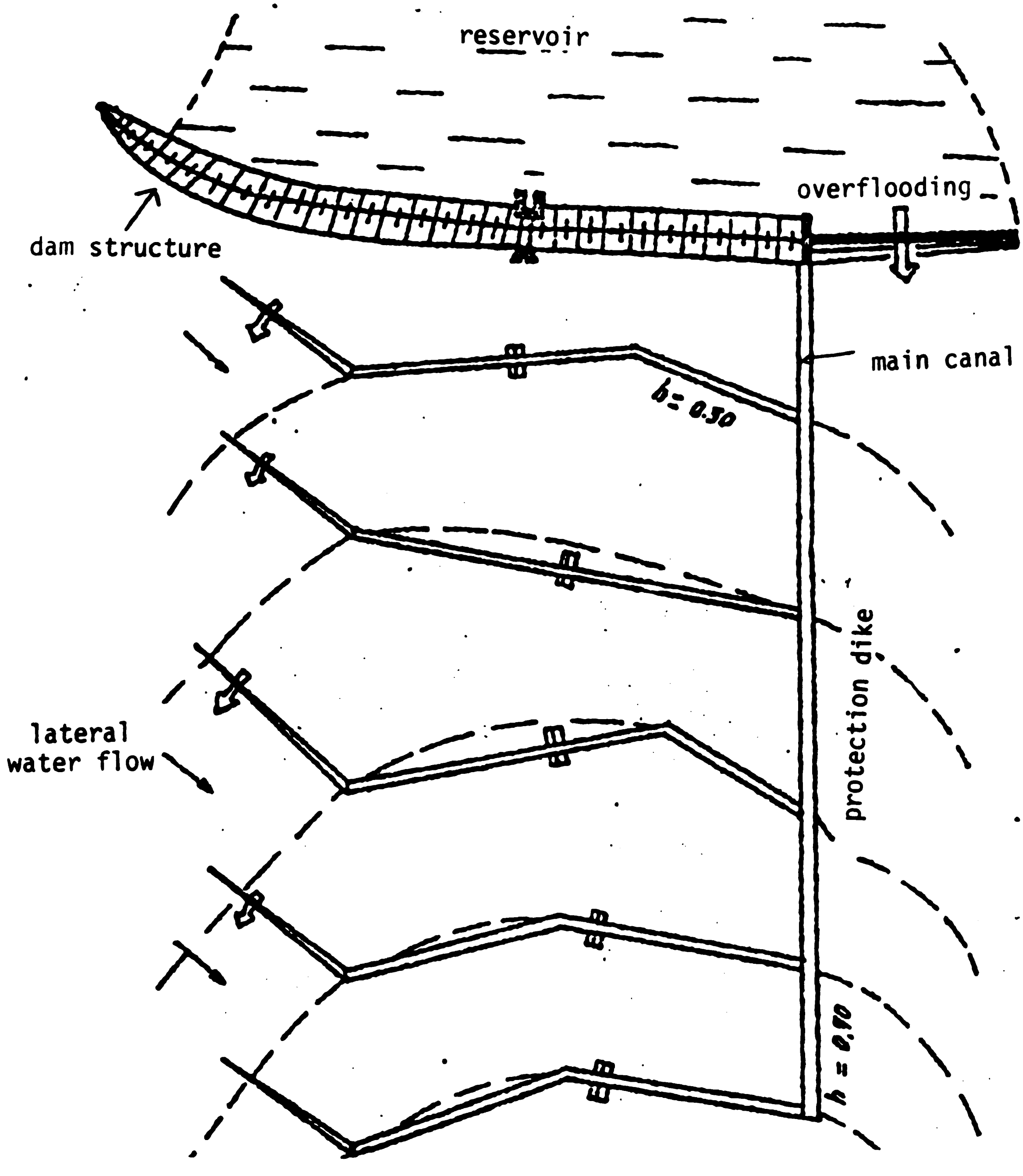

FIGURE 3.3

SKETCH OF THE BAS-FOND IMPROVEMENT STRUCTURE,
CASE OF DAM IRRIGATION

Source: Adapted from Ministry of Rural Development, HER, "Annual report," 1980.

2.4. Research and Technological Problems

The main agricultural research centers in Upper Volta are located around Ouagadougou and Bobo-Dioulasso. No experiments are mounted in the EORD. Because agricultural research is non-existent in the EORD, there is currently no proven technological package available to the extension services. The adaptation of different rice varieties to different types of bas-fonds as well as the relevance of mineral fertilization is yet to be defined. Furthermore, in order to have a better quality of rice, batches of paddy should be as homogenous as possible. This is only possible with stabilized varieties maintained through the provision of new seeds every year. This ideal situation does not exist in the EORD. Most farmers grow on the average two or three varieties of rice (C74, Gambiaka, Dourado, Sintane Diofor, IR8) of different sizes. Average yields of these varieties are low, around 0.8-1.5t/ha. The existing seed multiplication units do not nearly satisfy the needs of farmers, forcing them to rely on their old stocks for the next cropping season.

2.5. Extension Problems

In addition to the lack of technological improvements to be transferred to farmers as mentioned above (in section 2.4), two other problems cripple the extension service. They are: a) the level of training of agents involved in bas-fonds improvement, and b) the turn-over of personnel.

With respect to the level of training of personnel, most bas-fond extension agents have had no previous exposure to water management in the bas-fonds during their training in Matourkou. Moreover, they are totally unfamiliar with most of the rice growing activities.

With respect to the turn-over of the personnel, nearly 50 percent of the extension agents dealing with bas-fonds were new (i.e., less than one year) at their post during the 1980-81 survey. Consequently, their knowledge of their area of jurisdiction and of their farmers was very poor.

3. PRODUCTION SYSTEMS STUDIED

3.1. Definition of the Systems

On the basis of the reconnaissance survey, four systems of production were delineated and representative areas were selected in consultation with the senior ORD personnel. Areas selected were:

1. Zanre in the Diabo sector which represents the system based on traditional bas-fonds. No attempt is made in this system to control water in the bas-fonds (System 1).
2. Kalbouli - Kouakouli in the Diapaga sector. These areas are representative of the transitional stage between the system based on traditional bas-fonds and the system based on improved bas-fonds (System 2). Improvements here in an attempt to control water are rudimentary and are all done by farmers without any government intervention.
3. Komboari - Panpangou I and II, in the Fada sector which represents the system based on improved bas-fonds. The improvement here consists of the building of dikes to retain water longer on the plots than otherwise (System 3).

4. Tapoa in the Diapaga sector, which represents the system based on bas-fonds located downstream of a dam. The degree of water control is higher here than in any of the previous systems (System 4). Irrigation is done by gravity in this system.

3.2. Descriptive Profile of Sample Farmers

In the survey area, two main categories of resources available to sample farmers could be distinguished: land and labor.

3.2.1. Land

All cultivated land can be subdivided into two major categories: dryland and low-lands (or bas-fonds). In the dryland category, we can further distinguish plots around the house (46 percent of total land under cultivation) and bush fields (20 percent of total cultivated land) generally located beyond 2 km from the village. In the bas-fond category, we can distinguish rice fields from fields under other crops such as sorghum, vegetables and cassava. Tables 3.3 and 3.4 illustrate the spatial organization of fields on each research site or zone.

Tables 3.3 and 3.4 show that on the average, farms are made up of eight fields with an average of .45 ha per field. One thing that can be seen from these tables is the high degree of fragmentation of fields; the bigger the farm, the higher the number of fields. For instance, in System 3 where the average area of farm is the highest, 6.32 ha, that is where we find also the highest average number of fields, 10.7. Another striking thing to note is the relative importance of rice (both in terms of number of fields and in terms of hectarage) in the cropping

TABLE 3.3

AVERAGE NUMBER OF FIELDS IN TOTAL AND IN THE BAS-FONDS, PER HOUSEHOLD, 1980-81

System	Average Total Number of Fields Per Household	Fields in the Bas-Fonds	
		Average Total Number	Percent of Total Fields
1	8.6	2.7	32
2	8.1	4.2	52
3	10.7	1.8	17
4	6.3	2.1	34
Total	8.5	2.8	32

TABLE 3.4

AVERAGE AREA OF FARMS IN TOTAL AND IN THE BAS-FONDS, 1980-81

System	Average Total Area (ha.) Per Farm	Average Area of Fields in the Bas-Fonds (ha.)	Rice Fields	
			Average Total Area (ha.)	Percent of Total Area
1	3.55	.40	.40	11
2	3.49	1.89	.71	20
3	6.32	.30	.22	3
4	1.86	.32	.32	17
Total	3.81	.74	.41	11

system. In terms of hectarage, rice represents on the average only 11 percent of the total farm area, varying from 3 percent in System 3 to 31 percent in System 1. This relative importance of rice in the cropping system will surely have to be reckoned with in any effort to expand rice production in the EORD, i.e., rice is still a relatively minor crop in the cropping system of EORD farmers.

3.2.2. Labor

Fifty-three percent of the plots surveyed were prepared using human energy while on 32 percent of the fields, zero-tillage was the main method of land preparation. Only 15 percent of the fields were prepared using animal traction. So the crucial role of human energy (i.e., labor) in the production system cannot be over-emphasized.

Three main categories of labor were identified in the research sites: family labor, hired labor, and social labor. Figure 3.4 depicts the various categories of labor found in the surveyed villages. Hired labor is generally labor which is engaged for cash payments, although there may or may not also be a payment in kind such as meals, tobacco or drinks. Social labor includes communal and exchange labor. Communal labor is labor provided by the community (friends and/or relatives and/or in-laws) without cash payment or without the expectation of receiving labor in return. Exchange labor occurs when one or more farmers or members of their household agree to work on someone else's farm with the understanding that members of the other farmer's household will undertake an equivalent amount of work on their farm without payment. This category of labor is often referred to in the literature as rotational group labor (Norman, 1975).

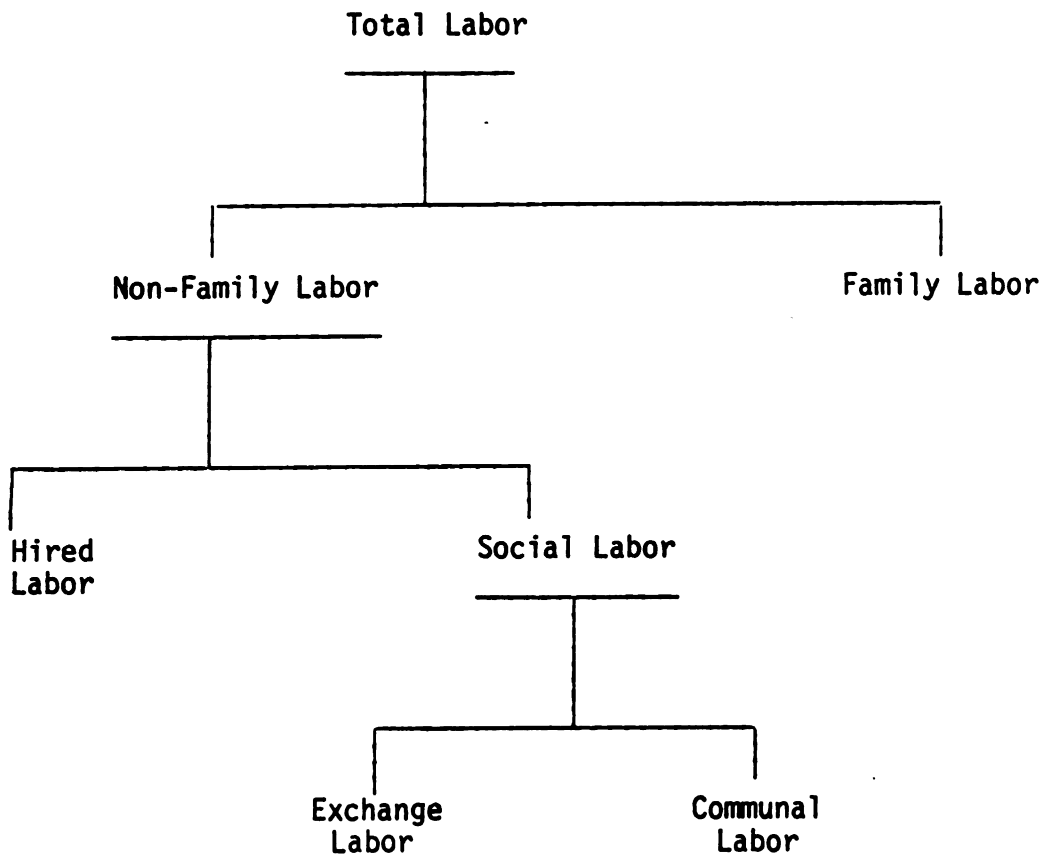

FIGURE 3.4

DIFFERENT CATEGORIES OF FARM LABOR
IN THE EORD, 1980-81

3.2.2.1. Size and Composition of the Household

In peasant agriculture, the size of the household largely determines the total area cultivated. Thus, any policy measure which aims at expanding output through land expansion must give serious consideration to the size of the household, the basic unit of agricultural production in traditional agriculture.

The average size of the household in the research sites was about eight members with the following composition: 24 percent adult male, 26 percent adult female, 23 percent children and 27 percent infant.[2] This relative proportion has implications for the family labor force available since it depends upon the age at which children are expected to help on the farm and/or in other productive activities and whether small children and old men are included or not. Similarly, a distinction should be made between the size of the household and the size of the family farm labor force because the number of hours available per person per period for farm work depends upon the number of hours family members do farm work and the extent of off-farm commitments such as trading, weaving, agricultural processing, and school attendance. Thus, the number of hours available for farm work depends upon the availability of off-farm jobs and the attitudes towards education, leisure and income.

3.2.2.2. Average Age of Heads of Households

The average age of the heads of household varied from 36 years in System 2 to 51 years in System 3 (see Table 3.5). The weighted average age of household heads across all the four production systems was 44 years.

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[2]All children less than seven years of age are considered infants and do not belong to the family labor work force. Adults are defined as those ranging from 15 years to 65 years of age.

TABLE 3.5

AVERAGE AGE OF HOUSEHOLD HEADS
BY SYSTEM, 1980-81

System	Average Age (Years)
1	46
2	36
3	51
4	42
Total	44

3.2.3 Importance of Non-Farm Activities

Recently, many development agencies and national governments have shown an increased interest in the role of non-farm rural enterprises in the overall rural development effort because of their employment and income generation potential. So, even though rural non-farm enterprises were not the main thrust of this study, some information was obtained in the questionnaire concerning the full range of income-earning activities other than farm activities.

Survey data showed that on the average, 67 percent of household heads are involved in at least one non-farm activity, this percentage varying from 58 percent in System 2 to 80 percent in System 4 as shown in Table 3.6. In comparing and contrasting these percentages in the different systems, it is interesting to note that farmers who are closer to a major center (e.g., Fada, Diapaga, Namounou, Diapangou) were more involved in non-farm activities than those located further away with poor road infrastructure. Wherever non-farm activities exist, they

TABLE 3.6

RELATIVE PERCENTAGE OF HOUSEHOLD HEADS WITH AT LEAST ONE NON-FARM ACTIVITY PER SYSTEM, 1980-81

System	Number of Heads of Household with at Least One Non-Farm Activity	Percent of Total per System
1	15	58
2	18	60
3	21	70
4	24	80
Total	78	67

range from agricultural processing (dolo making, shea butter extraction, rice hulling, etc.), to weaving, pottery, blacksmithing, tailoring, masonry, and repair shops.

4. SUMMARY

An overview of agricultural production in eastern Upper Volta shows that a wide variety of crops are grown, both for domestic consumption (e.g., sorghum, millet, maize, groundnuts, etc.) and for export (e.g., cotton). Farmers generally are growing more than one crop, but on different plots. Fifty-seven percent of total cultivated area was sole cropped. There are numerous factors that affect agricultural development in the EORD among which are: land tenure, marketing and processing infrastructure, lack of improved technology, poor water management, and poor extension services. With regard to water, the main problem is not insufficient level of rainfall, but rather the poor management of available water.

Four production systems were defined based on the degree of water control. System 1 represents the traditional bas-fonds or unimproved swamps. No attempt is made in this system to control water in the bas-fonds. System 2 is based on semi-traditional bas-fonds; in this system water control improvements are rudimentary (based on the use of dikes) and are all done by farmers without any government intervention. In System 3, the improvement consists of the building of dikes to retain water longer on the plots than otherwise. The topographic mapping and dike building are done with heavy government assistance. System 4 represents the system based on irrigated bas-fonds; here the degree of water control is higher than in any of the previous systems. The dam structure here is built and managed by the government, and irrigation is done by gravity.

On the average, farms were made up of eight fields with an average area of .45 ha per field. Rice represented on the average only 11 percent of the total cultivated area, varying from 3 percent in System 3 to 31 percent in System 1. Three main categories of labor were identified in the research sites: family labor, hired labor and social labor. Finally, it was found that on the average, 67 percent of household heads were involved in at least one non-farm activity.

CHAPTER FOUR

A FINANCIAL AND ECONOMIC ANALYSIS OF THE FOUR RICE-BASED PRODUCTION SYSTEMS IN THE EORD

The purpose of this chapter is two-fold: first, to estimate crop enterprise budgets by system of production or zone to provide the data base for establishing the relative profitability of rice versus sorghum and millet, groundnuts, etc., and second, to appraise the alternative rice production techniques existing in the EORD, both from the private and economic point of view.

1. DISTINCTION BETWEEN FINANCIAL AND ECONOMIC ANALYSIS

In the financial analysis, the main objective was to answer the question whether a particular enterprise under a given system of production will pay its way in strict monetary terms (are returns greater than monetary costs?). Towards this end, inputs were valued at the average market prices that farmers paid for each type of resource, e.g., seeds, fertilizers, labor, etc.

Output was valued at the average unit price received at harvest period by farmers in each research zone. For each enterprise budget, financial returns to land, family labor, operating capital and management were computed. Other performance measures computed from the budget data included: net returns per field hour of family labor, costs of production, etc.

In the economic analysis,[1] the objective was to find out the social opportunity costs of different enterprises under each system of production, i.e., to determine the relative enterprise and system profitabilities from the national point of view. Among the four systems under study, all resource prices except seeds and expenditures on labor, contain subsidies. Subsidies were estimated and resource costs were increased by the amount of subsidy to obtain adjusted prices to reflect true social values. Output was valued at its estimated import parity price. These prices essentially reflect the true economic costs of factor inputs involved in the production process and the true social value of output. Furthermore, the costs of investments to control water borne by the government were taken into consideration in the economic analysis.

2. DEFINITION OF CROP ENTERPRISES AND PROCEDURES USED TO SELECT CROP MIXTURES

Enterprises were defined on the basis of distinct products or groups of jointly produced products. Thus crops like rice, maize, soybeans, etc., were considered as single enterprises. Also, several systems of rice production (swamp rice, irrigated rice) were considered distinct enterprises because of the unique conditions under which each system operates and because of the importance of rice in the population studied.

A budget for an enterprise in this study was calculated from households in which that enterprise was considered important, i.e., households in which at least 10 percent of all area under cultivation was absorbed

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[1]Economic analysis will be done only for rice enterprises across the four systems under study.

by the enterprise under consideration, or households where that enterprise was an important part of family consumption (e.g., okra, groundnuts and maize), or households where that enterprise was an important source of cash income. This chapter presents crop enterprise budgets by system for rice, sorghum/millet/cowpeas (S/M/C), maize, groundnuts, bambera nuts, soybeans, cotton and okra. Few of these enterprises are commonly based upon inter-cropping and inter-planting[2] though a field or plot can often consist of a mosaic of sole-cropped sub-suplots. True inter-cropping mixtures in the survey zones do consist of combinations of sorghum plus millet plus cowpeas and groundnuts plus bambera nuts. Although systematic calculations of field size were made, we did not measure the area planted to each crop type or the plant density in a given crop mixture mainly because of the prevalence of complex patterns of crop inter-cropping or inter-planting. In summary, it was ascertained that S/M/C and groundnuts/bambera nut mixtures typically require a given bundle of production inputs and yield an output of X_i kilograms of sorghum, millet, cowpeas, or groundnuts and bambera nuts.

The identification of the most important crop mixtures for enterprise budget purposes proved to be a complex process. Following Matlon (1977) and Crawford (1980), data for each field were first checked for consistency by comparing the mixtures implied by the planting and harvest data with mixtures reported by farmers in a separate interview (plot use inventory survey form). We also checked whether crops reported as planted had been harvested and vice versa. Second, for each research

[2]For more details on inter-cropping and inter-planting, see Igbozurike, 1971.

site, fields belonging to the same mixture type were then aggregated despite the superficial differences and field variability. However, it should be noted that very simple data manipulations were performed to aid the process of narrowing down the number of mixtures. Two mixtures were eventually selected on the basis of their importance (in terms of total number of fields and total cultivated area) in the local farming system. Mixtures containing rice and sorghum, maize and sorghum, maize and okra and groundnuts and cowpeas were eliminated. Such mixtures cover only a small number of fields and very little cultivated area. Vegetable sub-plots such as okra were considered as a separate enterprise rather than as a part of other mixtures because household demand for okra was assumed here to be essentially a fixed function of household composition rather than a function of profitability considerations.

3. CROP ENTERPRISE BUDGETS

The aim of input-output budget analysis here is to derive farm recommendations which are consistent with the farmer's desires to increase expected income and to make the best possible use of the resources available to him. Furthermore, enterprise budgets are important in farm income analysis because they help to explain the internal structure of the farm as a whole and to show the relative contribution of each enterprise to the whole organization. So, these enterprise studies are very instrumental in an attempt to (i) assess the profitability of each enterprise relative to the resources used, (ii) compare relative efficiency of various enterprises on the farm and (iii) provide a basis for making rational decisions about the kind and size of enterprise to be expanded.

The budget data are presented here by rice-based production system for all the major enterprises. For each enterprise budget, three main parts can be distinguished:

1. Input use: This section includes non-labor and labor input use as well as costs attached to their use and some agronomic data. Costs were classified into two categories: variable costs (seeds, fertilizer, hired labor, non-wage payments[3]) and fixed costs (fixed costs here only refers to the depreciation of tools and equipment; no animal depreciation or appreciation was included). Furthermore, no attempt was made in this study to value land, the reason being that land for most parts is communally owned in the EORD. Because of this communal system of land tenure, there is no market price for agricultural land. Token fees rather than real economic rents are sometimes paid by farmers for use of land but these are minor in most cases and paid by a small proportion of farmers. Return to land and management was therefore considered as a residual. Depreciation on tools and equipment was computed using the straight line method and assuming zero salvage value and it was allocated to each crop enterprise proportionally to the area covered by that enterprise.

2. Output: This section comprises the yields of crops included in the enterprise as well as prices used to value production. Prices used to value production represent average prices realized by all farmers in the system at harvest period. However, it should be noted that the value of total output as well as the expenditures on seeds are

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[3]Non-wage payments referred to here are food and drink provided by the household head to non-family laborers when they are performing work on his fields.

seldom realized in cash since very few farmers sell their total output or purchase their seeds.

3. Performance measures: This section looks at various performance measures available to compare the relative efficiency of various enterprises within a given production system and between production systems.

3.1. System 1: Production System Based on Farmers Growing Rice in Traditional Bas-Fonds

In this production system the most important enterprises in terms of objective of study, area cultivated, labor used, and income generated were: rice, sorghum/millet/cowpeas (S/M/C), maize, groundnuts, bambera nuts and soybeans.

3.1.1. Overview of the Enterprise Budgets in System 1

Costs and returns to the six major enterprises in System 1, derived from the 1980/81 survey are shown in Tables 4.1.1 - 4.1.6. The average areas planted in rice, S/M/C, maize, groundnuts, bambera nuts and soybeans were in hectares, .411, .429, .079, .319, .476 and .252, respectively. The mean labor utilization per hectare in all field activities ranged from 106.6 hours for the bambera nut enterprise to 1,627.5 hours for the S/M/C enterprise. In this system, 81-100 percent of the total labor input was family labor and 0-19 percent was social labor. No hired labor was used in this production system (Tables 4.1.1 - 4.1.6). This is particularly important as we know that the use of non-family labor is resorted to when family labor has become a constraint on production of the subsistence farmer. As regards this system, the low dependence on non-family labor gives us an idea of the poor employment

TABLE 4.1.1

AVERAGE COSTS AND RETURNS PER HECTARE FOR RICE
SYSTEM 1, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	64		
2. Average size (ha.)	.411		
B. Non-labor input use			
1. Seed rate (kg/ha)	23.6 @(83./CFA/kg)	1,961	
Total			1,961
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	19.7		
1.2 Hand tools	80.2		
1.3 Zero tillage	.1		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	194.1 hrs.		
1.2 Social labor	14.0 hrs	0	
1,3 Hired labor	0 hrs	0	
1.4 Sub-total	208.1 hrs		
2. Harvest activities			
2.1 Family labor	51.1 hrs		
2.2 Social labor	42.3 hrs	897	
2.3 Hired labor	0 hrs	0	
2.4 Sub-total	93.4 hrs	897	
3. Total	301.5 hrs		897
E. Total variable costs			2,858
F. Tools and equipment (depreciation on)			850
G. Total costs			3,708
II. OUTPUT			
A. Crop yields (kg/ha)			
Rice paddy	458.3		
B. Unit price (CFA/kg)			
Rice paddy	60.6		
C. Total value of output		27,773	
III. PERFORMANCE MEASURES			
A. Gross income			27,773
Less: Total variable costs			2,858
B. Gross margin			24,915
Less: Total fixed costs			850
C. Net margin			24,065
Less: Opportunity cost of equity capital @ 1%/month (1,961 x .01 x 8)			157
D. Net returns to land, FL (family labor) and management			23,908
Less: Opportunity costs of FL: (245 hrs @ 47 CFA/hr)			11,515
E. Net returns to land and management			12,393
F. Net returns per field-hour of family labor 23,908 ÷ 245			97.6
G. Output - seed ratio			19.4
H. Costs of production (CFA/kg) (3,708 ÷ 458.3)			8.1
I. Total costs of production (CFA/kg) (15,380 ÷ 458.3)			33.6

TABLE 4.1.2

AVERAGE COSTS AND RETURNS PER HECTARE FOR SORGHUM/MILLET/COWPEAS
SYSTEM 1, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	88		
2. Average size (ha)	.429		
B. Non-labor input use			
1. Seed rate (kg/ha)			
1.1 Sorghum	14.8 @ (84 CFA/kg)	1,243	
1.2 Millet	20.4 @ (70.6 CFA/kg)	1,440	
1.3 Cowpeas	12.5 @ (66.9 CFA/kg)	836	
Total			3,519
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	48.6		
1.2 Hand tools	50.2		
1.3 Zero tillage	1.2		
2. Percentage of area fertilized:			
2.1 Chemically	11.4		
2.2 Organically	2.1		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	1,247.2 hrs.		
1.2 Social labor	22.3 hrs	190	
1.3 Hired labor	2.5 hrs @ 105 CFA/hr)	263	
1.4 Sub-total	1,272.0 hrs	453	
2. Harvest activities			
2.1 Family labor	266.3 hrs		
2.2 Social labor	89.2 hrs	365	
2.3 Hired labor	0 hrs	0	
2.4 Sub-total	355.5 hrs	365	
3. Total	1,627.5 hrs		820
E. Total variable costs			4,339
F. Tools and equipment (depreciation on)			1,065
G. Total costs			5,404
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Sorghum	311		
2. Millet	270		
3. Cowpeas	41		
B. Unit price (CFA/kg)			
1. Sorghum/millet	48.5		
2. Cowpeas	63.8		
C. Total value of output		30,794	
III. PERFORMANCE MEASURES			
A. Gross income			30,794
Less: Total variable costs			4,339
B. Gross margins			26,455
Less: Total fixed costs			1,065
C. Net margin			25,390
Less: Opportunity cost of equity capital @ 1%/month [(3,519 x 8) + (453 x 3)] (.01)			295
D. Net returns to land, FL (family labor) and management			25,095
Less: Opportunity costs of FL: (1,513 hrs @ 47 CFA/hr)			71,111
E. Net returns to land and management			-46,016
F. Net returns per field-hour of family labor 25,095 ÷ 1,513			16.6
G. Output - seed ratios			21.0, 13.2, 3.3
H. Costs of production (CFA/ hg of grain) (5,404 ÷ 622)			8.7
I. Total costs of production (CFA/kg of grain) (76,810 ÷ 622)			123.5

TABLE 4.1.3

AVERAGE COSTS AND RETURNS PER HECTARE FOR MAIZE
SYSTEM 1, IN THE EORD, 1980

			CFA	CFA
I.	INPUT USE			
	A. Basic data			
	1. # of cases	15		
	2. Average size (ha)	.079		
	B. Non-labor input use			
	1. Seed rate (kg/ha)	23.7 @ (57 CFA/kg)	1,351	
	Total			1,351
	C. Agronomic data			
	1. Percentage of area ploughed using:			
	1.1 Animal traction	24.6		
	1.2 Hand tools	75.0		
	1.3 Zero tillage	.4		
	2. Percentage of area fertilized:			
	2.1 Chemically	0		
	2.2 Organically	72.0		
	D. Labor input use			
	1. Pre-harvest activities			
	1.1 Family labor	389 hrs		
	1.2 Social labor	13 hrs		
	1.3 Hired labor	0 hrs		
	1.4 Sub-total	402 hrs		
	2. Harvest activities			
	2.1 Family labor	149 hrs		
	2.2 Social labor	0 hrs		
	2.3 Hired labor	0 hrs		
	2.4 Sub-total	149 hrs		
	3. Total	551 hrs		
	E. Total variable costs			1,351
	F. Tools and equipment (depreciation on)			382
	G. Total costs			1,733
II.	OUTPUT			
	A. Crop yields (kg/ha)			
	1. Shelled corn	1,194		
	B. Unit price (CFA/kg)			
	1. Shelled corn	35.2		
	C. Total value of output (CFA)		42,029	
III.	PERFORMANCE MEASURES			
	A. Gross income			42,029
	Less: Total variable costs			1,351
	B. Gross margin			40,678
	Less: Total fixed costs			382
	C. Net margin			40,296
	Less: Opportunity cost of equity capital @ 1%/month (1,351 x 8 x .01)			108
	D. Net returns to land, FL (family labor) and management			40,188
	Less: Opportunity costs of FL: (540 hrs @ 47 CFA/hr)			25,380
	E. Net returns to land and management			14,808
	F. Net returns per field-hour of family labor (40,188 ÷ 540)			74.4
	G. Output - seed ratio			50.4
	H. Costs of production (CFA/kg) (1,733 ÷ 1,194)			1.4
	I. Total costs of production (CFA/kg) (27,221 ÷ 1,194)			22.8

TABLE 4.1.4

AVERAGE COSTS AND RETURNS PER HECTARE FOR GROUNDNUTS
SYSTEM 1, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	21		
2. Average size (ha)	.319		
B. Non-labor input use			
1. Seed rate (kg/ha)	16.4 @ (91.1 CFA/kg)	1,494	
Total			1,494
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	43.3		
1.2 Hand tools	56.1		
1.3 Zero tillage	.6		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	137.3 hrs		
1.2 Social labor	0		
1.3 Hired labor	0 hrs		
1.4 Sub-total	137.3 hrs		
2. Harvest activities			
2.1 Family labor	56.1 hrs		
2.2 Social labor	10.3 hrs		
2.3 Hired labor	0 hrs		
2.4 Sub-total	66.4 hrs		
3. Total	203.7 hrs		0
E. Total variable costs			1,494
F. Tools and equipment (depreciation on)			217
G. Total costs			1,711
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Shelled groundnuts	168		
B. Unit price (CFA/kg)			
1. Shelled groundnuts	54.2		
C. Total value of output		9,106	
III. PERFORMANCE MEASURES			
A. Gross income			9,106
Less: Total variable costs			1,494
B. Gross margin			7,612
Less: Total fixed costs			217
C. Net margin			7,395
Less: Opportunity cost of equity capital @ 1%/month (1,494 x 8 x.01)			119
D. Net returns to L, FL (family labor) and management			7,276
Less: Opportunity costs of FL: (193 hrs @ 47 CFA/hr)			9,071
E. Net returns to land and management			-1,795
F. Net returns per field-hour of family labor (7,276 ÷ 193)			37.7
G. Output - seed ratio			10.2
H. Costs of production (CFA/kg) (1,711 ÷ 168)			10.2
I. Total costs of production (CFA/kg) (10,901 ÷ 168)			64.9

TABLE 4.1.5

AVERAGE COSTS AND RETURNS PER HECTARE FOR BAMBERA NUTS
SYSTEM 1, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	9		
2. Average size (ha)	.476		
B. Non-labor input use			
1. Seed rate (kg/ha)	5.4 @ (125 CFA/kg)	675	
Total			675
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	11.6		
1.2 Hand tools	87.9		
1.3 Zero tillage	.5		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	79.8 hrs		
1.2 Social labor	0 hrs		
1.3 Hired labor	0 hrs		
1.4 Sub-total	79.8 hrs		
2. Harvest activities			
2.1 Family labor	26.3 hrs		
2.2 Social labor	.5 hrs		
2.3 Hired labor	0 hrs		
2.4 Sub-total	26.8 hrs		
3. Total	106.6 hrs		
E. Total variable costs			675
F. Tools and equipment (depreciation on)			139
G. Total costs			814
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Shelled pois de terre	32		
B. Unit price (CFA/kg)			
1. Shelled pois de terre	73.3		
C. Total value of output		2,346	
III. PERFORMANCE MEASURES			
A. Gross income			2,346
Less: Total variable costs			675
B. Gross margin			1,671
Less: Total fixed costs			139
C. Net margin			1,532
Less: Opportunity cost of equity capital @ 1%/month (675 x .01 x 8)			54
D. Net returns to land, FL (family labor) and management			1,478
Less: Opportunity costs of FL: (106 hrs @ 47 CFA/hr)			4,982
E. Net returns to land and management			-3,504
F. Net returns per field-hour of family labor (1,478 ÷ 106)			13.9
G. Output - seed ratio			5.9
H. Costs of production (CFA/kg) (814 ÷ 32)			25.4
I. Total costs of production (CFA/kg) (5,850 ÷ 32)			182.8

TABLE 4.1.6

AVERAGE COSTS AND RETURNS PER HECTARE FOR SOYBEANS
SYSTEM 1, IN THE EORD, 1980

			CFA	CFA
I.	INPUT USE			
	A. Basic data			
	1. # of cases	7		
	2. Average size (ha)	.252		
	B. Non-labor input use			
	1. Seed rate (kg/ha)	37.5 @ (117 CFA/kg)	4,391	
	2. Fertilizer (18-35-0) rate (kg/ha)	16.2 @ (100 CFA/kg)	1,620	
	Total			6,011
	C. Agronomic data			
	1. Percentage of area ploughed using:			
	1.1 Animal traction	100		
	1.2 Hand tools	0		
	1.3 Zero tillage	0		
	2. Percentage of area fertilized:			
	2.1 Chemically	15.1		
	2.2 Organically	0		
	D. Labor input use			
	1. Pre-harvest activities			
	1.1 Family labor	988.8 hrs		
	1.2 Social labor	0 hrs		
	1.3 Hired labor	0 hrs		
	1.4 Sub-total	988.8 hrs		
	2. Harvest activities			
	2.1 Family labor	133.5 hrs		
	2.2 Social labor	0 hrs		
	2.3 Hired labor	0 hrs		
	2.4 Sub-total	133.5 hrs		
	3. Total	1,122.3 hrs		0
	E. Total variable costs			6,011
	F. Tools and equipment (depreciation on)			550
	G. Total costs			6,561
II.	OUTPUT			
	A. Crop yields (kg/ha)			
	Threshed soybeans	828		
	B. Unit price (CFA/kg)			
	Threshed soybeans	103.3		
	C. Total value of output		85,532	
III.	PERFORMANCE MEASURES			
	A. Gross income			85,532
	Less: Total variable costs			6,011
	B. Gross margin			79,521
	Less: Total fixed costs			550
	C. Net margin			78,971
	Less: Opportunity cost of equity capital @ 1%/month (6,011 x .01 x 8)			481
	D. Net returns to L, FL (family labor) and management			78,490
	Less: Opportunity costs of FL: (1,122 hrs @ 47 CFA/hr)			52,734
	E. Net returns to land and management			25,756
	F. Net returns per field-hour of family labor (78,490 ÷ 1,122)			70.0
	G. Output - seed ratio			22.1
	H. Costs of production (CFA/kg) (6,561 ÷ 828)			7.9
	I. Total costs of production (CFA/kg) (59,776 ÷ 828)			72.2

opportunities for the non-farm rural population which exist within this system of production. This could have important implications for policies aimed at discouraging or encouraging rural-urban migrations or the creation or promotion of non-farm rural enterprises.

The mean-expenditures per hectare for social labor in rice and S/M/C enterprises where it is used were 897 CFA and 820 CFA, respectively. For the rice enterprise, all expenditures were on harvest activities whereas under the S/M/C enterprise, 55 percent of these expenditures were spent in pre-harvest activities (Tables 4.1.1 and 4.1.2). Tables 4.1.1 and 4.1.2 further indicate that expenditures on social labor in the form of drink and food account for 24 percent and 15 percent of total farm expenditures. So in this system, the expenditures on social labor which is generally claimed to be unpaid labor, is quite appreciable.

The seed rates observed in this production system were quite often far from the recommended rates. The mean quantity of paddy rice seeds used by farmers of this system was 23.6 kg/ha which is only about 30 percent of the recommended rate of 80 kg/ha. In the case of the groundnut enterprise, on the average, only 21 percent of the recommended seed rate was used. Now, in the case of maize and soybeans, the average seed rates observed (23.7 kg/ha and 37.5 kg/ha, respectively) were very close to the recommended rates of 25 kg/ha and 40 kg/ha, respectively.

The yields in Tables 4.1.1 - 4.1.6 clearly reflect certain general characteristics of the 1980/81 season, such as average rainfall and its distribution. Crop yields were generally low, which is indicative on the one hand of the low level of soil fertility in the EORD and on the other hand of the poor crop varieties at the disposal of farmers coupled with low seeding rate. Cereal yields in EORD in general are among the lowest in the world (IRAT, 1979). This observation amply demonstrates that one of the major problems facing this system of production is how to increase cereal yields from the present levels of 300-500 kgs of grains per hectare. It should be pointed here that low farm productivity in this system is not the result of any single factor. It reflects a combined effect of physical, technological, human and institutional factors.

3.1.2. Comparison and Appraisal of the Six Major Enterprises in System 1

This section puts together the findings of the analysis of the six major enterprises comprising this system of production. A summary of general characteristics, costs and returns as well as performance measures for all six enterprises and provided in Table 4.5.1. The discussion will mainly concern the analysis of the performance measures so as to identify the enterprises with the highest financial return and lowest cost of production.

3.1.2.1. Gross Margin (GM)

Among the six major enterprises of System 1, the variation in gross margin ranged from 1,671 CFA/ha to 79,521 CFA/ha (Table 4.5.1). The soybean enterprise had the highest gross margin and the groundnut and bambera nut enterprises had the lowest gross margin. One thing interesting to note though is that all enterprises were able to cover their variable costs and therefore are all valid candidates to stay in the farm business organization.

3.1.2.2. Net Margin (NM)

To compute the net margin, depreciation on tools and equipment was deducted from the gross margin. Among the six major enterprises, the

TABLE 4.5.1

COMPARATIVE ANALYSIS OF THE MAJOR ENTERPRISES IN SYSTEM 1, BASED ON SURVEY DATA FROM 26 HOUSEHOLDS, 1980

Criteria	Enterprises					
	Rice	S/M/C	Maize	Ground-nuts	Bambera nuts	Soybeans
I. General Characteristics						
1. # of cases (fields)	64	88	15	21	9	7
2. Average size (ha)	.411	.429	.079	.319	.476	.252
3. Average yield (kg/ha)	458.3	311/270/41	1,194	168	32	828
II. Financial Situation (CFA/ha)						
1. Gross income	27,773	30,794	42,029	9,106	2,346	85,532
2. Variable costs	2,858	4,339	1,351	1,494	675	6,011
3. Total expenditures (including depreciation on tools & equipment)	3,708	5,404	1,733	1,711	814	6,561
4. Opportunity costs of						
4.1 Family labor	11,515	71,111	25,380	9,071	4,982	52,734
4.2 Equity capital	157	295	108	119	54	481
5. Total costs	15,380	76,810	27,221	10,901	5,850	59,776
III. Performance Measures						
1. Gross margin (II.1 - II.2)	24,915	26,455	40,678	7,612	1,671	79,521
2. Net margin (II.1 - II.3)	24,065	25,390	40,296	7,395	1,532	78,971
3. Net returns to land, family labor & management (CFA/ha) (III.2 - II.4.2)	23,908	25,095	40,188	7,276	1,478	78,490
4. Net returns to land & management (CFA/ha) (III.3 - II.4.1)	12,393	-46,016	14,808	-1,795	-3,504	25,756
5. Net returns per hour of family labor (CFA/phr) (III.3 ÷ total family labor)	97.6	16.6	74.4	37.7	13.9	70.0
6. Total cost of production (CFA/kg)	33.6	123.5	22.8	64.9	182.8	72.2
7. Output - seed ratio	19.4	21/13/3	50.4	10.2	5.9	22.1

variation in NM ranged from 1,532 CFA/ha to 78,971 CFA/ha. The ranking of enterprises was the same as for the first performance criterion, GM.

3.1.2.3. Net Returns to Land, Family Labor and Management (NRLFLM)

To compute the NRLFLM, an opportunity cost was assigned to equity capital. Normally, operating capital is treated as an input without any opportunity costs in the accounting period. But since more operating inputs (e.g., seeds) are tied up for more than eight to ten months, they effectively become capital expenditure items, which have an opportunity cost.[4]

The NRLFLM for the six enterprises ranged from 78,490 CFA/ha for soybean enterprises to 1,478 CFA/ha for the bambera nut enterprise (Table 4.5.1). In all enterprises the return per field hour of family labor was less than the average wage rate paid to the hired labor, 105 CFA/hr. This result suggests that there may be financial gain in seeking employment on other farms[5] or in urban areas where the SMIG (minimum guaranteed wage in urban areas) is 90 CFA/hr. However, in the case of rice enterprise, the returns of 97.6 CFA/hr is slightly above the minimum wage rate paid to unskilled labor in urban areas. Thus, there is no financial advantage of family members seeking wage employment in urban areas when they are needed on their rice fields.

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[4]The private opportunity cost of equity capital is assumed to be 12 percent per year, which is the rate used by Tapsoba (1981). Equity capital is made up of seeds and cash used to pay labor or buy food and drink for workers during pre-harvest activities. Eight months and three months were considered as relevant periods for the computation of opportunity cost of seeds and labor cash cost, respectively.

[5]However rural wage labor opportunities are so rare that few farmers could consider wage labor as a viable alternative to farming. It should also be kept in mind that farmers usually use family labor beyond the point where hired labor is used.

The returns to family labor per hour give a rough indication of the shifts farmers are likely to make if the present cost and return structure continues. The following shifts could be expected:

a) farmers will put more of their land and labor under rice, maize and soybeans if the minimum sorghum needed for family consumption is attained; and

b) low returns per person-hour of family labor in bambera nut enterprise may force farmers to abandon this crop despite the critical role it plays in the diet before the harvesting of other crops. Furthermore, no research is being currently done on this crop which is producing a very low yield (32 kg/ha).

3.1.2.4. Returns to Land and Management (RLM)

To compute the RLM, opportunity costs were assigned to family labor.[6] It was assumed that the internal opportunity cost of the family labor was equal to the weighted average net returns per field hour of family labor across all the enterprises in each production system. The weighted average net returns per field hour of family labor was computed using the following general formula:

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[6]Some planners may argue that a farm family's labor has no social "opportunity cost," but the members of that family probably have a different perspective. It is important that in the financial analysis, we try to determine whether the farmer will want to participate in any rice expansion scheme that we want to launch. This, of course, will depend on how the farmer values his own time. If we call the farmer's price that he puts on his own labor his reservation price, this price will be a bit different for each person depending on how rich or poor he is, on what alternative work or other uses of time there are, and on how energetic or lazy he is. Because farmers very rarely work for wages off the farm, it was felt that the hired labor wage was not an appropriate indicator of the opportunity cost of family labor. Instead, the best alternative to the use of family labor in any given enterprise is the returns available from other on-farm production activities.

$$\overline{NR}_i = \sum_j NR_{ij} W_{ij}, \quad i = 1, 2, 3, 4$$
$$j = k, 2 \ldots 7$$

Where:

$\overline{NR}_i$ = weighted average net returns per field hour of family labor in production system i

NR_{ij} = net returns per field hour of family labor for enterprise j in system i

$$W_{ij} = \text{weight} = \frac{\text{family labor used for enterprise j in system i}}{\text{total family labor used across all enterprises in system i}}$$

For System 1,

$$\overline{NR}_1 = \frac{(97.6)(245) + (16.6)(1{,}513) + \ldots + (70.0)(1{,}122)}{245 + 1{,}513 + \ldots + 1{,}122}$$
$$= 47.4 \text{ CFA/hr}$$

Returns per hour of family labor found by Lassiter (1981,p. 31) average only 39.4 CFA for hoe farmers and only 36 CFA for animal traction farmers. But as he acknowledged, these returns vary greatly across zones, primarily due to the high variability of yields. It is not rare to find in Lassiter's sample, returns per hour as high as 156 CFA (Lassiter, 1981:37). Other reasons for this high variability in returns per hour of family labor include labor market segmentation and labor scarcity in some specific areas.

Using 47 CFA/hr as the opportunity cost of family labor, in System 1 three enterprises realized a negative return to land and management (Table 4.5.1); they are: S/M/C, bambera nuts and groundnuts. However, it should be stressed here that negative RLM observed does not mean that farmers are losing money on these crops but rather, it means that net margin is not enough to yield a positive return to the fixed land and management factors.

3.1.2.5. Costs of Production

Two types of costs of production were computed. The first cost of production took into consideration only variable and fixed costs. Using this type of cost of production, maize showed the lowest cost of production (1.4 CFA/kg of shelled corn) and bambera nuts had the highest cost of production (25.4 CFA/kg) (Tables 4.1.1.-4.1.6.). The second type of cost of production computed was obtained by adding the opporunity costs of equity capital and family labor to total expenditures and the result was divided by the yield. Among the six enterprises, maize still showed the lowest opportunity cost of production (22.8 CFA/kg) and bambera nuts had the highest cost of production (182.8 CFA/kg). The second highest total cost of production was found in S/M/C (123.5 CFA/kg), probably due to the large quantity of family labor input per hectare. Rice showed the second lowest total costs of production (33.6 CFA/kg of paddy).

3.2. System 2: Production System Based on Farmers Growing Rice on Semi-Traditional Bas-Fonds

In this production system the most important enterprises in terms of area cultivated, labor used and income generated were: rice, sorghum/millet/cowpeas (S/M/C), maize, groundnuts, soybeans, okra and cotton.

3.2.1. Overview of the Enterprise Budgets in System 2

Costs and returns to the seven major enterprises in System 2, derived from the 1980/81 survey are shown in Tables 4.2.1 - 4.2.7. The average areas planted in rice, S/M/C, maize, groundnuts, soybeans, okra and cotton were in hectares, .270, 1.574, .049, .070, .131, .011, and .277,

TABLE 4.2.1

AVERAGE COSTS AND RETURNS PER HECTARE FOR RICE
SYSTEM 2, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	76		
2. Average size (ha)	.270		
B. Non-labor input use			
1. Seed rate (kg/ha)	50.8 @ (90.8 CFA/kg)	4,613	
2. Pesticides (kg/ha)	2.2 @ (196.1 CFA/kg)	431	
Total			5,044
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	0		
1.2 Hand tools	100		
1.3 Zero tillage	0		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	1,804.2 hrs		
1.2 Social labor	15.9 hrs	68	
1.3 Hired labor	0 hrs		
1.4 Sub-total	1,820.1 hrs	68	
2. Harvest activities			
2.1 Family labor	406 hrs		
2.2 Social labor	51.9 hrs	1,049	
2.3 Hired labor	0 hrs		
2.4 Sub-total	457.9 hrs	1,049	
3. Total	2,278.0 hrs		1,117
E. Total variable costs			6,161
F. Tools and equipment (depreciation on)			924
G. Total costs			7,085
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Rice paddy	1,172		
B. Unit price (CFA/kg)			
1. Rice paddy	41.7		
C. Total value of output		48,872	
III. PERFORMANCE MEASURES			
A. Gross income			48,872
Less: Total variable costs			6,161
B. Gross margin			42,711
Less: Total fixed costs			924
C. Net margin			41,787
Less: Opportunity cost of equity capital @ 1%/month [(5,044 x 8) + (68 x 3)] (.01)			406
D. Net returns to Land, FL (family labor) and management			41,381
Less: Opportunity costs of FL (2,210 hrs @ 20 CFA/hr)			44,200
E. Net returns to land and management			-2,819
F. Net returns per field-hour of family labor (41,381 ÷ 2,210)			18.7
G. Output - seed ratio			23.1
H. Costs of production (CFA/kg) (7,085 ÷ 1,172)			6.0
I. Total costs of production (CFA/kg) (51,691 ÷ 1,172)			44.1

TABLE 4.2.2

AVERAGE COSTS AND RETURNS PER HECTARE FOR SORGHUM/MILLET/COWPEAS SYSTEM 2, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	40		
2. Average size (ha)	1.574		
B. Non-labor input use			
1. Seed rate (kg/ha)			
1.1 Sorghum/millet	15.1 @ (88.1 CFA/kg)	1,330	
1.2 Cowpeas	1.4 @ (93 CFA/kg)	130	
2. Pesticides (kg/ha)	1.0 @ (196.1 kg)	196	
3. Total			1,656
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	4.1		
1.2 Hand tools	2.5		
1.3 Zero tillage	93.4		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	452.3 hrs		
1.2 Social labor	7.7 hrs	75	
1.3 Hired labor	0 hrs	0	
1.4 Sub-total	460 hrs	75	
2. Harvest activities			
2.1 Family labor	99 hrs		
2.2 Social labor	23.5 hrs	262	
2.3 Hired labor	0 hrs	0	
2.4 Sub-total	122.5 hrs	262	
3. Total	582.5 hrs		337
E. Total variable costs			1,993
F. Tools and equipment (depreciation on)			3,316
G. Total costs			5,309
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Sorghum	579		
2. Millet	13		
3. Cowpeas	1		
B. Unit price (CFA/kg)			
1. Sorghum/millet	32.6		
2. Cowpeas	61.7		
C. Total value of output		19,361	
III. PERFORMANCE MEASURES			
A. Gross income			19,361
Less: Total variable costs			1,993
B. Gross margin			17,368
Less: Total fixed costs			3,316
C. Net margin			14,052
Less: Opportunity cost of equity capital @ 1%/month [(1,656 x 8) + (75 x 3)] (.01)			135
D. Net returns to Land, FL (family labor) and management			13,917
Less: Opportunity costs of FL: (551 hrs @ 20 CFA/hr)			11,020
E. Net returns to land and management			2,897
F. Net returns per field-hour of family labor (13,917 ÷ 551)			25.3
G. Output - seed ratio			38, 9, 1
H. Costs of production (CFA/kg of grain) (5,309 ÷ 593)			8.9
I. Total costs of production (CFA/kg of grain) (16,464 ÷ 593)			27.8

TABLE 4.2.3

AVERAGE COSTS AND RETURNS PER HECTARE FOR MAIZE
SYSTEM 2, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	23		
2. Average size (ha)	.049		
B. Non-labor input use			
1. Seed rate (kg/ha)	12.8 @ (84.3 CFA/kg)	1,079	
2. Pesticides (kg/ha)	.6 @ (196.1 CFA/kg)	118	
Total			1,197
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	11.4		
1.2 Hand tools	87.7		
1.3 Zero tillage	.9		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	20.8		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	1,058 hrs		
1.2 Social labor	22.6 hrs	228	
1.3 Hired labor	0 hrs	0	
1.4 Sub-total	1,080.6 hrs	228	
2. Harvest activities			
2.1 Family labor	82.9 hrs		
2.2 Social labor	30.2 hrs	171	
2.3 Hired labor	0 hrs	0	
2.4 Sub-total	113.1 hrs	171	
3. Total	1,193.7 hrs		399
E. Total variable costs			1,596
F. Tools and equipment (depreciation on)			158
G. Total costs			1,754
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Shelled corn	514		
B. Unit price (CFA/kg)	29.1		
1. Shelled corn			
C. Total value of output		14,957	
III. PERFORMANCE MEASURES			
A. Gross income			14,957
Less: Total variable costs			1,596
B. Gross margin			13,361
Less: Total fixed costs			158
C. Net margin			13,203
Less: Opportunity cost of equity capital @ 1%/month [(1,197 x 8) + (228 x 3)] (.01)			103
D. Net returns to Land, FL (family labor) and management			13,100
Less: Opportunity costs of FL: (1,141 hrs @ 20 CFA/hr)			22,820
E. Net returns to land and management			-9,720
F. Net returns per field-hour of family labor (13,100 ÷ 1,141)			11.5
G. Output - seed ratio			40.1
H. Costs of production (CFA/kg) (1,754 ÷ 514)			3.4
I. Total costs of production (CFA/kg) (24,677 ÷ 514)			48.0

TABLE 4.2.4

AVERAGE COSTS AND RETURNS PER HECTARE FOR GROUNDNUTS
SYSTEM 2, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	33		
2. Average size (ha)	.070		
B. Non-labor input use			
1. Seed rate (kg/ha)	15.7 @ (74.1 CFA/kg)	1,163	
Total			1,163
C. Agronomic			
1. Percentage of area ploughed using:			
1.1 Animal traction	8.6		
1.2 Hand tools	77.8		
1.3 Zero tillage	13.6		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	504.3 hrs		
1.2 Social labor	0 hrs	0	
1.3 Hired labor	0 hrs	0	
1.4 Sub-total	504.3 hrs	0	
2. Harvest activities			
2.1 Family labor	276.5 hrs		
2.2 Social labor	31.7 hrs	3,043	
2.3 Hired laobr	0 hrs	0	
2.4 Sub-total	308.2 hrs	3,043	
3. Total	812.5 hrs		3,043
E. Total variable costs			4,206
F. Tools and equipment (depreciation on)			104
G. Total costs			4,310
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Shelled groundnuts	215		
B. Unit price (CFA/kg)			
1. Shelled groundnuts	40.4		
C. Total value of output		8,686	
III. PERFORMANCE MEASURES			
A. Gross income			8,686
Less: Total variable costs			4,206
B. Gross margin			4,480
Less: Total fixed costs			104
C. Net margin			4,376
Less: Opportunity cost of equity capital @ 1%.month (1,163 x 8 x .01)			93
D. Net returns to Land, FL (family labor) and management			4,283
Less: Opportunity costs of FL: (781 hrs @ 20 CFA/hr)			15,620
E. Net returns to land and management			-11,337
F. Net returns per field-hour of family labor (4,283 ÷ 781)			5.5
G. Output - seed ratio			13.7
H. Costs of production (CFA/kg) (4,310 ÷ 215)			20.0
I. Total costs of production (CFA/kg) (20,023 ÷ 215)			93.1

TABLE 4.2.5

AVERAGE COSTS AND RETURNS PER HECTARE FOR SOYBEANS
SYSTEM 2, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	13		
2. Average size (ha)	.131		
B. Non-labor input use			
1. Seed rate (kg/ha)	58.8 @ (72.4 CFA/kg)	4,257	
Total			4,257
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	0		
1.2 Hand tools	0		
1.3 Zero tillage	100		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	10.4		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	627.1 hrs		
1.2 Social labor	29.4 hrs	765	
1.3 Hired labor	0 hrs	0	
1.4 Sub-total	656.5 hrs	765	
2. Harvest activities			
2.1 Family labor	194.1 hrs		
2.2 Social labor	90 hrs	629	
2.3 Hired labor	0 hrs	0	
2.4 Sub-total	284.1 hrs	629	
3. Total	940.6 hrs		1,394
E. Total variable costs			5,651
F. Tools and equipment (depreciation on)			77
G. Total costs			5,728
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Soybeans	362		
B. Unit price (CFA/kg)			
1. Soybeans	120		
C. Total value of output		43,440	
III. PERFORMANCE MEASURES			
A. Gross income			43,440
Less: Total variable costs			5,651
B. Gross margin			37,789
Less: Total fixed costs			77
C. Net margin			37,712
Less: Opportunity cost of equity capital @ 1%/month [(4,257 x 8) + (765 x 3)] (.01)			364
D. Net returns to land, FL (family labor) and management			37,348
Less: Opportunity costs of FL: (821 hrs @ 20 CFA/hr)			16,420
E. Net returns to land and management			20,928
F. Net returns per field-hour of family labor (37,348 ÷ 821)			45.5
G. Output - seed ratio			6.2
H. Costs of production (CFA/kg) (5,728 ÷ 362)			15.8
I. Total costs of production (CFA/kg) (22,512 ÷ 362)			62.2

TABLE 4.2.6

AVERAGE COSTS AND RETURNS PER HECTARE FOR OKRA
SYSTEM 2, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	23		
2. Average size (ha)	.011		
B. Non-labor input use			
1. Seed rate (kg/ha)	69 @ (144 CFA/kg)	9,936	
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	0		
1.2 Hand tools	74.5		
1.3 Zero tillage	25.5		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	18.2		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	666.7 hrs		
1.2 Social labor	0 hrs		
1.3 Hired labor	0 hrs		
1.4 Sub-total	666.7 hrs	0	
2. Harvest activities			
2.1 Family labor	216.7 hrs		
2.2 Social labor	0 hrs		
2.3 Hired labor	0 hrs		
2.4 Sub-total	216.7 hrs	0	
3. Total	883.4 hrs		0
E. Total variable costs			9,936
F. Tools and equipment (depreciation on)			130
G. Total costs			10,066
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Fresh okra	643		
B. Unit price (CFA/kg)			
1. Fresh okra	74.2		
C. Total value of output		47,711	
III. PERFORMANCE MEASURES			
A. Gross income			47,711
Less: Total variable costs			9,936
B. Gross margin			37,775
Less: Total fixed costs			130
C. Net margin			37,645
Less: Opportunity cost of equity capital @ 1%/month (9,936 x 8 x .01)			795
D. Net returns to land FL (family labor) and management			36,850
Less: Opportunity costs of FL: (883 hrs @ 20 CFA/hr)			17,660
E. Net returns to land and management			19,190
F. Net returns per field-hour of family labor (36,850 ÷ 883)			41.7
G. Output - seed ratio			9.3
H. Costs of production (CFA/kg) (10,066 ÷ 643)			15.6
I. Total costs of production (CFA/kg) (28,521 ÷ 643)			44.3

TABLE 4.2.7

AVERAGE COSTS AND RETURNS PER HECTARE FOR COTTON
SYSTEM 2, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	4		
2. Average size (ha)	.277		
B. Non-labor input use			
1. Seed rate (kg/ha)	60 @ (68.5 CFA/kg)	4,110	
2. Fertilizer (18-35-0) rate (kg/ha)	29.1 @ (56 CFA/kg)	1,630	
Total			5,740
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	44.4		
1.2 Hand tools	55.3		
1.3 Zero tillage	.3		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	746.4 hrs		
1.2 Social labor	13.1 hrs	455	
1.3 Hired labor	0 hrs	0	
1.4 Sub-total	759.5 hrs	455	
2. Harvest activities			
2.1 Family labor	57.3 hrs		
2.2 Social labor	144.9 hrs	5,000	
2.3 Hired labor	0 hrs	0	
2.4 Sub-total	202.2 hrs	5,000	
3. Total	961.8 hrs		5,455
E. Total variable costs			11,195
F. Tools and equipment (depreciation on)			500
G. Total costs			11,695
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Cotton	212		
B. Unit price (CFA/kg)			
1. Cotton	62.8		
C. Total value of output		13,314	
III. PERFORMANCE MEASURES			
A. Gross income			13,314
Less: Total variable costs			11,195
B. Gross margin			2,119
Less: Total fixed costs			500
C. Net margin			1,619
Less: Opportunity cost of equity capital @ 1%/month [(5,740 x 8) + (455 x 3)] (.01)			473
D. Net returns to land FL(family labor) and management			1,146
Less: Opportunity costs of FL: (804 hrs @ 20 CFA/hr)			16,080
E. Net returns to land and management			-14,934
F. Net returns per field-hour of family labor (1,146 ÷ 804)			1.4
G. Output - seed ratio			3.5
H. Costs of production (CFA/kg) (11,695 ÷ 212)			55.1
I. Total costs of production (CFA/kg) (28,248 ÷ 212)			133.2

respectively. Except for the S/M/C enterprise, plots were much smaller in System 2 than in System 1. The mean labor utilization per hectare in all field activities ranged from 582.5 hours for the S/M/C enterprise to 2,278.0 hours for the rice enterprise. Compared to System 1, the labor use in S/M/C enterprise is low because of the difference in land preparation technique. Zero tillage was used on 93.4 percent of the S/M/C fields. In this system of production, family labor input as a percentage of total labor input varied between 83 percent for the cotton enterprise and 100 percent for the okra enterprise. Social labor varied between 0 percent and 17 percent. No hired labor was used in this production system (Tables 4.2.1 - 4.2.7). The mean expenditure per hectare for social labor where it was used in this system ranged from 337 CFA under the S/M/C enterprise to 5,455 CFA for the cotton enterprise, representing 6 to 47 percent of total expenditures.

The seed rates observed in this production system were quite far from the recommended rates.[7] The mean quantity of paddy rice seeds used in this system was 50.8 kg/ha which is only about 64 percent of the recommended rate of 80 kg/ha. In the case of groundnut enterprise, on the average, only about 20 percent of the recommended seed rate was applied. Maize, millet and cowpeas suffer the same problem and seed rates observed were only 51, 11 and 4 percent of the recommended rates, respectively. However, in the cases of cotton and soybeans, seed rates observed were 50 percent and 47 percent above the recommended rates.

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[7]Rates referred to here are rates recommended by the research unit of the AVV settlement schemes in the center-east region of Upper Volta.

Crop yields were generally low in this sytem, particularly for groundnuts, soybeans, cotton and millet where they were only 215, 362, 212, and 13 kg/ha, respectively.

3.2.2. Comparison and Appraisal of the Seven Major Enterprises in System 2

Following the scheme used in analyzing System 1, the discussion here will mainly focus on the performance measures so as to identify the enterprises with the highest financial return and the lowest cost of production.

3.2.2.1. Gross Margin (GM)

Among the seven major enterprises of System 2, the variation in gross margin ranged from 2,119 CFA/ha to 42,711 CFA/ha (Table 4.5.2). The rice enterprise had the highest gross margin and the groundnut and cotton enterprises had the lowest gross margin; however, all enterprises in this system were able to cover their variable costs.

3.2.2.2. Net Margin (NM)

Among the seven major enterprises the variation in NM ranged from 1,619 CFA/ha under the cotton enterprise to 41,787 CFA/ha under the rice enterprise. So, according to the first two performance measures considered, rice appears to provide the highest returns per hectare of all crops in this system.

3.2.2.3. Net Returns to Land, Family Labor and Management (NRLFLM)

The NRLFLM for the seven enterprises ranged from 1,146 CFA/ha for the cotton enterprise to 41,381 CFA/ha for the rice enterprise (Table 4.5.2).

TABLE 4.5.2

A COMPARATIVE ANALYSIS OF THE MAJOR ENTERPRISES IN SYSTEM 2, BASED ON SURVEY DATA FROM 30 HOUSEHOLDS, 1980

Criteria	Enterprises						
	Rice	S/M/C	Maize	Groundnuts	Soybeans	Okra	Cotton
I. General Characteristics							
1. # of cases	76	40	23	33	13	23	4
2. Average size (ha)	.270	1.574	.049	.070	.131	.011	.277
3. Average yield (kg/ha)	1,172	579/13/1	514	215	362	643	212
II. Financial Situation (CFA/ha)							
1. Gross income	48,872	19,361	14,957	8,686	43,440	47,711	13,314
2. Variable costs	6,161	1,993	1,596	4,206	5,651	9,936	11,195
3. Total expenditures (including depreciation on tools & equipment)	7,085	5,309	1,754	4,310	5,728	10,066	11,695
4. Opportunity costs of							
4.1 Family labor	44,200	11,020	22,820	15,620	16,420	17,660	16,080
4.2 Equity capital	406	135	103	93	364	795	473
5. Total costs	51,691	16,464	24,677	20.023	22,512	28,521	28,248
III. Performance Measures							
1. Gross margin (CFA/ha) (II.1 - II.2)	42,711	17,368	13,361	4,480	37,789	37,775	2,119
2. Net margin (CFA/ha) (II.1 - II.3)	41,787	14,052	13,203	4,376	37,712	37,645	1,619
3. Net returns to land, family labor & management (CFA/ha) (III.2 - II.4.2)	41,381	13,917	13,100	4,283	37,348	36,850	1,146
4. Net returns to land & management (CFA/ha) (III.3 - II.4.1)	-2,819	2,897	-9,720	-11,337	20,928	19,190	-14,934
5. Net returns per hour of family labor (CFA/phr) (III.3 ÷ total FL)	18.7	25.3	11.5	5.5	45.5	41.7	1.4
6. Total costs of production (CFA/kg)	44.1	27.8	48.0	93.1	62.2	44.3	133.2
7. Output - seed ratio	23.1	38/9/1	40.1	13.7	6.2	9.3	3.5

In all the enterprises considered in this system, the return per field hour of family labor was less than the minimum average wage rate paid to the hired labor in the other systems studied (i.e., 105 CFA/hr) and also less than the minimum wage paid to unskilled labor in urban areas (i.e., 90 CFA/hr). This result suggests that there may be some financial gain for family members in seeking employment on other farms outside this system or in urban areas. Returns per field hour of family labor in this system ranged from 1.4 CFA/hr in the case of cotton enterprise to 45.5 CFA/hr in the case of soybeans. As regards the rice enterprise, the return per field hour of family labor was only 18.7 CFA/hr. If the present costs and returns structure continues, the following shifts could be expected in this system:

a) farmers will put more of their land and labor into soybeans, okra, S/M/C and rice in that order; and

b) low returns per field hour of family labor in cotton enterprise may force farmers to abandon this crop despite the government support of this export crop.

3.2.2.4. Returns to Land and Management (RLM)

Four enterprises realized a negative return to land and management. They are cotton, groundnuts, maize and rice. The RLM for the seven enterprises ranged from -14,934 CFA/ha for the cotton enterprise to 20,928 CFA/ha for the soybean enterprise (Table 4.5.2). The high negative returns to land and management for cotton and groundnuts was probably due to the low yields of these two enterprises. And because of this low yield, the NM was not enough to yield a positive return to land and management.

3.2.2.5. Cost of Production

Taking into consideration only variable and fixed costs, (direct costs) maize showed the lowest cost of production (3.4 CFA/kg of shelled corn) and cotton had the highest cost of production (55.1 CFA/kg)--Tables 4.2.1 - 4.2.7. The second type of cost of production computed was obtained by adding the opportunity costs of equity capital and family labor to the total expenditures and the result was divided by the yield. Among the seven enterprises, S/M/C showed the lowest total cost of production (27.8 CFA/kg) and cotton had the highest cost of production (133.2 CFA/kg). The second highest total cost of production was found in groundnuts (93.1 CFA/kg), probably due to the low yield of groundnut in this system. Rice showed the second lowest total costs of production (44.1 CFA/kg of paddy).

3.3. System 3: Production System Based on Farmers Growing Rice in Improved Bas-Fonds

The most important enterprises in terms of the objective of study, area cultivated, labor used and income generated were: rice, sorghum/millet/cowpeas (S/M/C), maize, groundnuts/bambera nuts (GN/BN), and soybeans.

3.3.1. Overview of the Enterprise Budgets in System 3

Costs and returns to the five major enterprises in System 3, derived from the 1980/81 survey are shown in Tables 4.3.1 - 4.3.5. The average areas planted in rice, S/M/C, maize, GN/BN, and soybeans were in hectares, .488, .707, .431, .582 and .494, respectively. The mean labor utilization per hectare in all field activities ranged from 175.6 hours for the soybean enterprise to 1,435.8 hours for the S/M/C enterprise. In this

TABLE 4.3.1

AVERAGE COSTS AND RETURNS PER HECTARE FOR RICE
SYSTEM 3, IN THE EORD, 1980

			CFA	CFA
I.	INPUT USE			
	A. Basic data			
	1. # of cases	45		
	2. Average size (ha)	.488		
	B. Non-labor input use			
	1. Seed rate (kg/ha)	38.0 @ (100.4 CFA/kg)	3,815	
	Total			3,815
	C. Agronomic data			
	1. Percentage of area ploughed using:			
	1.1 Animal traction	21.9		
	1.2 Hand tools	47.9		
	1.3 Zero tillage	30.2		
	2. Percentage of area fertilized:			
	2.1 Chemically	0		
	2.2 Organically	0		
	D. Labor input use			
	1. Pre-harvest activities			
	1.1 Family labor	267.6 hrs		
	1.2 Social labor	69.7 hrs	450	
	1.3 Hired labor	9.6 hrs @ 125 CFA/hr)	1,200	
	1.4 Sub-total	346.9 hrs	1,650	
	2. Harvest activities			
	2.1 Family labor	250.5 hrs		
	2.2 Social labor	79.8 hrs	231	
	2.3 Hired labor	0 hrs	0	
	2.4 Sub-total	330.3 hrs	231	
	3. Total	677.2 hrs		1,881
	E. Total variable costs			5,696
	F. Tools and equipment (depreciation on)			234
	G. Total costs			5,930
II.	OUTPUT			
	A. Crop yields (kg/ha)			
	1. Paddy rice	501		
	B. Unit price (CFA/kg)	65.7		
	C. Total value of output		32,916	
III.	PERFORMANCE MEASURES			
	A. Gross income			32,916
	Less: Total variable costs			5,696
	B. Gross margin			27,220
	Less: Total fixed costs			234
	C. Net margin			26,986
	Less: Opportunity cost of equity capital @ 1%/month [(3,815 x 8) + (1,650 x 3)] (.01)			355
	D. Net returns to land, FL (family labor) and management			26,631
	Less: Opportunity costs of FL: (518 hrs @ 55 CFA/hr)			28,490
	E. Net returns to land and management			-1,859
	F. Net returns per field-hour of family labor (26,631 ÷ 518)			51.4
	G. Output - seed ratio			13.2
	H. Costs of production (CFA/kg) (5,930 ÷ 501)			11.8
	I. Total costs of production (CFA/kg) (34,775 ÷ 501)			69.4

TABLE 4.3.2

AVERAGE COSTS AND RETURNS PER HECTARE FOR SORGHUM/MILLET/COWPEAS
SYSTEM 3, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	56		
2. Average size (ha)	.707		
B. Non-labor input use			
1. Seed rate (kg/ha)			
1.1 Sorghum	19.3 @ (63.1 CFA/kg)	1,218	
1.2 Millet	22.9 @ (48.2 CFA/kg)	1,104	
1.3 Cowpeas	7.8 @ (63 CFA/kg)	491	
2. Pesticides (kg/ha)	.9 @ (196.1 CFA/kg)	176	
3. Total			2,989
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	8.1		
1.2 Hand tools	.8		
1.3 Zero tillage	91.1		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	1,133.6 hrs		
1.2 Social labor	40.9 hrs	1,383	
1.3 Hired labor	3.9 hrs @ 145 (CFA/hr)	565	
1.4 Sub-total	1,178.4 hrs	1,948	
2. Harvest activities			
2.1 Family labor	213.4 hrs		
2.2 Social labor	44 hrs	415	
2.3 Hired labor	0 hrs	0	
2.4 Sub-total	257.4 hrs	415	
3. Total	1,435.8 hrs		2,363
E. Total variable costs			5,352
F. Tools and equipment (depreciation on)			661
G. Total costs			6,013
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Sorghum	125		
2. Millet	315		
3. Cowpeas	15		
B. Unit price (CFA/kg)			
1. Sorghum/millet	42.6		
2. Cowpeas	76.8		
C. Total value of output		19,896	
III. PERFORMANCE MEASURES			
A. Gross income			19,896
Less: Total variable costs			5,352
B. Gross margin			14,544
Less: Total fixed costs			661
C. Net margin			13,883
Less: Opportunity cost of equity capital @ 1%/month [(2,989 x 8) + (1,948 x 3)] (.01)			298
D. Net returns to land, FL (family labor) and management			13,585
Less: Opportunity costs of FL: (1,347 hrs @ 55 CFA/hr)			74,085
E. Net returns to land and management			-60,500
F. Net returns per field-hour of family labor (13,585 ÷ 1,347)			10.1
G. Output - seed ratio			6/14/17
H. Costs of production (CFA/kg of grain) (6,013 ÷ 455)			13.2
I. Total costs of production (CFA/kg of grain) (80,396 ÷ 455)			176.7

TABLE 4.3.3

AVERAGE COSTS AND RETURNS PER HECTARE FOR MAIZE
SYSTEM 3, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	39		
2. Average size (ha)	.431		
B. Non-labor input use			
1. Seed rate (kg/ha)	17.8 @ (55.4 CFA/kg)	986	
2. Fertilizer (18-35-0) (kg/ha)	1.3 @ (100 CFA/kg)	130	
Total			1,116
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	15.5		
1.2 Hand tools	19.6		
1.3 Zero tillage	65.1		
2. Percentage of area fertilized:			
2.1 Chemically	69.0		
2.2 Organically	83.1		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	231.1 hrs		
1.2 Social labor	0 hrs		
1.3 Hired labor	.1 hrs @ 106 (CFA/hr)	11	
1.4 Sub-total	231.2 hrs	11	
2. Harvest activities			
2.1 Family labor	46.1 hrs		
2.2 Social labor	8.3 hrs	280	
2.3 Hired labor	.1 hrs @ 106 (CFA/hr)	11	
2.4 Sub-total	53.5 hrs	291	
3. Total	284.7 hrs		302
E. Total variable costs			1,418
F. Tools and equipment (depreciation on)			179
G. Total costs			1,597
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Shelled corn	885		
B. Unit price (CFA/kg)			
1. Shelled corn	38.2		
C. Total value of output		33,807	
III. PERFORMANCE MEASURES			
A. Gross income			33,807
Less: Total variable costs			1,418
B. Gross margin			32,389
Less: Total fixed costs			179
C. Net margin			32,210
Less: Opportunity cost of equity capital @ 1%/month [(1,116 x 8) + (11 x 3)] (.01)			90
D. Net returns to land, FL (family labor) and management			32,120
Less: Opportunity costs of FL: 277 hrs @ 55 CFA/hr)			15,235
E. Net returns to land and management			16,885
F. Net returns per field-hour of family labor (32,120 ÷ 277)			116.0
G. Output - seed ratio			49.7
H. Costs of production (CFA/kg) (1,597 ÷ 885)			1.8
I. Total costs of production (CFA/kg) (16,922 ÷ 885)			19.1

TABLE 4.3.4

AVERAGE COSTS AND RETURNS PER HECTARE FOR GROUNDNUTS/BAMBERA NUTS
SYSTEM 3, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	47		
2. Average size (ha)	.582		
B. Non-labor input use			
1. Seed rate (Kg/ha)			
1.1 Groundnuts	7.7 @ (142.8 CFA/kg)	1,100	
1.2 Bambera nuts	4.3 @ (84.4 CFA/kg)	363	
2. Total			1,463
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	24.9		
1.2 Hand tools	1.7		
1.3 Zero tillage	73.4		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	1.2		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	271.9 hrs		
1.2 Social labor	5.9 hrs	44	
1.3 Hired labor	.2 hrs @ 106 (CFA/hr)	21	
1.4 Sub-total	278.0 hrs	65	
2. Harvest activities			
2.1 Family labor	208.5 hrs		
2.2 Social labor	7.3 hrs	205	
2.3 Hired labor	0 hrs @ (CFA/hr)	0	
2.4 Sub-total	215.8 hrs	205	
3. Total	493.8 hrs		270
E. Total variable costs			1,733
F. Tools and equipment (depreciation on)			291
G. Total costs			2,024
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Shelled groundnuts	119		
2. Shelled bambera nuts	6		
B. Unit price (CFA/kg)			
1. Shelled groundnuts	67.4		
2. Shelled bambera nuts	35.8		
C. Total value of output		8,235	
III. PERFORMANCE MEASURES			
A. Gross income			8,235
Less: Total variable costs			1,733
B. Gross margin			6,502
Less: Total fixed costs			291
C. Net margin			6,211
Less: Opportunity cost of equity capital @ 1%/month [(1,463 x 8) + (65 x 3)] (.01)			119
D. Net returns to land, FL (family labor) and management			6,092
Less: Opportunity costs of FL: (480 hrs @ 55 CFA/hr)			26,400
E. Net returns to land and management			-20,300
F. Net returns per field-hour of family labor (6,092 ÷ 480)			12.7
G. Output - Seed ratio			15/1
H. Costs of production (CFA/kg) (2,024 ÷ 125)			16.2
I. Total costs of production (CFA/kg) (28,543 ÷ 125)			228.3

TABLE 4.3.5

AVERAGE COSTS AND RETURNS PER HECTARE FOR SOYBEANS
SYSTEM 3, IN THE EORD, 1980

			CFA	CFA
I.	INPUT USE			
	A. Basic data			
	1. # of cases	18		
	2. Average size (ha)	.494		
	B. Non-labor input use			
	1. Seed rate (kg/ha)	25.0 @ (157.3 CFA/kg)	3,932	
	Total			3,932
	C. Agronomic data			
	1. Percentage of area ploughed using:			
	1.1 Animal traction	58.4		
	1.2 Hand tools	2.6		
	1.3 Zero tillage	39.1		
	2. Percentage of area fertilized:			
	2.1 Chemically	0		
	2.2 Organically	0		
	D. Labor input use			
	1. Pre-harvest activities			
	1.1 Family labor	147.2 hrs		
	1.2 Social labor	.9 hrs	56	
	1.3 Hired labor	0 hrs	0	
	1.4 Sub-total	148.1 hrs	56	
	2. Harvest activities			
	2.1 Family labor	23.5 hrs		
	2.2 Social labor	1.5 hrs	0	
	2.3 Hired labor	2.5 hrs @ 106 (CFA/hr)	265	
	2.4 Sub-total	27.5 hrs	265	
	3. Total	175.6 hrs		321
	E. Total variable costs			4,253
	F. Tools and equipment (depreciation on)			950
	G. Total costs			4,348
II.	Output			
	A. Crop yields (kg/ha)			
	1. Soybeans	707		
	B. Unit price (CFA/kg)			
	1. Soybeans	116.7		
	C. Total value of output		82,507	
III.	PERFORMANCE MEASURES			
	A. Gross income			82,507
	Less: Total variable costs			4,253
	B. Gross margin			78,254
	Less: Total fixed costs			950
	C. Net margin			77,304
	Less: Opportunity cost of equity capital @ 1%/month [(3,932 x 8) + (56 x 3)] (.01)			316
	D. Net returns to land, FL (family labor) and management			76,988
	Less: Opportunity costs of FL: (171 hrs @ 55 CFA/hr)			9,405
	E. Net returns to land and management			67,583
	F. Net returns per field-hour of family labor (76,988 ÷ 171)			450.2
	G. Output - seed ratio			28.2
	H. Costs of production (CFA/kg) (4,348 ÷ 707)			6.1
	I. Total costs of production (CFA/kg) (14,069 ÷ 707)			19.9

system, 76 to 97 percent of the total labor input was family labor. For the rice enterprise, family labor accounted for 76 percent of total labor input while for maize, GN/BN or soybean enterprises, it accounted up to 97 percent of total labor input per hectare. In this system of production, hired labor was used in all enterprises, its contribution to total labor input under all enterprises being less than 2 percent. But total non-family labor contribution to total labor input in this system varied between 3 percent and 24 percent. The relatively high dependence on non-family labor in this system gives us an idea of some employment opportunities for the rural population existing within this production system. And at the same time, it lets us suspect that family labor may rapidly be becoming a constraint on production in this system, or that farmers in this system are beginning to substitute hired labor for family labor in order to free family labor for other purposes (e.g., leisure).

The mean expenditure per hectare for non-family labor in this system varied from 270 CFA for GN/BN enterprise to 2,363 CFA for S/M/C enterprise. Total labor expenditures on non-family labor in the form of wages, food and drink varied from 7 percent of total farm expenditures (TFE) under the soybean enterprise to 39 percent of TFE under the S/M/C enterprise.

The seed rates observed in this production system were quite often far from the recommended rates. The mean quantity of paddy seeds used by farmers here was 38 kg/ha which is only 47 percent of the recommended rate of 80 kg/ha. In the case of the maize enterprise, the mean quantity of seeds used was only 71 percent of the recommended rate. Also, in the case of soybeans, the average seed rate observed, 25 kg/ha was only 62 percent of the recommended rate. In this production system, fertilizer was used only in maize but at a very low rate (1.3 kg/ha) which is only 1.3 percent of the recommended rate. The average application rate of fertilizer is so low that it suggests only farmer experimentation on a small proportion of "fertilized" area.

Crop yields were generally low, particularly for sorghum, groundnuts and bambera nuts. However, it should be noted that yields obtained under crop mixtures may understate the potential yields of those crops when grown in pure stands. A cowpea yield of 15 kg/ha represents only the average contribution of cowpeas to the grain production enterprise, taking into consideration that sometimes no cowpeas were harvested even though they were planted. While the yield so computed may understate the potential yield of cowpeas as an enterprise itself, it correctly measures its average importance or contribution to the grain production enterprise. However, it remains true that one of the major problems facing this production system is how to increase cereal yields from their present levels of 200-500 kg/ha.

3.3.2. Comparison and Appraisal of the Five Major Enterprises in System 3

A summary of general characteristics, costs and returns as well as performance measures for all five enterprises are provided in Table 4.5.3. The discussion will mainly concern the analysis of the performance measures so as to identify the enterprises with the highest financial return and lowest cost of production.

TABLE 4.5.3

A COMPARATIVE ANALYSIS OF THE MAJOR ENTERPRISES IN SYSTEM 3, BASED ON SURVEY DATA FROM 30 HOUSEHOLDS, 1980

Criteria	Enterprises				
	Rice	S/M/C	Maize	GN/BN	Soybeans
I. General Characteristics					
1. # of cases	45	56	39	47	18
2. Average size (ha)	.488	.707	.431	.582	.494
3. Average yield (kg/ha)	501	125/315/15	885	119/6	707
II. Financial Situation (CFA/ha)					
1. Gross income	32,916	19,896	33,807	8,235	82,507
2. Variable costs	5,696	5,352	1,418	1,733	4,253
3. Total expenditures (including depreciation on tools and equipment)	5,930	6,013	1,597	2,024	4,348
4. Opportunity costs of					
4.1 Family labor	28,490	74,085	15,235	26,400	9,405
4.2 Equity capital	355	298	90	119	316
5. Total costs	34,775	80,396	16,922	28,543	14,069
III. Performance Measures					
1. Gross margin (CFA/ha) (II.1 - II.2)	27,220	14,544	32,389	6,502	78,254
2. Net margin (CFA/ha) (II.1 - II.3)	26,986	13,883	32,210	6,211	77,304
3. Net returns to land, family labor & management (CFA/ha) (III.2 - II.4.2)	26,631	13,585	32,120	6,092	76,988
4. Net returns to land & management (CFA/ha) (III.3 - II.4.1)	-1,859	-60,500	16,885	-20,300	67,583
5. Net returns per hour of family labor (CFA/phr) (III.3 ÷ Total FL)	51.4	10.1	116.0	12.7	450.2
6. Total costs of production (CFA/kg)	69.4	176.7	19.1	228.3	19.9
7. Output - seed ratio	13.2	6/14/2	49.7	15/1	28.2

3.3.2.1. Gross Margin (GM)

Among the five major enterprises of System 3, the variation in gross margin ranged from 6,502 CFA/ha to 78,254 CFA/ha (Table 4.5.3). The soybean enterprise had the highest gross margin and the GN/BN enterprise had the lowest gross margin. One thing interesting to note though is that the gross margins for all enterprises studied was positive and hence, all the enterprises are valid candidates to stay in the farm business organization according to the neo-classical economic theory.

3.3.2.2. Net Margin (NM)

Among the five major enterprises, the variation in the NM ranged from 6,211 CFA/ha to 77,304 CFA/ha. So far, the soybean enterprise appears to provide the highest returns per hectare of all crops under consideration in this system followed by maize (32,210 CFA/ha) and rice (26,986 CFA/ha) (Table 4.5.3).

3.2.2.3. Net Returns to Land, Family Labor and Management (NRLFLM)

The NRLFLM for the five enterprises ranged from 76,988 CFA/ha for soybean enterprise to 6,092 CFA/ha for the GN/BN enterprise (Table 4.5.3). In all enterprises, except for soybeans and maize, the return per field hour of family labor was less than the minimum wage rate paid to unskilled urban workers (i.e., 90 CFA/hr). This result suggests that there may be some financial gain in seeking employment in urban areas or other farms where the minimum observed wage to hired labor is 45 CFA/hr (e.g., rice farms). In the case of soybean and maize enterprises where the returns are 450.2 CFA/hr and 116.0 CFA/hr, respectively, returns here are far above the minimum average agricultural wage rate and also have the SMIG. Thus there is no financial advantage of family members seeking wage employment in other enterprises or in urban areas when they are needed on their soybean and maize fields. In the case of rice, there is some financial advantage of family members seeking wage employment in other enterprises or in urban areas since the returns are only 51.4 CFA/hr. But compared to returns under S/M/C enterprise, farmers are better off working on their rice fields. The following shifts could be expected to take place:

a) farmers will put more of their land and labor into soybeans and maize if the minimum sorghum needed for family consumption is attained; and

b) low returns per hour of family labor in rice enterprise compared to the SMIG, may force farmers to abandon this crop since as a grain, it is not yet an important part of the diet. Some incentive structure must be urgently found if rice growing is to survive in this system where some important investments in water control have already been made.

3.3.2.4. Returns to Land and Management (RLM)

All enterprises in this system, except soybeans and maize, realized a negative return to land and management (Table 4.5.3). The RLM for the five enterprises ranged from 67,583 CFA/ha for soybeans to -60,500 CFA/ha for the S/M/C enterprise.

3.3.2.5. Costs of Production

Taking into consideration only variable and fixed costs, maize showed the lowest cost of production (1.8 CFA/kg) and rice had the highest cost of production (11.8 CFA/kg of paddy) (Tables 4.3.1 - 4.3.5). The second type of cost of production computed was obtained by adding the opportunity cost of equity capital and family labor to total expenditures and the result was divided by the yield. Among the five enterprises, maize showed the lowest total costs of production (19.1 CFA/kg) and GN/BN had the highest total cost of production (228.3 CFA/kg). The second lowest total cost of production was found in soybeans (19.9 CFA/kg). The third lowest total cost of production was found in rice (69.4 CFA/kg).

3.4. System 4: Production System Based on Farmers Growing Irrigated Paddies with Fertilizer

In this production system, the most important enterprises in terms of the objectives of study, area cultivated, labor used, and income generated were: rice, sorghum/millet/cowpeas (S/M/C), maize, groundnuts, bambera nuts and okra.

3.4.1. Overview of the Enterprise Budgets in System 4

Costs and returns to the six major enterprises in System 4, derived from the 1980 survey are shown in Tables 4.4.1 - 4.4.6. The average areas planted in rice, S/M/C, maize, groundnuts, bambera nuts and okra were in hectares, .151, .766, .093, .118, .042 and .065, respectively. The mean labor utilization per hectare in all field activities ranged from 145.4 hours for the okra enterprise to 3,054 hours for the rice enterprise. In this system, 98 to 100 percent of the total labor input per hectare was family labor. No hired labor was used in this system. The low dependence on non-family labor gives us an idea of the poor employment opportunities which exist in this production system.

The mean expenditure per hectare for social labor in rice and S/M/C enterprises where it is used were 1,220 CFA and 41 CFA, respectively.

TABLE 4.4.1

AVERAGE COSTS AND RETURNS PER HECTARE FOR RICE
SYSTEM 4, IN THE EORD, 1980

			CFA	CFA
I.	INPUT USE			
	A. Basic data			
	1. # of cases	62		
	2. Average size (ha)	.151		
	B. Non-labor input use			
	1. Seed rate (kg/ha)	57.7 @ (125 CFA/kg)	7,212	
	2. Fertilizer (18-35-0) (kg/ha)	120.3 @ (56 CFA/kg)	6,737	
	3. Pesticides (kg/ha)	3.3 @ (196.1 CFA/kg)	647	
	Total			14,596
	C. Agronomic data			
	1. Percentage of area ploughed using:			
	1.1 Animal traction	14.7		
	1.2 Hand tools	70.9		
	1.3 Zero tillage	14.4		
	2. Percentage of area fertilized:			
	2.1 Chemically	76.4		
	2.2 Organically	0		
	D. Labor input use			
	1. Pre-harvest activities			
	1.1 Family labor	1,925 hrs		
	1.2 Social labor	22 hrs	301	
	1.3 Hired labor	0 hrs	0	
	1.4 Sub-total	1,947 hrs	301	
	2. Harvest activities			
	2.1 Family labor	1,051 hrs		
	2.2 Social labor	56.3 hrs	919	
	2.3 Hired labor	0 hrs	0	
	2.4 Sub-total	1,107 hrs	919	
	3. Total	3,054 hrs		1,220
	E. Total variable costs			15,816
	F. Tools and equipment (depreciation on)			1,226
	G. Total costs			17,042
II.	OUTPUT			
	A. Crop yields (kg/ha)			
	1. Paddy rice	1,736		
	B. Unit price (CFA/kg)			
	1. Paddy rice	51.8		
	C. Total value of output		89,925	
III.	PERFORMANCE MEASURES			
	A. Gross income			89,925
	Less: Total variable costs			15,816
	B. Gross margin			74,109
	Less: Total fixed costs			1,226
	C. Net margin			72,883
	Less: Opportunity cost of equity capital @ 1%/month [(14,596 x 8) + (301 x 3)] (.01)			1,177
	D. Net returns to land, FL (family labor) and management			71,706
	Less: Opportunity costs of FL: 2,976 hrs @ 27 CFA/hr)			80,352
	E. Net returns to land and management			-8,646
	F. Net returns per field-hour of family labor (71,706 ÷ 2,976)			24.1
	G. Output - seed ratio			30.2
	H. Costs of production (CFA/kg) (17,042 ÷ 1,736)			9.8
	I. Total costs of production (CFA/kg) (98,571 ÷ 1,736)			56.8

TABLE 4.4.2

AVERAGE COSTS AND RETURNS PER HECTARE FOR SORGHUM/MILLET/COWPEAS
SYSTEM 4, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	48		
2. Average size (ha)	.766		
B. Non-labor input use			
1. Seed rate (kg/ha)			
1.1 Sorghum	7.9 @ (93.2 CFA/kg)	736	
1.2 Millet	2.7 @ (83.4 CFA/kg)	225	
1.3 Cowpeas	3.2 @ (93.0 CFA/kg)	298	
Total			1,259
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	0		
1.2 Hand tools	98.2		
1.3 Zero tillage	.8		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	0		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	1,233 hrs		
1.2 Social labor	.9 hrs	29	
1.3 Hired labor	0 hrs	0	
1.4 Sub-total	1,233 hrs	29	
2. Harvest activities			
2.1 Family labor	205.3 hrs		
2.2 Social labor	2.2 hrs	12	
2.3 Hired labor	0 hrs	0	
2.4 Sub-total	207.5 hrs	12	
3. Total	1,440 hrs		41
E. Total variable costs			1,300
F. Tools and equipment (depreciation on)			4,919
G. Total costs			6,219
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Sorghum	401		
2. Millet	20		
3. Cowpeas	12		
B. Unit price (CFA/kg)			
1. Sorghum/millet	33.9		
2. Cowpeas	56.9		
C. Total value of output		14,955	
III. PERFORMANCE MEASURES			
A. Gross income			14,955
Less: Total variable costs			1,300
B. Gross margin			13,655
Less: Total fixed costs			4,919
C. Net margin			8,736
Less: Opportunity cost of equity capital @ 1%/month [(1,259 x 8) + (29 x 3)] (.01)			102
D. Net returns to land, FL (family labor) and management			8,634
Less: Opportunity costs of FL: (1,417 hrs @ 27 CFA/hr)			38,259
E. Net returns to land and management			-29,625
F. Net returns per field-hour of family labor (8,634 ÷ 1,417)			6.1
G. Output - seed ratio			51/7/4
H. Costs of production (CFA/kg of grain) (6,219 ÷ 433)			14.4
I. Total costs of production (CFA/kg of grain) (44,580 ÷ 433)			103.0

TABLE 4.4.3

AVERAGE COSTS AND RETURNS PER HECTARE FOR MAIZE
SYSTEM 4, IN THE EORD, 1980

			CFA	CFA
I.	INPUT USE			
	A. Basic data			
	1. # of cases	18		
	2. Average size (ha)	.093		
	B. Non-labor input use			
	1. Seed rate (kg/ha)	24.6 @ (81.7 CFA/kg)	2,010	
	Total			2,010
	C. Agronomic data			
	1. Percentage of area ploughed using:			
	1.1 Animal traction	18.7		
	1.2 Hand tools	75.0		
	1.3 Zero tillage	7.3		
	2. Percentage of area fertilized:			
	2.1 Chemically	0		
	2.2 Organically	31.8		
	D. Labor input use			
	1. Pre-harvest activities			
	1.1 Family labor	601.2 hrs		
	1.2 Social labor	0 hrs		
	1.3 Hired labor	0 hrs		
	1.4 Sub-total	601.2 hrs		
	2. Harvest activities			
	2.1 Family labor	238.1 hrs		
	2.2 Social labor	0 hrs		
	2.3 Hired labor	0 hrs		
	2.4 Sub-total	238.1 hrs		
	3. Total	839.3 hrs		0
	E. Total variable costs			2,010
	F. Tools and equipment (depreciation on)			211
	G. Total costs			2,221
II.	OUTPUT			
	A. Crop yields (kg/ha)			
	1. Shelled corn	2,197		
	B. Unit price (CFA/kg)			
	1. Shelled corn	31.8		
	C. Total value of output		69,895	
III.	PERFORMANCE MEASURES			
	A. Gross income			69,895
	Less: Total variable costs			2,010
	B. Gross margin			67,855
	Less: Total fixed costs			211
	C. Net margin			67,644
	Less: Opportunity cost of equity capital @ 1%/month (2,010 x 8 x .01)			161
	D. Net returns to land, FL (family labor) and management			67,483
	Less: Opportunity costs of FL: (839 hrs @ 27 CFA/hr)			22,653
	E. Net returns to land and management			44,830
	F. Net returns per field-hour of family labor (67,483 ÷ 839)			80.4
	G. Output - seed ratio			89.3
	H. Costs of production (CFA/kg) (2,221 ÷ 2,197)			1.0
	I. Total costs of production (CFA/kg) (25,035 ÷ 2,197)			11.4

TABLE 4.4.4

AVERAGE COSTS AND RETURNS PER HECTARE FOR GROUNDNUTS
SYSTEM 4, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	20		
2. Average size (ha)	.118		
B. Non-labor input use			
1. Seed rate (kg/ha)	44.0 @ (80.8 CFA/kg)	3,555	
Total			3,555
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	24.3		
1.2 Hand tools	72.9		
1.3 Zero tillage	2.8		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	18.2		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	355.6 hrs		
1.2 Social labor	0 hrs		
1.3 Hired labor	0 hrs		
1.4 Sub-total	355.6 hrs		
2. Harvest activities			
2.1 Family labor	323.9 hrs		
2.2 Social labor	0 hrs		
2.3 Hired labor	0 hrs		
2.4 Sub-total	323.9 hrs		
3. Total	679.5 hrs		0
E. Total variable costs			3,555
F. Tools and equipment (depreciation on)			303
G. Total costs			3,858
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Shelled groundnuts	422		
B. Unit price (CFA/kg)			
1. Shelled groundnuts	41.2		
C. Total value of output		17,386	
III. PERFORMANCE MEASURES			
A. Gross income			17,386
Less: Total variable costs			3,555
B. Gross margin			13,831
Less: Total fixed costs			303
C. Net margin			13,528
Less: Opportunity cost of equity capital @ 1%/month (3,555 x 8 x .01)			284
D. Net returns to land, FL (family labor) and management			13,244
Less: Opportunity costs of FL: (679 hrs @ 27 CFA/hr)			18,333
E. Net returns to land and management			-5,089
F. Net returns per field-hour of family labor (13,244 ÷ 679)			19.5
G. Output - seed ratio			9.6
H. Costs of production (CFA/kg) (3,858 ÷ 422)			9.1
I. Total costs of production (CFA/kg) (22,475 ÷ 422)			53.3

TABLE 4.4.5

AVERAGE COSTS AND RETURNS PER HECTARE FOR BAMBERA NUTS
SYSTEM 4, IN THE EORD, 1980

			CFA	CFA
I.	INPUT USE			
	A. Basic data			
	1. # of cases	3		
	2. Average size (ha)	.042		
	B. Non-labor input use			
	1. Seed rate (kg/ha)	79 @ (109.1 CFA/kg)	8,619	
	Total			8,619
	C. Agronomic data			
	1. Percentage of area ploughed using:			
	1.1 Animal traction	0		
	1.2 Hand tools	100		
	1.3 Zero tillage	0		
	2. Percentage of area fertilized:			
	2.1 Chemically	0		
	2.2 Organically	0		
	D. Labor input use			
	1. Pre-harvest activities			
	1.1 Family labor	770 hrs		
	1.2 Social labor	0 hrs		
	1.3 Hired labor	0 hrs		
	1.4 Sub-total	770 hrs		
	2. Harvest activities			
	2.1 Family labor	750 hrs		
	2.2 Social labor	0 hrs		
	2.3 Hired labor	0 hrs		
	2.4 Sub-total	750 hrs		
	3. Total	1,520 hrs		0
	E. Total variable costs			8,619
	F. Tools and equipment (depreciation on)			130
	G. Total costs			8,749
II.	OUTPUT			
	A. Crop yields (kg/ha)			
	1. Shelled bambera nuts	540		
	B. Unit price (CFA/kg)			
	1. Shelled bambera nuts	48.2		
	C. Total value of output		26,028	
III.	PERFORMANCE MEASURES			
	A. Gross income			26,028
	Less: Total variable costs			8,619
	B. Gross margin			17,409
	Less: Total fixed costs			130
	C. Net margin			17,279
	Less: Opportunity cost of equity capital @ 1%/month (8,619 x 8 x .01)			690
	D. Net returns to land, FL (family labor) and management			16,589
	Less: Opportunity costs of FL: (1,530 hrs @ 27 CFA/hr)			41,310
	E. Net returns to land and management			-24,721
	F. Net returns per field-hour of family labor (16,589 ÷ 1,530)			10.8
	G. Output - seed ratio			6.8
	H. Costs of production (CFA/kg) (8,749 ÷ 540)			16.2
	I. Total costs of production (CFA/kg) (50,749 ÷ 540)			94.0

TABLE 4.4.6

AVERAGE COSTS AND RETURNS PER HECTARE FOR OKRA
SYSTEM 4, IN THE EORD, 1980

		CFA	CFA
I. INPUT USE			
A. Basic data			
1. # of cases	20		
2. Average size (ha)	.065		
B. Non-labor input use			
1. Seed rate (kg/ha)	12.3 @ (144 CFA/kg)	1,771	
Total			1,771
C. Agronomic data			
1. Percentage of area ploughed using:			
1.1 Animal traction	2.3		
1.2 Hand tools	92.3		
1.3 Zero tillage	4.4		
2. Percentage of area fertilized:			
2.1 Chemically	0		
2.2 Organically	6.8		
D. Labor input use			
1. Pre-harvest activities			
1.1 Family labor	120.8 hrs		
1.2 Social labor	0 hrs		
1.3 Hired labor	0 hrs		
1.4 Sub-total	120.8 hrs		
2. Harvest activities			
2.1 Family labor	24.6 hrs		
2.2 Social labor	0 hrs		
2.3 Hired labor	0 hrs		
2.4 Sub-total	24.6 hrs		
3. Total	145.4 hrs		0
E. Total variable costs			1,771
F. Tools and equipment (depreciation on)			171
G. Total costs			1,942
II. OUTPUT			
A. Crop yields (kg/ha)			
1. Fresh okra	370		
B. Unit price (CFA/kg)			
1. Fresh okra	83.3		
C. Total value of output		30,821	
III. PERFORMANCE MEASURES			
A. Gross income			30,821
Less: Total variable costs			1,771
B. Gross margin			29,050
Less: Total fixed costs			171
C. Net margin			28,879
Less: Opportunity cost of equity capital @ 1%/month (1,771 x 8 x .01)			142
D. Net returns to land, FL (family labor) and management			28,737
Less: Opportunity costs of FL: (145 hrs @ 27 CFA/hr)			3,915
E. Net returns to land and management			24,822
F. Net returns per field-hour of family labor (28,737 ÷ 145)			198.2
G. Output - seed ratio			30.1
H. Costs of production (CFA/kg) (1,942 ÷ 370)			5.2
I. Total costs of production (CFA/kg) (5,999 ÷ 370)			16.2

For the rice enterprise, 75 percent of all expenditures were on harvest activities whereas under the S/M/C enterprise, 71 percent of these expenditures were spent on pre-harvest activities (Tables 4.4.1 - 4.4.2).

The seed rates observed in this production system were quite far from the recommended rates. The mean quantity of paddy rice seeds used by farmers of this system was 57.7 kg/ha which is about 72 percent of the recommended rate of 80 kg/ha. For the groundnut enterprise, only 55 percent of the recommended seed rate was applied, and for maize, the average seed rate observed (24.6 kg/ha) was very close to the recommended rate of 25 kg/ha.

Crop yields were generally low, but relative to other systems studied, yields were quite high. This certainly reflects certain general ecological conditions such as rainfall, humidity, soil type, etc., of the area where System 4 was located. In general, yields are higher with a higher rainfall and a better rain distribution. And as Baker and Lassiter (1980, pp. 48-49) pointed out, the higher rainfall and better distribution of rain in the Diapaga area goes with higher plant density, except for millet, which explains why, in general, we have higher yields in this system for all crops. It can also be observed that a large quantity of family labor input per hectare was used in this system of production. These observations amply demonstrate that yields in any system of production is not the result of any single factor.

3.4.2. Comparison and Appraisal of the Six Major Enterprises in System 4

A summary of general characteristics, costs and returns, as well as performance measures for all six enterprises are provided in Table 4.5.4.

TABLE 4.5.4

A COMPARATIVE ANALYSIS OF THE MAJOR ENTERPRISES IN SYSTEM 4, BASED ON SURVEY DATA FROM 30 HOUSEHOLDS, 1980

Criteria	Enterprises					
	Rice	S/M/C	Maize	Ground-nuts	Bambera nuts	Okra
I. General Characteristics						
1. # of cases	62	48	18	20	3	20
2. Average size (ha)	.151	.766	.093	.118	.042	.065
3. Average yield (kg/ha)	1,736	401/20/12	2,197	422	540	370
II. Financial Situation (CFA/ha)						
1. Gross income	89,925	14,955	69,895	17,386	26,028	30,821
2. Variable costs	15,816	1,300	2,010	3,555	8,619	1,771
3. Total expenditures (including depreciation on tools and equipment)	17,042	6,219	2,221	3,858	8,749	1,942
4. Opportunity costs of						
4.1 Family labor	80,352	38,259	22,653	18,333	41,310	3,915
4.2 Equity capital	1,177	102	161	284	690	142
5. Total costs	98,571	44,580	25,035	22,475	50,749	5,999
III. Performance Measures						
1. Gross margin (CFA/ha) (II.1 - II.2)	74,109	13,655	67,855	13,831	17,409	29,050
2. Net margin (CFA/ha) (II.1 - II.3)	72,883	8,736	67,644	13,528	17,279	28,879
3. Net returns to land, family labor and management (CFA/ha) (III.2 - II.4.2)	71,706	8,634	67,483	13,244	16,589	28,737
4. Net returns to land & management (CFA/ha) (III.3 - II.4.1)	-8,646	-29,625	44,830	-5,089	-24,721	24,822
5. Net returns per hour of family labor (CFA/phr) (III.3 ÷ Total FL)	24.1	6.1	80.4	19.5	10.8	198.2
6. Total costs of production (CFA/kg)	56.8	103.0	11.4	53.3	94.0	16.2
7. Output-seed ratio	30.2	51/7/4	89.3	9.6	6.8	30.1

The discussion will mainly concern the analysis of the performance measures so as to identify the enterprise with the highest financial return and lowest cost of production.

3.4.2.1. Gross Margin (GM)

Among the six major enterprises of System 4, the variation in gross margin ranged from 13,655 CFA/ha to 74,109 CFA/ha (Table 4.5.4). The rice enterprise had the highest gross margin and the S/M/C enterprise had the lowest gross margin, but all the GMs were positive.

3.4.2.2. Net Margin (NM)

Among the six major enterprises, the variation in NM ranged from 8,736 CFA/ha to 72,883 CFA/ha. Rice so far, appears to provide the highest return per hectare of all crops in this system.

3.4.2.3. Net Returns to Land, Family Labor and Management (NRLFLM)

The NRLFLM for the six enterprises ranged from 8,634 CFA/ha for the S/M/C enterprise to 71,706 CFA/ha for the rice enterprise (Table 4.5.4). In all enterprises, except for okra the return per field hour of family labor was less than the minimum wage rate paid to unskilled urban workers, i.e., 90 CFA/hr. This result suggests that there may be some financial gain in seeking employment in urban areas. However, in the case of the okra enterprise, the returns of 198 CFA/hr is far above the minimum wage rates. Thus, there is no financial advantage of family members seeking wage employment when they are needed on their okra fields. In the case of rice, the returns of 24.1 CFA/hr of family labor is far smaller than the minimum wage rates. This may be enough to initiate an exit process in this fragile industry. The following shifts could be expected:

a) farmers will put more of their land and labor under okra, maize and groundnuts if the minimum sorghum needed for home consumption is attained; and

b) low returns per hour of family labor in rice may force farmers to abandon this crop despite the government support of this crop.

3.4.2.4. Returns to Land and Management (RLM)

All enterprises, except okra and maize, realized a negative return to land and management (Table 4.5.4). The high negative RLM under S/M/C, bambera nuts and rice, was probably due to the large quantity of family labor input per hectare.

3.4.2.5. Costs of Production

Taking into consideration only variable and fixed costs, maize showed the lowest cost of production (1.0 CFA/kg) and bambera nuts had the highest cost of production (16.2 CFA/kg) (Tables 4.4.1 - 4.4.6). The second type of cost of production computed was obtained by adding the opportunity costs of equity capital and family labor to total farm expenditures and the result was divided by the yield. Among the six enterprises, maize still showed the lowest total cost of production (11.4 CFA/kg) and S/M/C had the highest total cost of production (103.0 CFA/kg). The second highest total cost of production was found in bambera nuts (94.0 CFA/kg). Okra showed the second lowest total costs of production (16.2 CFA/kt), and rice showed the third lowest total costs of production (56.8 CFA/kg).

3.5. Comparison and Appraisal of the Rice Enterprises Across the Four Production Systems Studied

Four basic systems of water control in rice farming were identified in the EORD. One relies on uncertain surface flooding (System 1) and attains a yield of less than 500 kg/ha (with no modern inputs). The other three provide partial or complete water control, with yields of .5 to 1.2 ton per hectare for improved swamps (Systems 2 and 3) and 1.7 tons per hectare for the dam system with fertilizer use. Table 4.5.5 summarizes the general characteristics, costs and returns as well as measures of efficiency for all four rice production techniques in the EORD. The discussion will focus mainly on the private profitability measures. These measures are based on average costs and returns for existing methods of rice farming in the EORD.

The NRLFLM at the farm level ranged from a high of about 71,706 CFA/ha on irrigated paddies in System 4 to a low of 23,908 CFA/ha on traditional bas-fonds in System 1. The greatest part of this difference is caused by variations in the method of water control which has a clear impact on yields. Rice cultivation is cheapest by a wide margin on traditional bas-fonds (System 1). Most expensive is the production on irrigated bas-fonds (Table 4.5.5). Cost variations among the three systems with partial or complete water control are quite appreciable (cf. family labor use between Systems 2 and 3 or Systems 3 and 4). Part of the difference in labor requirements as we mentioned earlier is probably due to the difference in the method of land preparation, yield differences and/or intensity of weeding. For instance, while in System 2, 100 percent of rice fields were prepared using hand-tools, in System 3, zero tillage during the 1980 survey was used on almost 78 percent of

TABLE 4.5.5

A COMPARATIVE FINANCIAL ANALYSIS OF THE FOUR MAJOR RICE PRODUCTION TECHNIQUES IN THE EORD, BASED ON SURVEY DATA FROM 116 HOUSEHOLDS, 1980-81

Criteria	Production Techniques			
	Traditional Bas-Fonds I	Semi-Traditional Bas-Fonds II	Improved Bas-Fonds III	Irrigated Bas-Fonds IV
I. General Characteristics				
1. # of cases	64	76	45	62
2. Average size (ha)	.411	.270	.488	.151
3. Average yield (kg/ha)	458.3	1,172	501	1,736
4. Seed rate (kg/ha)	23.6	50.8	38.0	57.7
II. Financial Situation (CFA/ha)				
1. Gross income	27,773	48,872	32,916	89,925
2. Variable costs	2,858	6,161	5,696	15,816
3. Total expenditures (including depreciation on tools & equipment)	3,708	7,085	5,930	17,042
4. Opportunity costs of				
4.1 Family labor	11,515	44,200	28,490	80,352
4.2 Equity capital	157	406	355	1,177
5. Total costs	15,380	51,691	34,775	98,571
III. Performance Measures				
1. Gross margin (II.1 - II.2)	24,915	42,711	27,220	74,109
2. Net margin (II.1 - II.3)	24,065	41,787	26,986	72,883
3. Net returns to land, family labor & management (CFA/ha) (III.2 - II.4.2)	23,908	41,381	26,631	71,706
4. Net returns to land & management (CFA/ha) (III.3 - II.4.1)	12,393	-2,819	-1,859	-8,646
5. Net returns per hour of family labor (CFA/phr) (III.3 ÷ Total FL)	97.6	18.7	51.4	24.1
6. Total costs of production (CFA/kg)	33.6	44.1	69.4	56.8

rice fields; and in System 4, higher yields realized called for a higher level of family labor use. Other factors that may explain differences in labor requirements among the four systems include soil quality, field size and length of growing season.

3.6. Social Profitability of Rice Cultivation Under the Four Systems Studied

The objective of this section is to determine the economic returns to the four alternative methods of rice cultivation in the absence of distorting government policies and imperfection in factor and product markets. Market imperfections due, for example, to economies of scale or the existence of externalities or monopoly elements in the economy, are difficult to measure and are probably not so quantitatively important as the distortions introduced by government. Hence, emphasis here is placed on the effects of government policies on the rice production.

3.6.1. Shadow Prices of Domestic Factors and Output

The shadow price of a scarce factor will be adequately approximated by its market price if the imperfections and other distortions in the market are minor. These conditions are largely fulfilled for labor and seeds. So the factor price distortions facing rice producers are mainly budget subsidies on inputs such as fertilizers and land improvement costs as well as on the average invested capital.

3.6.1.1. Fertilizer

Farmers in the EORD are in general paying low prices for urea and fertilizer (18-35-0). The price paid by farmers per kilo of urea and 18-35-0 were 60 CFA and 56 CFA, respectively. Their true cost-prices are estimated at 90 CFA and 80 CFA per kilo, which translate into 50 and 43 percent subsidy for urea and fertilizer (18-35-0), respectively.[8] Thus an average of 44 percent subsidy weighted by the quantities of each fertilizer used was added to farmer's total expenditures on fertilizer to approximate its true economic cost.

3.6.1.2. Water Control Costs

Part of or total cost of land improvement work and/or water control in the EORD is supported by government funds. These investment costs vary from 18,000 CFA/ha in System 2 to 68,000 CFA/ha in System 4.[9] There is no fee charged to farmers using these newly developed areas. Thus, the annual investment costs borne by the government were added to farmers' total farm expenditure to approximate its true economic cost.

3.6.1.3. Import Parity Price of Rice

The world price is used to evaluate the profitability of domestic production of rice in the EORD since rice imports are the major alternative to increased rice output in the EORD.

To determine the gross economic benefits from each alternative technique of rice cultivation, the import parity price of domestic production was computed as shown in Table 4.5.6. The import parity price of a kilogram of paddy was determined to be 56.4 CFA (Table 4.5.6). So in System 2, farmers were receiving a lower price for their output of rice (41.7 CFA/kg of paddy) comparatively to the world price

[8]The source of cost-price information is World Bank Report No. 3296-UV, September 1980.

[9]The source of information on investment costs is FDR, "Rapport technique," Campagne, 1977-78.

TABLE 4.5.6

IMPORT PARITY PRICE OF A TON OF PADDY PRODUCED IN THE EORD, 1980

Item		Value (CFA)
1. Cost C.I.F. Abidjan (CFA/mt)		97,000
plus port handling		1,870
plus transhipment to rail		1,000
plus rail transport Abidjan-Ouaga		9,500
plus road transport Ouaga-Fada		6,500
plus unloading Fada		300
2. Wholesale price Fada area (CFA/mt)		116,170
less milling costs		12,000
	Sub-total	104,170
3. Paddy equivalent[a]		67,711
less transport to mill (in Fada)		2,100
less bag costs		3,000
less collection costs of paddy		6,200
4. Economic price of paddy (CFA/mt)		56,411

SOURCE: Adapted from FAO trade year book and OFNACER's Report, 1979.

[a]At the average milling rate of 65%.

equivalent (56.4 CFA/kg). In Systems 1 and 3, farmers were receiving 60.6 CFA/kg and 65.7 CFA/kg, respectively, which were greater than the world price equivalent. In Systems 2 and 4, farmers were receiving a lower price for their output, i.e., 41.7 CFA/kg and 51.8 CFA/kg, respectively.

In comparison with the financial analysis (Table 4.5.5), the economic costs of production for the four techniques of rice cultivation were higher, varying from an increase of 35 percent increase in System 1 to 132 percent increase in System 3 (see Table 4.5.7). These increases in costs are explained by the high rate of subsidy and the costs of water control which were not taken into consideration in the financial analysis. Moreover, the variation in increases observed may be due to the mix of subsidized resources in the different systems studied. The fact that System 3 showed the highest percentage increase in cost is mainly due to low yield achieved in this system.

Table 4.5.7 shows that the least cost technique for producing rice even from an economic point of view remains the traditional cultivation on unimproved swamps. The introduction of water control to date does not compete effectively with this basic system, and total costs per kilogram of paddy rise in every case. The most efficient means of producing rice under "secure" water control appears to be by partial water control (System 2 where economic losses are only 4,798 CFA/ha). Production on irrigated bas-fonds with complete water control and fertilizer use is most expensive with economic losses averaging 70,966 CFA/ha. Nevertheless, when considering whether rice production should be increased by promoting a particular technique of cultivation, it is possible to decide in general terms that only System 1 will be economically feasible. Despite the importance of water control in raising yields and expanding physical output of rice, the high capital costs of increasing water control are seldom offset by sufficiently higher yields, which means that net returns to land and labor do not necessarily rise.

TABLE 4.5.7

A COMPARATIVE ECONOMIC ANALYSIS OF THE FOUR MAJOR RICE PRODUCTION TECHNIQUES IN THE EORD, 1980

Criteria	Production Techniques			
	Traditional Bas-fonds (I)	Semi-Traditional Bas-fonds (II)	Improved Bas-fonds (III)	Irrigated Bas-fonds (IV)
1. Total cost of labor[a] (CFA/ha)	12,412	45,317	30,371	81,572
2. Seeds (CFA/ha)	1,961	4,613	3,815	7,212
3. Fertilizer (CFA/ha)	--	--	--	9,701
4. Interest on investment and depreciation on farm tools (CFA/ha)[b]	1,970	2;969	653	2,391
5. Water control costs (CFA/ha)	--	18,000	32,000	68,000
6. Total economic costs per hectare (CFA/ha)	16,343	70,899	66,839	168,876
7. Economic cost per kilo of paddy	35.7	60.5	133.4	97.3
8. Gross economic value of production (CFA/ha)	25,848	66,101	28,256	97,910
9. Net economic returns (8 - 6) (CFA/ha)	9,505	-4,798	-38,583	-70,966

[a]Non-family labor is valued at the market wage rate, and family labor at its opportunity cost.

[b]Interest on investment = average invested value (AIV) x interest rate and AIV = $\frac{\text{acquisition cost}}{2}$ (assuming a zero salvage value). A 35 percent money rate of interest was assumed, giving us a real rate of interest of 5 percent since the 1980 inflation rate was estimated at about 30 percent (IFAD, 1981).

4. SUMMARY

It was found that in System 1, the gross margins ranged from 1,671 CFA/ha to 79,521 CFA/ha. The soybean enterprise had the highest gross margin and the groundnut and bambera nut enterprises had the lowest gross margin. For all the six enterprises, the returns per field hour of family labor varied from 97.6 CFA for rice to 13.9 CFA for bambera nuts. For the rice enterprise, the returns of 97.6 CFA/hr of family labor suggest that there is no financial advantage of family members seeking wage employment in urban areas when they are needed on their rice fields (minimum guaranteed wage in urban areas is 90 CFA/hr). Among the six enterprises comprising System 1, maize showed the lowest total cost of production, 22.8 CFA/kg and bambera nuts had the highest cost of production, 182.8 CFA/kg. Rice showed the second lowest total cost of production, 33.6 CFA/kg of paddy. Using 47 CFA/hr as the opportunity cost of family labpr. three enterprises in System 1 realized a negative RLM; they are S/M/C, bambera nuts and groundnuts.

In System 2, the gross margin ranged from 2,119 CFA/ha to 42,711 CFA/ha. The rice enterprise had the highest gross margins and the groundnut and cotton enterprises had the lowest gross margins; however, all enterprises in this system were able to cover their variable costs. Returns per field hour of family labor in this system ranged from 1.4 CFA for cotton to 45.5 CFA for soybeans. For the rice enterprise, the return per field hour of family labor was only 18.7 CFA. If the present costs and returns structure continues, the following shifts could be expected:

a) farmers will put more of their land and labor into soybeans, okra, S/M/C and rice in that order; and

b) low returns per field hour of family labor for the cotton enterprise may force farmers to abandon this crop despite the heavy government support of this export crop.

The return per hour of family labor alone cannot determine the change in enterprise mix. Other factors include: (1) fixity of some inputs to some enterprises (e.g., lowland fields during the wet season can only be used to grow rice); (2) the family size and the division of labor within the family; (3) the labor requirements of different crops as well as their market potentials (e.g., currently, the market potentials of soybeans and okra are very limited and their home consumption levels are very low); and (4) the relocating costs and the job search costs. Four enterprises (cotton, groundnuts, maize and rice) realized a negative return to land and management. Among the seven enterprises, S/M/C showed the lowest total cost of production, 27.8 CFA/kg, and cotton had the highest cost of production, 133.2 CFA/kg. The second highest total cost of production was found for the groundnut enterprise, 93.1 CFA/kg, probably due to the low yield of groundnut (215 kg/ha) in this system. Rice showed the second lowest total costs of production, 44.1 CFA/kg of paddy.

It was found that in System 3, gross margin ranged from 6,502 CFA/ha to 78,254 CFA/ha. The soybean enterprise had the highest GM and the groundnut/bambera nut mixture had the lowest GM. For all the five enterprises comprising this system, except for soybeans and maize, the return per field hour of family labor was less than the minimum wage rate paid to unskilled urban workers, i.e., 90 CFA/hr. For the maize and soybean enterprises, returns per field hour of family labor were 116.0 CFA and 450.2 CFA, respectively. For the rice enterprise, returns per field hour of family labor were 51.4 CFA. As a result, if the present costs and returns structure persist, farmers will likely put more of their land and labor into soybeans and maize if the minimum sorghum needed for home consumption is attained; and low returns per hour of family labor under rice may force farmers to abandon this crop since as a grain, it is not yet an important part of the diet. Some incentive structure must be urgently found if rice growing is to survive in this system where some important investments in water control have already been made. Except for soybeans and maize, all enterprises in this system realized a negative return to land and management. Among the five enterprises, maize showed the lowest total costs of production (19.1 CFA/kg) and GN/BN had the highest total cost of production (228.3 CFA/kg).

In System 4, the variation in GM ranged from 13,655 CFA/ha to 74,109 CFA/ha. The rice enterprise had the highest gross margin the S/M/C enterprise had the lowest gross margin ; but all the GMs were positive. In all the six enterprises comprising System 4, except for okra, the returns per field hour of family labor was less than the minimum wage rate paid to unskilled urban workers, i.e., 90 CFA/hr. For okra, returns per field hour were 198.2 CFA, while for rice, it was only 24.1 CFA. These low returns per hour for rice may be enough to initiate the exit process from this fragile industry. All enterprises, except maize and okra, realized a negative return to land and management. Among the six enterprises comprising System 4, maize showed the lowest total cost of production, 11.4 CFA/kg, and S/M/C had the highest total cost of production, 103.0 CFA/kg. The second highest cost of production was found in bambera nuts, 94.0 CFA/kg. Okra showed the second lowest total cost of production followed by rice (56.8 CFA/kg).

The financial analysis of the different rice production techniques showed that System 4 yielded the highest gross margins per hectare (74,109 CFA) but the second lowest returns per field hour of family labor (24.1 CFA) due to the high labor requirement of this system (irrigated bas-fonds). The traditional bas-fond (System 1) yielded the lowest gross margins per hectare (24,915) but the highest returns per field hour of family labor (97.6 CFA). The most expensive way to grow rice was found in System 3 (69.4 CFA/kg of paddy), probably due to water costs coupled with low rice yields. The least expensive way of producing rice was found in System 1 (traditional bas-fonds), i.e., 33.6 CFA per kg of paddy.

The economic analysis of the different rice enterprises from society's perspective showed that the least cost technique for producing rice remains traditional cultivation in unimproved swamps. The introduction of water control to date does not compete effectively with this basic system, and total costs per kilogram of paddy rise in every case. The most efficient means of producing rice under "secure" water control appears to be by partial water control (System 2). Production on irrigated bas-fonds with complete water control and fertilizer use is the second most expensive with cost per kilogram of paddy some 173 percent above the least expensive, traditional bas-fonds, and 96 percent above the more attractive improved alternative (System 2). When considering whether rice production in the EORD should be increased by promoting a particular technique of cultivation, only production in traditional bas-fonds will be economically justifiable under current technologies and yield levels.

CHAPTER FIVE

RICE PRODUCTION VERSUS PRODUCTION OF OTHER MAJOR COMPETING CROPS: AN OVERVIEW OF THE ANALYTICAL MODEL

In Chapter Four, net margins per hectare or per hour of family labor for the different enterprises in each system were compared, with a possible view to substituting enterprises with high net margins for those with low ones. Four important points have to be remembered, however. First, the different enterprises may be utilizing very different types of land: there may be only a limited area of the farm suitable for growing rice, for example, and dryland crops may be using land totally unsuitable for rice production because of the rainfall. Secondly, different enterprises obviously have different requirements for the various "fixed" resources--family labor and land. Thirdly, expansion of an existing enterprise may necessitate a large increase in some resources, such as labor, land or even new machinery. And fourth, when based only on one cropping season data, net margin analysis, though a useful and widely-applicable tool in farm management, is known to be weak in identifying optimum solutions under the economic and environment realities in operation.

For all these reasons, a simple comparison of net margins per hectare or per field hour of family labor has only a very limited use for farm planning and policy orientation, except perhaps as a rough initial guide. Hence, in order to make realistic evaluations of existing cropping enterprises in the different systems under study, an approach is needed which will simultaneously take into account interrelationships among all production processes through their dependence on common resources. The whole-farm modeling approach was considered adequate in this context. Such an approach could also be used to assess short- and long-run consequences of technologies in terms of social costs and benefits and macro-level planning objectives.

1. THE ANALYTICAL MODEL

The approach of whole-farm modeling is primarily based on the fact that different production processes depend on common resources. It will therefore be appropriate to look at the farm as a system. Following the TAC (1978) report,

> A farm system or whole-farm system is not simply a collection of crops and animals to which one can apply this input or that and expect immediate results. Rather it is a complicated interwoven mesh of soils, plants, animals, implements, workers, other inputs and environmental influence with the strands held and manipulated by a person called the farmer who, given his preferences and aspirations, attempts to produce output from the inputs and technology available to him. It is the farmer's awareness of his immediate environment both natural and socioeconomic that results in his farm system.

There exist a wide range of programming models that can be used to evaluate cropping systems.[1] Following Ghodake and Hardaker (1981, pp. 8-9), methods of whole-farm modeling include, in approximate order of increasing complexity:

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[1]For more details on these models and their applications, see Dillon and Hardaker, 1980; Barnard and Mix, 1973; Anderson, Dillon and Hardaker, 1977; Anderson, 1974; Hardaker, 1974; and Ghodake, 1981.

- whole-farm budgeting
- simplified programming
- linear programming
- linear risk programming
- quadratic risk programming
- linear stochastic programming
- non-linear stochastic programming
- goal programming
- Monte-Carlo programming
- systems simulation

The different models listed above will not be discussed here; however, it is useful to consider some criteria that are relevant to the choice of a particular method for use in cropping system evaluation. As Ghodake and Hardaker (1981, pp. 9-11) pointed out, a number of criteria that are judged to be relevant include:

> a) the capacity to handle many constraints and variables, the need for which arises from the complexity of agricultural production; b) the capacity to incorporate risk in a realistic way; c) the capacity to incorporate the real goals and objectives of farmers; and d) the need to introduce a criterion of degree of objectivity, for if the system evaluation performed is to be accepted by scientists, extension workers and policy makers, they should depend no more than is absolutely necessary on subjective judgements by the analyst using the method. Of course, complete objectivity is not attainable, but methods do vary in the extent to which they depend on judgements by the analyst.

Linear programming (LP) was considered adequate as a tool of analysis in this study; however, no contention is made here that farmers are always profit maximizers.

Although linear programming is by no means a new technique in agricultural studies, Heyer (1971) has pointed out that "the large body of literature that now exists on the use of LP in farm production analysis includes remarkably little about small-scale farmers in developing countries." According to Hopkins (1975),

> This method of analysis seemed particularly appropriate to a changing situation where new crops and techniques would not only affect farmers' incomes, but would also imply repercussions in the pattern of farming activities and resource allocations too complex to be analyzed by conventional budgeting or other farm planning methods.

LP is therefore used in this study in order to help answer questions concerning: a) the optimal combination of enterprises that will maximize total gross margins in light of existing constraints; b) the marginal value product of each resource and/or constraint; c) the cost of forcing in non-optimal activities (or enterprises); and d) the ranges of the gross margins of different enterprises in the basis for which the optimal plan remains constant, ceteris paribus.

1.1. Building the "Representative" Farm Model for Each Production System Studied

Following Collinson (1972), five elements are important to analysis and planning using the representative farm technique in traditional agriculture: a) cropping pattern; b) labor profile and supply levels; c) scale of operation and output; and d) ethnic characteristics and technology used.

In constructing the initial representative farm for each production system, labor requirements and supply levels per period, farm sizes, and gross margins per enterprise were averaged[2] across the sampled households and all activities in the model were defined on a per hectare basis.

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[2]Later on in Section 3 of Chapter Six, average labor coefficients for each production system were replaced with field specific labor coefficients.

The problem with this procedure is that the mean computed for most characteristics may not necessarily typify the whole sample of farms due to considerable inherent variation among farms. However, it is not usually possible to obtain a close match between the circumstances assumed for the representative farm and the circumstances of any large proportion of actual farms for each single characteristic. Rather, following Dillon and Hardaker (1980, pp. 50-51), the representative farm approach was used here to derive technical coefficients in an attempt to identify general guidelines about the economical use of farm resources for farms of a particular type in a given area.

1.2. Model Structure

This section is devoted to a description of the main structural elements of the model and the derivation of the numerical coefficients which it comprises.

According to Heady (1971), there is a homogeneity in the agricultural planning environment among regions and countries in that all farms have:

> (1) plans or goals, (2) limited physical resources such as land, labor, capital and water which restrain the range of plans or programs which are feasible, (3) institutional or subjective restraints which restrict the range of feasible plans considered or put into actual operation, (4) an objective function of some type to be maximized or goal to be approached, (5) weights which must exist to evaluate or express the contribution of alternative feasible plans toward objective function maximization or goal attainment, and (6) enterprises, technologies or activities which are competitive in the use of resources.

The model, therefore, is comprised of an objective function and a set of inequalities in which the right-hand side represents a vector of resource supplies or other constraints. The left-hand side of the inequalities contains technical coefficients of requirements for these resources multiplied by variables representing the levels of enterprises to be produced. These inequalities define the technologies to be used. In matrix notation, the model for each production system has the following familiar form:

$$\text{Maximize } \sum_{j=1}^{n} C_j X_j, \qquad j=1,2...7$$

Subject to

$$\sum_{j=1}^{n} A_{ij} X_j \underset{>}{\overset{<}{=}} b_i, \qquad i=1,2...23$$

$$X_j \geq 0$$

where C_j is the return per unit of quantity j allocated,

X_j is the number of units of quantity j allocated,

A_{ij} is the use of resource i per unit of quantity j allocated,

b_i is the endowment of resource i.

The resource constraints considered in the model are land and family labor. Borrowing from Delgado (1979), other resources such as capital are not dealt with explicitly for three main reasons. First, the capital cost associated with the cultivation techniques and the animal traction is minimal since most farmers use hand-tools. Furthermore, sample farmers used virtually no purchased inputs and cash is only needed for marketing activities of some crops (e.g., soybeans). Second, the maximum production constraints serve the same purpose as a capital constraint in cases relating to specific activities (e.g., soybean enterprise). The MAXSOY constraint effectively limits production of soybeans to the area that can be sustained by actual techniques and cash available. If marketing soybeans in distant markets becomes an option for the farmer, both in terms of financial affordability and physical availability, then this assumption may have to be revised. Third, the production factors (land and labor) considered in the model are those common to all the farmers in the EORD, although the magnitude of use differs within and between the production systems studied. In any case, the assumptions made are consistent with the technology and resources currently available to farmers.

1.2.1. Resource Constraints Used

a) Land Constraints

Following Norman (1973, pp. 5-6), a basic distinction can be made between lowland and upland. Lowland is usually centered around rainy season watercourses or swampy areas with poor drainage between mid-July and mid-September. It supports relatively labor intensive crops such as rice, fruits, vegetables and tubers. Since the survey only covered the rainy season, only rice will be considered as a possible crop to be planted on lowland fields. Upland can be further divided into two categories depending on its proximity to human habitation: housefields (HF) and bushfields (BF).

This division of land into three categories allows us to include constraints on areas of particular crops or crop mixtures, reflecting, for example, water, distance or fertility considerations. Although all farmers in the survey area indicated that more land can be obtained just by clearing, this statement can only apply to the bushfield category. However, even in this category, distance and labor requirements mean that bushfields are not freely available. So, in our models, the bushfield category of land was considered as a constraint.

b) Labor Constraints

An understanding of the demand and supply of labor is an important pre-condition in the design of improvements of small-holder agriculture in the EORD and other areas in developing countries. Generally, seasonal labor profiles are based on division of the year or cropping season into planning periods that may be chosen either conventionally, such as calendar weeks or months, or to correspond with the biological timetalbe of field activities (e.g., land preparation, planting, weeding, harvesting). Although the latter approach was used in collecting the survey data, conventional planning periods were used in the linear programming model.

Seventeen labor periods for the model were defined (Tables 5.1 - 5.4). The length of each labor period was established by analyzing the crops' cycles as reported by Lassiter (1981, p. 20), and labor profiles for the main crops and crop mixtures found in each production system during the survey. Because the LP solution alogrithm treats the entire time period as a single point in time, making no distinction between the beginning and the end of the period, as Crawford (1980) pointed out, it was necessary not to allow labor needed in one period to be drawn from a different period. For example, if labor is needed in the first two weeks of June for planting, the program should not be allowed to draw from labor available in the second part of June. This was accomplished by narrowing down the labor period to two-week periods around the most critical field activities for the major crops considered under each system of production.

TABLE 5.1

MAIN LABOR PERIODS AND ACTIVITIES COVERED, SYSTEM 1, 1980

Labor Period	Weeks Covered	Dates Covered, 1980	Principal Field Activities[a]
1	1-18	Jan. 1-May 4	Land preparation/grains (sorghum/millet and maize)
2	19-20	May 5-May 18	Land preparation/grain (sorghum/millet and rice) planting/grain (sorghum/millet and rice)
3	21-22	May 19-June 1	Land preparation and planting/groundnuts + activities in period 2
4	23-24	June 2-June 15	Activities in period 3 cont'd
5	25-26	June 16-June 29	Activities in period 4 cont'd + planting/bambera nuts
6	27-28	June 30-July 13	Weeding/grain (sorghum/millet and rice), planting/ maize and soybeans
7	29-30	July 14-July 27	Weeding/grain, weeding/soybeans
8	31-32	July 28-Aug. 10	Planting/cowpeas, weeding/grains
9	33-34	Aug. 11-Aug. 24	Weeding/grain, weeding/groundnuts, fertilization/ soybeans
10	35-35	Aug. 25-Sept. 7	Relative slack, weeding/grains
11	37-38	Sept. 8-Sept. 21	Activities in period 10 cont'd
12	39-40	Sept. 22-Oct. 5	Harvest/grains (rice + maize), further weeding/ groundnuts, harvest/groundnuts
13	41-42	Oct. 6-Oct. 19	Harvest/grains + cowpeas, harvest/bambera nuts, harvest/soybeans
14	43-44	Oct. 20-Nov. 2	Harvest/grains + cowpeas
15	45-46	Nov. 3-Nov. 16	Harvest/grains + nuts
16	47-48	Nov. 17-Nov. 30	Harvest/grains
17	49-53	Dec. 1-Dec. 31	Slack, harvest/grains

[a]Note that most field activities run across more than one period even though they are not always repeated in the table.

TABLE 5.2

MAIN LABOR PERIODS AND ACTIVITIES COVERED, SYSTEM 2, 1980

Labor Period	Weeks Covered	Dates Covered, 1980	Principal Field Activities[a]
1	1-18	Jan. 1-May 4	Slack, land preparation/grains (sorghum/millet and rice)
2	19-20	May 5-May 18	Planting/grains
3	21-22	May 19-June 1	Planting/grains, land preparation/maize
4	23-24	June 2-June 15	Weeding/grains, planting/maize and cowpeas
5	25-26	June 16-June 29	Planting/groundnuts and okra, land preparation/ soybeans
6	27-28	June 30-July 13	Weeding/grains, planting/groundnuts, planting/cotton
7	29-30	July 14-July 27	Weeding/grains, planting/(soybeans, cotton, bambera nuts)
8	31-32	July 28-Aug. 10	Activities in period 7 cont'd
9	33-34	Aug. 11-Aug. 24	Weeding/groundnuts
10	35-36	Aug. 25-Sept. 7	Weeding/soybeans and cotton
11	37-38	Sept. 8-Sept. 21	Harvest maize, weeding cont'd, harvest/cowpeas
12	39-40	Sept. 22-Oct. 5	Further weeding + relative slack
13	41-42	Oct. 6-Oct. 19	Harvest/maize, harvest/sorghum
14	43-44	Oct. 20-Nov. 2	Harvest/grains, harvest/okra
15	45-46	Nov. 3-Nov. 16	Harvest/grains and cotton
16	47-48	Nov. 17-Nov. 30	Harvest/grains and nuts
17	49-53	Dec. 1-Dec. 31	Slack, harvest/grains and cotton

[a]Note that most field activities run across more than one period even though they are not always repeated in the table.

TABLE 5.3

MAIN LABOR PERIODS AND ACTIVITIES COVERED,
SYSTEM 3, 1980

Labor Period	Weeks Covered	Dates Covered, 1980	Principal Field Activities[a]
1	1-18	Jan. 1-May 4	Slack, land preparation/(SIM/C) and rice
2	19-20	May 5-May 18	Planting/grains
3	21-22	May 19-June 1	Planting/grains and cowpeas
4	23-24	June 2-June 15	Planting/groundnuts, maize, weeding/grains
5	25-26	June 16-June 29	Weeding/grains, planting/soybeans
6	27-28	June 30-July 13	Weeding/grains and groundnuts, planting/bambora nuts
7	29-30	July 14-July 27	Weeding/grains
8	31-32	July 28-Aug. 10	Activities in period 7-cont'd
9	33-34	Aug. 11-Aug. 24	Relative slack + further weeding
10	35-36	Aug. 25-Sept. 7	Weeding/grains, harvesting/groundnuts
11	37-38	Sept. 8-Sept. 21	Harvesting/maize, + further weeding
12	39-40	Sept. 22-Oct. 5	Harvest/maize + groundnuts
13	41-42	Oct. 6-Oct. 19	Harvest/(bambora nuts + cowpeas + grains)
14	43-44	Oct. 20-Nov. 2	Harvest/(grains + soybeans)
15	45-46	Nov. 3-Nov. 16	Harvest/grains (rice, sorghum, millet), harvest/nuts
16	47-48	Nov. 17-Nov. 30	Harvest/grains
17	49-53	Dec. 1-Dec. 31	Slack, harvest/grains and nuts

[a]Note that most field activities run across more than one period even though they are not always repeated in the table.

TABLE 5.4

MAIN LABOR PERIODS AND ACTIVITIES COVERED, SYSTEM 4, 1980

Labor Period	Weeks Covered	Dates Covered, 1980	Principal Field Activities[a]
1	1-18	Jan. 1-May 4	Slack, land preparation/grains
2	19-20	May 5-May 18	Planting/grains
3	21-22	May 19-June 1	Planting/cowpeas, planting/grains and okra
4	23-24	June 2-June 15	Planting/(maize + groundnuts), weeding/sorghum-millet
5	25-26	June 16-June 29	Planting/groundnuts + activities in period 4 cont'd
6	27-28	June 30-July 13	Planting/bambera nuts, weeding/grains and groundnuts
7	29-30	July 14-July 27	Weeding/soybeans; weeding/grains and okra, fertilization/rice
8	31-32	July 28-Aug. 10	Activities in period 7 cont'd
9	33-34	Aug. 11-Aug. 24	Weeding/grains, fertilization/rice
10	35-36	Aug. 25-Sept. 7	Further weeding/grains
11	37-38	Sept. 8-Sept. 21	Harvest/maize, weeding/grains
12	39-40	Sept. 22-Oct. 5	Harvest/groundnuts + maize
13	41-42	Oct. 6-Oct. 19	Harvest/okra + groundnuts, harvest/grains
14	43-44	Oct. 20-Nov. 2	Harvest/grains, harvest/bambera nuts
15	45-46	Nov. 3-Nov. 16	Harvest/grains + nuts
16	47-48	Nov. 17-Nov. 30	Harvest/grains + relative slack
17	49-53	Dec. 1-Dec. 31	Harvest/grains, slack

[a]Note that most field activities run across more than one period even though they are not always repeated in the table.

c) Production Constraints

In addition to the limits imposed on output by resource supplies, the model incorporates some direct constraints on the level of certain enterprises like sorghum/millet, maize, okra and soybeans. The minimum and maximum output levels serve to express limitations other than those of the basic land and labor constraints; indirectly, they represent scarce resources which are relevant to the sorghum/millet, maize, soybean, and okra enterprises.

Farms in the EORD are generally characterized by a strong subsistence orientation. Commonly, a significant proportion of family food needs is produced on the farm. Thus, the general level of health and welfare of the members of the household is strongly dependent on the degree of success achieved in farm food production. So, despite the fact that the main purpose of an LP model of farm behavior is to identify production strategies which maximize net farm revenue,or total gross margins, the model also needs to be realistic by incorporating other important household objectives. This is why the minimum food grain constraint was introduced here; sample farmers typically will not rely upon the market for their supply of the food staple, sorghum/millet. This objective was specified in terms of the minimum foodcrop area farmers are comfortable with, as opposed to the area necessary to feed the family in an average season. The problem is to specify this level correctly, in order that the model may give realistic results.

Maximum production constraints ensure that the optimal program only includes levels of activities that are plausible in the real world. However, we want to keep these production constraints to a minimum in order to allow some flexibility to the model to choose freely from existing alternatives, given the real resource constraints. The limit on maize takes into consideration special soil characteristics required by this crop which are not found on all housefields. Maize is typically planted immediately outside the house. This is the most fertile soil of the farmer's land holdings which has been receiving the manure since the establishment of the household compound. Without the production constraint, MAXMAI, the program would be free to allocate the entire supply of housefields to maize, ceteris paribus, even though in practice farmers will not do so. Here again, the principal problem is to know the correct level to specify the maximum.

The remaining ceiling applies to the soybean enterprise. In the real world, soybean production is limited by processing facilities and marketing outlets not included directly in the model.

1.2.2. Activities and Objective Function

The objective function of the model used for each production system involves maximization of total gross margins subject to resource use constraints and production constraints.

The choice of possible crop activities is limited to mixtures which are typically grown in the survey area as was discussed in Chapters Three and Four. There are nine major crop categories. These are rice, sorghum/millet/cowpeas, maize, groundnuts, bambera nuts, soybeans, cotton, okra, and groundnuts with bambera nuts. Survey data on the allocation of land to different crop activities is shown in Table 5.5. The high proportion of land put under S/M/C appears to reflect a concern with assuring an on-farm supply of staple foods. This allocation of land to different crop activities, besides its intrinsic interest for agricultural

TABLE 5.5

MEAN PERCENTAGE OF HOUSEHOLD LAND ALLOCATED TO EACH CROP CATEGORY, 1980

Crop Category	Mean Household Percentage			
	System 1	System 2	System 3	System 4
Rice (LF only)	31.4	54.3	16.0	32.2
S/M/C (HF+BF)	39.3	37.1	45.2	57.5
Maize (HF only)	14.1	3.4	12.3	3.1
Groundnuts (HF+BF)	8.0	2.2	-	4.1
Bambera Nuts (HF+BF)	5.1	-	-	.5
Soybeans (BF only)	2.0	1.6	6.5	-
Cotton (BF only)	-	1.1	-	-
Okra (HF only)	-	.3	-	2.5
GN/BN (HF+BF)	-	-	19.9	-
	100.0	100.0	100.0	100.0

LF stands for lowland fields

HF stands for housefields

BF stands for bush-fields

S/M/C stands for sorghum/millet/cowpeas

GN/BN stands for mixture groundnut/bambera nuts planning, will also be useful for comparing the actual allocation portrayed in Table 5.5 with the optimal allocations suggested by the LP model later on.

1.2.3. Derivation of the Numerical Coefficients of the Model

a) Labor Coefficients and Restriction Levels

The calculation of the numerical coefficients for the different enterprises is a crucial process in the design of any linear programming model. "As with the formulation of representative farm types, a major issue here is whether to calculate average coefficients, or to use actual coefficients from representative enterprise types, or to devise synthetic coefficients based on subjective evaluation of the data." (Crawford, 1980). Another approach suggested by Balcet and Chandler (1981) would be to estimate crop yields and labor requirements for the different enterprises by using multiple regression techniques. This latter method was ruled out because it was not possible to measure the area planted to different crops within a mixture type of each field. As a result, labor input per hectare could not be associated with specific crops within the mixture. Hence, the initial approach used in this study was to compute averages[3] per hectare for each enterprise type. The total number of

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[3]The problem with this procedure, as Collinson (1972, p. 134) pointed out, is that "interfarm differences in timing create different peak requirements on particular farms, which are damaged when averaged--and peaks on one farm are offset by relatively slack periods on another, so the whole labor profile is flattened." The effect of smoothing labor peaks is to reduce the incidence and size of seasonal labor bottlenecks. The implication of using figures for a mean household, then, is to lower the opportunity cost of rice in terms of foregone production of other crops. This is because this cost is incurred only as a result of the reallocation of labor during peak periods from other crops to rice. As peak labor requirements for crops are reduced, so is the opportunity cost of growing rice.

hours allocated by each household to each major crop category was calculated by period for the 17 periods defined above. The figures for each household were divided by the total household land area in hectares devoted to the crop category in question. The ratio obtained for each period, household and crop category was averaged over households to give the mean total household hours allocated to each major crop category by period. Accordingly, the basic model employed enterprises defined in terms of these averages. Comparisons of crop yields and total labor requirements for these enterprises with the figures reported from similar geographical areas by Lassiter (1981) indicated general consistency. A comparison of the results from the basic model with results from an alternative model incorporating labor coefficients based on individual fields will be discussed in Chapter Six.

Now, turning to the supply of family labor, in principle, estimating this supply is quite straightforward. The total labor time available in any period is found by adding for each available worker the time he or she can allocate to cropping activities in that period. In practice, however, while it is usually easy to determine the number of workers available, estimating the available labor time of each can present some difficulties.[4] The average size of the family labor force in the areas surveyed was fairly variable, ranging from 5.3 to 7.6 workers per household for all the systems studied (Table 5.6).

[4]It should be kept in mind that total household labor availability can be broken into five sectors: crop, livestock, domestic, nonagricultural work and social activity. This study focuses just on crop labor use. The labor available for each period for cropping activities is constrained in the model by the number of work days and the number of people in the household available to help on the farms. Five working days per week is assumed to be the available number of work days for cropping activities. A seven-hour day of 7 a.m. to 11 a.m. and 1 p.m. to 4 p.m. (Systems 1, 2, 3) or of 7 a.m. to 2 p.m. (System 4) as reported by the farmers defines the available hours of labor per day.

TABLE 5.6

AVERAGE NUMBER OF WORKERS PER HOUSEHOLD IN ALL THE FOUR PRODUCTION SYSTEMS UNDER STUDY IN THE EORD, 1980

	Systems of Production											
	I			II			III			IV		
	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max
Average Number of Workers[1]	7.6	3	15	5.6	1	15	5.7	4	13	5.3	1	14

[1]The average number of workers depends on the size and on the composition of the household. The average household size was 10.5, 7.5, 7.7 and 7.5 in Systems 1, 2, 3 and 4, respectively. However, a distinction was made between the size of the household and the size of the family labor force. Small children (less than seven years of age) and old men (over 65 years of age) were not included in the family labor force. The non-working household members constituted about 28 percent, 25 percent, 26 percent and 30 percent of the household size in Systems 1, 2, 3 and 4, respectively.

The procedure used to derive the exact number of hours of family labor available for crops over each period P_j is based upon the household averages contained in Table 5.6. The labor availability for crops in period P_j is set equal to the maximum amount of hours available per worker per week for crops during the j^{th} period of the year times the average number of workers times the number of weeks in period P_j.

$$f_j = \overline{W}_j \times 35 \times L_j$$

Where f_j = total family labor available in period P_j

$\overline{W}_j$ = average number of family workers available in period P_j

L_j = length of the period P_j expressed in weeks,

and where 35 represents the maximum amount of hours available per family worker per week for cropping activities.

In Systems 2 and 3, there were no children in the sample going to school and no migration of adult workers was observed during the dry season. So, W_j was constant throughout the year in these two systems.

So, for each labor period covering two weeks (LAB02 through LAB16), $f_j = 5.6 \times 35 \times 2 = 392$ hours (for System 2) and $f_j = 5.7 \times 35 \times 2 =$ 399 hours (for System 3). In System 2, since LAB01 covers 18 weeks, for that labor period, $f_j = 392 \times \frac{18}{2} = 3{,}528$ hours; and in System 3, for the labor period LAB01, $f_j = 399 \times \frac{18}{2} = 3{,}591$ hours. LAB17 covers four weeks in both systems. So f_j is equal to 784 hours (392 x 2) and 798 hours (399 x 2) in Systems 2 and 3, respectively.

In System 1 where children represented about 39.5 percent of the household size and where 5 percent of them attended school in the village, it was estimated that 2 percent [(.395) (.05) = .02] of available family labor for crops was lost during the school year. Similarly, it was estimated that in System 4, 4 percent of available family labor for crops was lost during the school year. In System 1, during two out of the 18 weeks comprising the labor period LAB01, there is no loss of available family labor due to schooling. So total labor available during this period (LAB01) is $(521 \times \frac{16}{2}) + 532 = 4{,}700$ hours. During the period running from mid-June through the beginning of October (LAB05 through LAB11), $f_j = 7.6 \times 35 \times 2 = 532$ hours for each labor period. During the periods running from May to mid-June (LAB02 to LAB04) and from the beginning of October to the end of November (LAB13 to LAB16), children are in school--so available labor every two weeks is: $f_j = 532 - (.02)(532) = 521$ hours. During the month of December, children are still in school the first two weeks, so available labor is 521; but in the last two weeks of December, children are on Christmas vacation, so available family labor is 532 hours, which makes total labor available for the period LAB17 equal to: $f_j = 521 + 532 = 1{,}053$ hours. Using the same procedure as in System 1 above, the amount of family labor available per period in System 4 was found to be as follows: $f_j = 5.3 \times 35 \times 2 = 371$ hours for j = LAB05 through LAB11; $f_j = 371 - (.04)(371) = 356$ hours, for j = LAB02 through LAB04 and LAB13 through LAB16; $f_j = (356 \times \frac{16}{2}) + 371 = 3{,}219$ hours for j = LAB01 and $f_j = 356 + 371 = 727$ hours for j = LAB17. Tables 5.10 - 5.13 contain all the information on labor coefficients and their right-hand side (RHS) values.

b) Land Restriction Levels

Housefields, bushfields and lowland fields are the three land types specified in the model. The average housefield area per farm was used as the total land available in this category (Table 5.7). Lowlands and

TABLE 5.7

SUMMARY OF AREA AND PROPORTION OF EACH TYPE OF LAND FARMED BY FARM SYSTEM, 1980 SURVEY

Systems	Land Category	Percentage of Total Household Area Cultivated in 1980	Average Field Area (ha.)
1	Housefield (HF)	47	1.6
	Lowlandfield (LF)	30.7	1.1
	Bushfield (BF)	22.3	.85
2	HF	25.7	.9
	LF	54.3	1.9
	BF	20.0	.7
3	HF	42.7	2.7
	LF	15.8	1.0
	BF	41.4	2.62
4	HF	64.5	1.2
	LF	32.2	.6
	BF	3.2	.06

bushfields that may be cropped were also limited under current practices. So, average field areas in these categories were used as the total land available in these categories.

c) Production Restriction Levels

The minimum food grain area in this study was derived using actual farm plantings of sorghum/millet/cowpea (S/M/C) in 1980 in terms of both absolute acreage and proportion of total land under cultivation suitable for S/M/C growing. The minimum food grain area for each production system was computed as the smallest percentage of land under S/M/C in the sample times the area of the representative farm (Table 5.8). This procedure ensures that the results are commensurate with the scale of

TABLE 5.8

MINIMUM AREA UNDER SORGHUM/MILLET/COWPEAS FOR THE FOUR PRODUCTION SYSTEMS, 1980

Systems	Total Land (HF + BF)	Minimum Percentage Under S/M/C	Minimum Area Under S/M/C (in ha)
1	2.45	21	.51
2	1.6	13	.21
3	5.32	27	1.44
4	1.26	6	.08

the representative farm. Additional care was also taken to ensure that the minimum percentage selected was not an outlier case--for example, in System 4, the smallest percentage of land under S/M/C happened to be zero. However, the household in which this percentage occurred contained only one person, which was not typical of the system under study. Hence, the next smallest percentage, i.e., 6 percent, was selected. The same concerns were kept in mind in the selection of maximum production levels.

The wide variation in the minimum area under sorghum/millet between systems shown in Table 5.8 may indicate that in some systems of production farmers are beginning to rely more and more on the market for their food-grain supply and/or that sorghum/millet is becoming less important in the diet of some farmers.

The maximum production constraint for maize was specified as either the maximum percentage of housefields in the sample attributed to maize times the area of housefields on the representative farm, or the maximum household area across the sample in maize, whichever is smallest

(Table 5.9). This procedure ensures that the chosen output ceiling is both a maximum based on the sample data and that it reflects the scale of the representative farm.

TABLE 5.9

MAXIMUM AREA THAT CAN BE GROWN IN MAIZE AND SOYBEAN FOR FOUR PRODUCTION SYSTEMS, 1980

Systems	Crops	
	Maize (max. area in ha)	Soybeans (max. area in ha)
1	.396	.242
2	.655	.373
3	.523	.490
4	.482	-

Finally, given the current market conditions and the assumed labor coefficients, the maximum soybean level was computed as either the maximum percentage of bushfields in the sample attributed to soybeans times the total area of bushfields on the representative farm or the maximum household area across the sample in the soybean enterprise, whichever was smallest (Table 5.9).

d) Objective Function Coefficients

The gross margins from one hectare of each crop enterprise were used in the basic model (Tables 5.10 - 5.13) as the objective function coefficients. These figures were taken from Tables 4.5.1, 4.5.2, 4.5.3 and 4.5.4, and they are all expressed in CFA per hectare.

2. TABLEAUX FOR THE FOUR REPRESENTATIVE FARMS OF THE SYSTEMS STUDIED

The tableaux of the basic models for the four production systems are displayed in Tables 5.10 - 5.13. For each table, activities (or enterprises) run across the top of the table. Right below the enterprise names, objective function values expressed in CFA/ha are found. The very first column gives the names of restrictions (resource constraints or production levels) imposed on the model. The column labeled B_i's contains the levels of resource supplies or production levels which should be met or cannot be exceeded. The figures in the body of the matrix or table are the a_{ij}, input-output coefficients expressed on a per hectare basis.

TABLE 5.10

BASIC EGRD FARM LINEAR PROGRAM, SYSTEM 1, 1980

Restrictions \ Activities[a]	Rice	S/M/C (HF)	Maize	G. Nuts (HF)	B. Nuts (HF)	Soy	S/M/C (BF)	G. Nuts (BF)	B. Nuts (BF)	Restriction Type[b]	B_i's	Row #
	24,915	26,455	40,678	7,612	1,671	79,521	26,455	7,612	1,671			
Land Constraints (ha.)												
Housefields (HF)	0	1	1	1	1	0	0	0	0	1	1.6	1
Lowlandfields (LF)	1	0	0	0	0	0	0	0	0	1	1.1	2
Bushfields (BF)	0	0	0	0	0	1	1	1	1	1	.85	3
Labor Constraints (hours)												
LAB01	0	47	3	0	0	0	47	0	0	1	4,700	4
LAB02	5	76	0	0	0	0	76	0	0	1	521	5
LAB03	4	48	0	3	0	0	48	3	0	1	521	6
LAB04	29	73	0	0	0	11	73	0	0	1	521	7
LAB05	38	124	185	15	12	0	124	15	12	1	532	8
LAB06	33	127	34	18	2	34	127	18	2	1	532	9
LAB07	14	127	104	27	31	276	127	27	31	1	532	10
LAB08	40	144	40	24	9	32	144	24	9	1	532	11
LAB09	65	176	23	15	10	219	176	15	10	1	532	12
LAB10	6	139	0	17	0	157	139	17	0	1	532	13
LAB11	6	131	105	16	17	136	131	16	17	1	532	14
LAB12	1	43	31	6	0	128	43	6	0	1	532	15
LAB13	4	46	13	4	1	88	46	4	1	1	521	16
LAB14	15	33	0	29	11	65	33	29	11	1	521	17
LAB15	25	76	0	10	12	0	76	10	12	1	521	18
LAB16	3	86	0	4	2	0	86	4	2	1	521	19
LAB17	0	17	0	5	0	0	17	5	0	1	1,053	20
Production Constraints (ha.)												
MINFG	0	1	0	0	0	0	1	0	0	3	.51	21
MAXMAI	0	0	1	0	0	0	0	0	0	1	.40	22
MAXSOY	0	0	0	0	0	1	0	0	0	1	.24	23

[a] All activities are on a per hectare basis.

[b]

Code	Restriction Type
1	(LE) ≤
2	(EQ) =
3	(GE) ≥

Table 5.11 BASIC EORD FARM LINEAR PROGRAM, SYSTEM 2, 1980

Restrictions / Activities[a]	Rice 42,711	S/M/C (HF) 17,368	Maize 13,361	G. Nuts (HF) 4,480	Soy 37,789	Cotton 2,119	Okra 37,775	S/M/C (BF) 17,368	G. Nuts (BF) 4,480	Restriction Type[b]	B_i's	Row #
Land Constraints (ha.)												
Housefields (HF)	0	1	1	1	0	0	1	0	0	1	.90	1
Lowlandfields (LF)	1	0	0	0	0	0	0	0	0	1	1.90	2
Bushfield (BF)	0	0	0	0	1	1	0	1	1	1	.70	3
Labor Constraints (hours)												
LAB01	5	11	0	0	0	0	0	11	0	1	3,528	4
LAB02	188	51	0	0	0	0	0	51	0	1	392	5
LAB03	174	14	45	0	0	0	0	14	0	1	392	6
LAB04	135	62	22	0	0	0	0	62	0	1	392	7
LAB05	173	34	49	6	47	0	23	34	6	1	392	8
LAB06	210	40	155	26	0	0	157	40	26	1	392	9
LAB07	130	72	357	228	248	184	80	72	228	1	392	10
LAB08	193	57	237	138	211	190	113	57	138	1	392	11
LAB09	281	29	103	32	13	22	53	29	32	1	392	12
LAB10	216	23	71	49	41	56	83	23	49	1	392	13
LAB11	82	41	15	22	0	273	157	41	22	1	392	14
LAB12	13	20	66	4	23	22	23	20	4	1	392	15
LAB13	0	1	12	0	0	0	17	1	0	1	392	16
LAB14	8	2	5	202	80	0	127	2	202	1	392	17
LAB15	130	22	2	60	65	25	50	22	60	1	392	18
LAB16	193	61	0	13	94	0	0	61	13	1	392	19
LAB17	80	11	0	0	0	32	0	11	0	1	784	20
Production Constraints (ha.)												
MINFG	0	1	0	0	0	0	0	1	0	3	.21	21
MAXMAI	0	0	1	0	0	0	0	0	0	1	.65	22
MAXSOY	0	0	0	0	1	0	0	0	0	1	.37	23
MAXOKRA	0	0	0	0	0	0	1	0	0	1	.10	24

[a] All activities are on a per hectare basis.

[b] Code	Restriction Type
1	(LE) $\leq$
2	(EQ) =
3	(GE) $\geq$

Table 5.12 BASIC EORD FARM LINEAR PROGRAM, SYSTEM 3, 1980

Restrictions / Activities[a]	Rice 27,220	S/M/C (HF) 14,544	Maize 32,389	GN/BN (HF) 6,502	Soy 78,254	S/M/C (BF) 14,544	GN/BN (BF) 6,502	Restriction Type[b]	B_i's	Row #
Land Constraints (ha.)										
Housefields (HF)	0	1	1	1	0	0	0	1	2.7	1
Lowlandfields (LF)	1	0	0	0	0	0	0	1	1.0	2
Bushfields (BF)	0	0	0	0	1	1	1	1	2.62	3
Labor Constraints (hours)										
LAB01	0	39	0	0	0	39	0	1	3,591	4
LAB02	12	38	0	0	0	38	0	1	399	5
LAB03	6	70	1	2	0	70	2	1	399	6
LAB04	67	24	16	3	0	24	3	1	399	7
LAB05	26	147	31	15	2	147	15	1	399	8
LAB06	14	204	27	25	2	204	25	1	399	9
LAB07	35	124	50	73	34	124	73	1	399	10
LAB08	12	136	49	57	39	136	57	1	399	11
LAB09	23	152	16	52	29	152	52	1	399	12
LAB10	28	118	34	34	31	118	34	1	399	13
LAB11	48	61	9	23	8	61	23	1	399	14
LAB12	20	23	20	16	5	23	16	1	399	15
LAB13	19	5	21	29	7	5	29	1	399	16
LAB14	48	28	1	109	8	28	109	1	399	17
LAB15	119	29	0	21	4	29	21	1	399	18
LAB16	35	121	0	10	1	121	10	1	399	19
LAB17	5	28	0	11	0	28	11	1	798	20
Production Constraints (ha.)										
MINFG	0	1	0	0	0	1	0	3	1.44	21
MAXMAI	0	0	1	0	0	0	0	1	.52	22
MAXSOY	0	0	0	0	1	0	0	1	.49	23

[a]All activities are on a per hectare basis.

[b]Code	Restriction Type
1	(LE) $\le$
2	(EQ) =
3	(GE) $\ge$

TABLE 5.13

BASIC EORD FARM LINEAR PROGRAM, SYSTEM 4, 1980

Restrictions \ Activities[a]	Rice	S/M/C (HF)	Maize	G. Nuts (HF)	B. Nuts (HF)	Okra	S/M/C (BF)	G. Nuts (BF)	B. Nuts (BF)	Restriction Type[b]	B_i's	Row #
	74,109	13,666	67,866	13,831	17,400	29,060	13,665	13,831	17,409			
Land Constraints (ha.)												
Housefields (HF)	0	1	1	1	1	1	0	0	0	1	1.2	1
Lowlandfields (LF)	1	0	0	0	0	0	0	0	0	1	.6	2
Bushfields (BF)	0	0	0	0	0	0	1	1	1	1	.06	3
Labor Constraints (hours)												
LAB01	20	2	0	0	0	0	2	0	0	1	3,219	4
LAB02	115	13	0	0	0	0	13	0	0	1	356	5
LAB03	81	20	0	3	0	5	20	3	0	1	356	6
LAB04	172	21	3	0	0	10	21	0	0	1	356	7
LAB05	217	48	40	10	30	15	48	10	30	1	371	8
LAB06	273	44	87	36	140	33	44	36	140	1	371	9
LAB07	356	177	100	94	80	22	177	94	80	1	371	10
LAB08	354	235	70	62	300	12	236	62	300	1	371	11
LAB09	174	171	107	37	100	17	171	37	100	1	371	12
LAB10	187	243	115	80	50	3	243	80	50	1	371	13
LAB11	275	212	71	17	0	3	212	17	0	1	371	14
LAB12	154	27	155	4	0	3	27	4	0	1	371	15
LAB13	115	0	0	90	0	20	0	90	0	1	356	16
LAB14	51	14	12	224	0	1	14	224	0	1	356	17
LAB15	123	28	0	22	750	0	28	22	750	1	356	18
LAB16	382	160	0	0	0	0	160	0	0	1	356	19
LAB17	623	2	0	0	0	0	2	0	0	1	727	20
Production Constraints (ha.)												
MINFG	0	1	0	0	0	0	1	0	0	3	.08	21
MAXMAI	0	0	1	0	0	0	0	0	0	1	.48	22
MAXOKRA	0	0	0	0	0	1	0	0	0	1	.40	23

[a] All activities are on a per hectare basis.

[b]

Code	Restriction Type
1	(LE) ≤
2	(EQ) =
3	(GE) ≥

CHAPTER SIX

EVALUATION OF THE BASIC MODEL, PRESENTATION OF RESULTS, AND SENSITIVITY ANALYSIS

Before discussing the results from the basic model, it is appropriate at this point to examine very briefly to what extent this model is an accurate representation of the true system from the standpoint of cropping pattern and labor use. So, the evaluation of the basic model will be discussed first, then in section 2, results from the basic model will be presented; in section 3, various experiments with the basic model will be discussed; and finally, in section 4, a summary of the results emerging from the modeling exercise will be presented.

1. EVALUATION OF THE MODEL

As Crawford (1980) pointed out, a common problem with linear programming models is their tendency to produce solutions in which cropping patterns are highly specialized. These are very uncommon in the EORD. So the issue here is how closely the solutions to the basic model reflect actual cropping patterns? Table 6.1 compares the optimal allocation suggested by the model with the actual allocation. In System 1 where the actual allocation of land to different enterprises comprised six enterprises, four are included in the optimal solution mix. Groundnuts and bambera nuts which actually made up 13 percent of land allocated

TABLE 6.1

ACTUAL VERSUS OPTIMAL ALLOCATION OF LAND TO EACH CROP CATEGORY, BY SYSTEM, 1980 (percentages)[1]

Crop Category	Representative Farm			
	System 1	System 2	System 3	System 4
Rice	31 (31)[1]	44 (54)	19 (16)	32 (32)
Sorghum/millet/cowpeas	51 (39)	40 (37)	30 (45)	4 (57)
Maize	11 (14)	0 (3)	10 (12)	26 (3)
Groundnuts	0 (8)	0 (2)	- -	2 (4)
Bambera nuts	0 (5)	- -	- -	14 (1)
Soybeans	7 (2)	13 (2)	9 (6)	- -
Cotton	- -	0 (1)	- -	- -
Okra	- -	3 (1)	- -	22 (2)
Groundnuts/bambera nuts	- -	- -	32 (20)	- -
Total	100	100	100	100

[1]The number in parentheses show the actual allocation of land in percentages to each crop category.

to crops were excluded from the optimal solution. S/M/C and soybeans saw their share of land in the optimal allocation increased by 30 and 250 percent, respectively. The maize share of land was reduced in the optimal solution by 21 percent, while the area under rice in the optimal solution remained about the same as in the actual cropping pattern. In System 2 where the actual allocation of land to different enterprises comprised seven enterprises, four were included in the optimal allocation. Maize, groundnuts and cotton, which actually made up about

7 percent of the total land under cultivation were dropped from the optimal solution. The percentage of land under soybeans, S/M/C and okra increased by 550, 8 and 200 percent, respectively, while the percentage amount of land under rice in the optimal allocation decreased by 18 percent. In System 3, all five enterprises included in the actual cropping pattern were included in the optimal solution. S/M/C and maize saw their percentage decreased by 33 and 17 percent, respectively, while soybeans, rice and GN/BN saw their percentage increased by 50, 18 and 60 percent, respectively. In System 4, while all the six enterprises originally present in the current farm plan were also included in the optimal farm organization, there was, however, a 93 percent decrease in the percentage amount of land allocated to S/M/C in favor of maize, bambera nuts and okra whose percentage in the optimal solution were increased by 766, 1,300 and 1,000 percent, respectively. So, it can be concluded that results of the optimal plan are quite comparable with those of the actual plan in terms of the number of enterprises included in the solution but the percentage of land area allocated to each crop category varies quite a bit.

Another important issue in deciding whether a model is believable and an appropriate one is the question of how closely does the labor use reflect the true system under study. Table 6.2 compares the labor use suggested by the model with the actual labor use. In System 1, total labor use suggested by the model is 25 percent higher than the actual labor use, whereas in Systems 2, 3 and 4, total labor use implied by the model is 28, 29 and 19 percent lower than the actual labor use, respectively. Tables 6.3 to 6.5 contain information on average family labor use as well as labor use on some specific rice fields for all the

TABLE 6.2

TOTAL LABOR USE UNDER ACTUAL ALLOCATION VERSUS TOTAL LABOR USE IMPLIED BY THE MODEL, BY CROP CATEGORY AND BY SYSTEM, 1980[1]

Crop Category	Labor Use by Representative Farm (hrs)							
	System 1		System 2		System 3		System 4	
Rice	271	(273)	2,746	(4,201)	517	(517)	1,786	(1,786)
Sorghum/ millet/ cowpeas	2,738	(2,103)	628	(716)	2,169	(3,852)	121	(1,539)
Maize	215	(269)	0	(137)	143	(216)	403	(50)
Groundnuts	0	(54)	0	(62)	-	-	27	(54)
Bambera nuts	0	(19)	-	-	-	-	395	(15)
Soybeans	270	(79)	296	(41)	83	(68)	-	-
Cotton	-	-	0	(32)	-	-	-	-
Okra	-	-	88	(9)	-	-	58	(7)
Groundnuts/ bambera nuts	-	-	-	-	802	(605)	-	-
Total	3,494	(2,797)	3,758	(5,198)	3,714	(5,258)	2,790	(3,451)

[1]The numbers in parentheses show the actual labor use, by crop category, by system.

TABLE 6.3

FAMILY LABOR PROFILE FOR SELECTED FIELDS BELONGING TO THE RICE ENTERPRISE, SYSTEM 1, 1980

Labor Period*	Hours per Hectare		
	Average	Field Reference	
		18/7**	6/7
1 (18)			
2 (2)	5		
3 (2)	4		
4 (2)	29	81	
5 (2)	28		
6 (2)	33		909
7 (2)	14		
8 (2)	28	150	
9 (2)	55		222
10 (2)	6		
11 (2)	6		263
12 (2)	1		
13 (2)	4		
14 (2)	15	122	182
15 (2)	15		
16 (2)	3		
17 (4)	0		
Total (hrs/ha)	246	353	1,576
Area (ha)	.411	.36	.456

*The numbers in parentheses represent the length of the period expressed in weeks.

**Field labor profile used in Version A of the model.

TABLE 6.4

FAMILY LABOR PROFILE FOR SELECTED FIELDS BELONGING TO THE RICE ENTERPRISE, SYSTEM 2, 1980

Labor Period*	Hours per Hectare					
	Average	Field Reference				
		27/2	32/2	37/4	52/16	36/6**
1 (18)	5					
2 (2)	188	312			450	262
3 (2)	174	150	145		450	262
4 (2)	135				225	
5 (2)	173		67	857		
6 (2)	210	75	88	686	350	590
7 (2)	130		50			
8 (2)	193	150	207	214	225	
9 (2)	281	87	198	371	225	402
10 (2)	216	62	257	357		574
11 (2)	82	8	249	343		
12 (2)	13					
13 (2)						
14 (2)	8					
15 (2)	130	37			200	159
16 (2)	193	33	239	143	200	271
17 (4)	80					418
Total (hrs/ha)	2,211	917	1,501	2,971	2,325	2,940
Area (ha)	.270	.24	1.43	.07	.04	.24

*The numbers in parentheses represent the length of the period expressed in weeks.

**Field labor profile used in Version A of the model

TABLE 6.5

FAMILY LABOR PROFILE FOR SELECTED FIELDS BELONGING TO THE RICE ENTERPRISE, SYSTEM 3, 1980

Labor Period*	Hours per Hectare			
	Average	Field Reference		
		57/2**	61/3	77/3
1 (18)				
2 (2)	12			
3 (2)	6			
4 (2)	67	723	1,191	
5 (2)	26			687
6 (2)	14			
7 (2)	35	96	58	190
8 (2)	12			
9 (2)	23		18	332
10 (2)	28	298	97	
11 (2)	48	1,021	282	
12 (2)	20		436	
13 (2)	19	500	194	
14 (2)	48	160		
15 (2)	119	926	288	
16 (2)	35		130	
17 (4)	5			190
Total (hrs/ha)	517	3,723	2,694	1,398
Area (ha)	.488	.468	.33	.518

*The numbers in parentheses represent the length of the period expressed in weeks.

**Field labor profile used in Version A of the model.

TABLE 6.6

FAMILY LABOR PROFILE FOR SELECTED FIELDS BELONGING TO THE RICE ENTERPRISE, SYSTEM 4, 1980

Labor Period*	Hours per Hectare				
	Average	Field Reference			
		87/4	102/3	113/4**	116/5
1 (18)	20				
2 (2)	115		30		40
3 (2)	81	45		80	
4 (2)	172		120		
5 (2)	121	160		165	118
6 (2)	273		47		20
7 (2)	256	702	533	329	773
8 (2)	354	15	1,973		910
9 (2)	174		387	82	268
10 (2)	187	185	390		367
11 (2)	175		353	18	340
12 (2)	154	15	13	94	550
13 (2)	115	62	67	35	432
14 (2)	51	120	10	59	79
15 (2)	123	430	13	3,120	282
16 (2)	182		3	741	131
17 (4)	423	185	1,767		850
Total (hrs/ha)	2,976	1,923	5,707	4,724	5,160
Area (ha)	.151	.065	.30	.17	.15

*The numbers in parentheses represent the length of the period expressed in weeks.

**Field labor profile used in Version A of the model.

different types of rice cultivation studied. The same information on the other enterprises can be found in Appendix B. The major points that can be made from examining Tables 6.3 - 6.6 are twofold: (i) the average total amount of family labor use per hectare is comparable to the total family labor use on some specific fields of similar size in some cases (e.g., fields 18/7, 36/6, 113/4 in Systems 1, 2 and 4, respectively), but quite variable in other cases (e.g., fields 6/7, 27/2, 57/2, 116/5 in Systems 1, 2, 3 and 4, respectively); (ii) in all cases, the labor profile from specific fields was quite different from the average labor profile. So, it was not possible to conclude whether or not total family labor use and profile demonstrated the closest resemblance between the model and reality. However, the hypothesized weakness of the average model in terms of its tendency to underestimate peak labor demand will be tested in section 3 of this chapter by using a field-specific labor profile in lieu of an average labor profile in the model.

2. PRESENTATION OF THE RESULTS FROM THE AVERAGE MODEL

The models displayed in Table 5.10 to 5.13 in Chapter Five yielded the results shown in Tables 6.7 to 6.10. For Systems 1 and 4, respectively, the optimal value of crop production was 20 and 45 percent higher than the value of crops produced by the average farm in 1980. For Systems 2 and 3, respectively, the optimal value of crops produced was 16 and 13 percent lower than the value of crop package produced by the average farm in 1980. This difference in results can be attributed to two main reasons. First, land is fully used in Systems 1 and 4 whereas in Systems 2 and 3, only 81 and 84 percent of land are used,

Table 6.7 RESULTS FROM THE BAISC MODEL: ENTERPRISES IN THE OPTIMAL SOLUTION FOR SYSTEM 1

Enterprises	Optimal Level (in ha)	Gross Margins (CFA/ha)	Ranges of Gross Margins Over Which Optimal Solution Holds (CFA)[b]		Cost of Forcing in Non-Optimal Enterprise[a] (CFA)
			Lower Bound	Upper Bound	
1. Rice	1.10	24915	0.0	9024915.0	
2. S/M/C (Housefield)	1.20	26455	7612.0 (4)	40678.0	
3. Maize	.40	40678	26455.0	9040678.0	
4. Groundnuts (HF)	0.00	7612			18843.0
5. Bambera Nuts (HF)	0.00	1671			24784.0
6. Soybeans	.24	79521	26455.0	9079521.0	
7. S/M/C (Bushfield)	.61	26455	7612.0 (8)	79521.0	
8. Groundnuts (BF)	0.00	7612			18843.0
9. Bambera Nuts (BF)	0.00	1671			24784.0

Note: Maximized objective function value = 110,646 CFA.

[a]These figures, which are part of the standard LP output, are valid only for a small range around the current optimal solution. They show the cost of forcing one hectare of the given enterprise into the solution. Forcing the farmer to grow more than one hectare of the specified enterprise (say groundnuts), with the complete reallocation of resources that this would entail, would not necessarily decrease maximum obtainable farm revenue by 18,843.0 CFA/ha.

[b]The numbers in brackets show the enterprises which would enter the solution when we hit the lower bound. For example, if the GM per hectare of S/M/C fall below 7612.0 CFA, enterprise 4 or 8 (i.e., groundnut) would enter the solution.

Table 6.8 RESULTS FROM THE BASIC MODEL: ENTERPRISES IN THE OPTIMAL SOLUTION FOR SYSTEM 2

Enterprises	Optimal Level (in ha)	Gross Margins (CFA/ha)	Ranges of Gross Margins Over Which Optimal Solution Holds (CFA)		Cost of Forcing in Non-Optimal Enterprises[a] (CFA)
			Lower Bound	Upper Bound	
1. Rice	1.2419	42711	25592.5	110157.7	
2. S/M/C (HF)	.80	17368	9544.2	28653.6	
3. Maize	0.00	13361			33146
4. Groundnuts (HF)	0.00	4480			24278
5. Soybeans	.3605	37789	14936	51448.2	
6. Cotton	0.00	2119			33273
7. Okra	.10	37775	26489.3	9037775.0	
8. S/M/C (BF)	.3395	17368	10979.9	40220.9	
9. Groundnuts (BF)	0.00	4480			24278

Note: Maximized objective function value = 90233.2 CFA.

[a]These figures, which are part of the standard LP output, are valid only for a small range around the current optimal solution, see Table 6.6. Forcing the farmer to grow more than one hectare of the specified enterprise (say groundnuts), with the complete reallocation of resources that this would ential, would not necessarily decrease maximum obtainable farm revenue by 24278 CFA/ha.

Table 6.9 RESULTS FROM THE BASIC MODEL: ENTERPRISES IN THE OPTIMAL SOLUTION FOR SYSTEM 3

Enterprises	Optimal Level (in ha)	Gross Margins (CFA/ha)	Ranges of Gross Margins Over Which Optimal Solution Holds (CFA)		Cost of Forcing in Non-Optimal Enterprises (CFA)
			Lower Bound	Upper Bound	
1. Rice	1.0000	27220	3161.0	9027220.0	
2. S/M/C (HF)	0.00	14544			
3. Maize	.5200	32389	4667.4	9032389.0	
4. Groundnuts/ Bambera Nuts (HF)	1.1477	6502	1123.2	6502.0	
5. Soybeans	.4900	78254	2819.4	9078254.0	
6. S/M/C (BF)	1.6091	14544	11044.5	53056.3	
7. Groundnuts/ Bambera Nuts (BF)	.5209	6502	6502.0	10001.5	

Note: Maximized objective function value = 116659.2 CFA.

Table 6.10 RESULTS FROM THE BASIC MODEL: ENTERPRISES IN THE OPTIMAL SOLUTION FOR SYSTEM 4

Enterprises	Optimal Level (in ha)	Gross Margins (CFA/ha)	Ranges of Gross Margins Over Which Optimal Solution Holds (CFA)		Cost of Forcing in Non-Optimal Enterprises (CFA)
			Lower Bound	Upper Bound	
1. Rice	.60	74109	3983.06	9074109	
2. S/M/C (HF)	.0596	13655	13655 (4)	17233	
3. Maize	.48	67855	13921	9067855.0	
4. Groundnuts (HF)	.00	13831			.000
5. Bambera Nuts (HF)	.2604	17409	13831	80403.5	
6. Okra	.40	29050	13268.4	9029050	
7. S/M/C (BF)	.024	13655	10077	13655 (4)	
8. Groundnuts (BF)	.0396	13831	13831 (4)	17409	
9. Bambera Nuts (BF)	.00	17409			.00

Note: Maximized objective function value = 94829.1 CFA.

respectively. Land left idle in System 2 is mostly lowland fields, whereas in System 3, land left idle was partly housefield and partly bushfield. One implication of this excess supply of land is that in System 2, rice intensification strategy rather than lowland expansion strategy should be pursued and in System 3, for dryland crops, intensification rather than land expansion strategy will be a much more appropriate strategy for agricultural growth in these systems. Second, 1980 rainfall was lower than average and poorly distributed. Systems 2 and 3 were the most affected areas, and hence realized relatively poor yields and lower gross margins per hectare.

It is significant to note that rice is grown by the net revenue maximizing representative farmer in all the production systems under study. Besides identifying the mix of enterprises which maximizes total gross margins (TGM), LP also generates additional useful economic information about the optimal solution, such as the ranges of the gross margins (GM) of the individual enterprises for which the optimal solution holds, ceteris paribus. This information is useful in assessing how stable the optimal solution is in the face of possible changes in costs and/or prices. The wider the range for an individual enterprise, the more likely the enterprise is to remain in solution.

Thus, in System 1, under ceteris paribus assumption, the gross margin for rice (24,915 CFA/ha) could vary between 0.0 CFA/ha and 9,024,915.0 CFA/ha without its optimal level moving from 1.1 hectare.[1]

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[1]This is partly because rice is the only crop which uses lowland in the model, hence it faces no competition from other crops. This specification reflects conditions during the survey period (the rainy season). Other crops are grown on lowland during the dry season in System 4 only.

Similarly, the GM for S/M/C (HF) (26,455 CFA/ha) could vary between 7,612.0 CFA/ha and 40,678 CFA/ha without its optimal level moving from 1.2 ha. In System 2, the GM for rice (42,711 CFA/ha) could vary from 25,592.5 CFA/ha to 110,157.7 CFA/ha without its optimal level moving from 1.24 ha. In System 3, the GM for rice (27,220 CFA/ha) could vary between 3,161.0 CFA/ha to 9,027,220 CFA/ha without its optimal level moving from 1.0 ha. Finally in System 4, the GM for rice (74,109 CFA/ha) could vary from 3,983 CFA/ha to 9,074,109 CFA/ha without its optimal level moving from .60 ha. From the above descriptive information, it can be concluded that in all production systems under investigation, apart from System 2, rice is entering the optimal plan under a relatively wide range of gross margins per hectare. So, given the model structure, it will take a big change in costs or prices for the level of rice activity in the optimal plan to change from their current levels, assuming other things remaining unchanged. In section 3 below, we will relax the lowland field constraint and look at its impact on the level of rice cultivation in the optimal plan for various production systems studied.

The last column of Tables 6.7 to 6.10 gives us the cost of forcing in non-optimal enterprises. This measure indicates the extent of improvement needed in the GM of each excluded enterprise before it could compete for a place in the optimal solution. This measure may serve as a basis for suggestions for adaptive trials in the different systems studied. For example, in System 1, other things remaining unchanged, groundnuts would need a GM of 18,843 CFA/ha compared to its current level of 7,612 CFA/ha before it could enter the optimal solution. Bambera nuts would need a GM of 24,784 CFA/ha compared to its current level of 1,671 CFA/ha before it could enter the optimal solution. In System 2, maize would need a GM of 33,146 CFA/ha before it could enter the optimal solution. And cotton would need a GM of 33,273 CFA/ha compared to its current level of 2,119 CFA/ha. These target gross margins could be achieved either through yield increases, or reduction in costs of production, or price increases, or a combination of all these three alternatives.

Another category of useful economic information about the optimal solution that the LP generates is the marginal value product of each resource used in the production process. This information is often useful in indicating where effort should be directed to relax operational constraints. Such information can be valuable in evaluating the feasibility and profitability of relaxing particular constraints. The results in Table 6.11 show the gain in total gross margins to be obtained from a marginal unit addition to the level of each individual constraint, ceteris paribus.

In System 1 for example, an additional hectare of housefield or bushfield would add 26,455 CFA to TGM while an additional hectare of lowland field would add 24,915 CFA. Labor periods are non-binding constraints in this system. In System 2, an additional hectare of lowland field will add nothing to TGM whereas an additional hectare of housefield or bushfield will add respectively 10,527 CFA and 7,824 CFA to TGM. Two labor periods are binding constraints in this system; they are labor periods 8 and 9, corresponding to the month of August. In period 8 which corresponds mainly to the weeding of grains, an additional hour or labor will add 139 CFA to TGM whereas in period 9 which corresponds to weeding of grains and groundnuts, an additional hour of labor will add 57 CFA to TGM.

TABLE 6.11

SHADOW PRICES OF RESOURCES AND CONSTRAINTS USED IN THE MODEL, BY SYSTEM, 1980

Resources or Constraints	Shadow Prices (CFA)			
	System 1	System 2	System 3	System 4
Housefields (HF)	26455	7824	0	13133
Lowlandfields (LF)	24915	0	24059	70126
Bushfields (BF)	26455	7824	0	13133
LAB01	0	0	0	0
LAB02	0	0	0	0
LAB03	0	0	0	0
LAB04	0	0	0	0
LAB05	0	0	0	0
LAB06	0	0	22	0
LAB07	0	0	82	0
LAB08	0	139	0	11
LAB09	0	57	0	0
LAB10	0	0	0	0
LAB11	0	0	0	0
LAB12	0	0	0	0
LAB13	0	0	0	0
LAB14	0	0	0	0
LAB15	0	0	0	0
LAB16	0	0	0	0
LAB17	0	0	0	0
MINFG	0	0	0	-2123
MAXMAI	14223	0	27722	53934
MAXSOY	53066	0	75435	N.A.
MAXOKRA	N.A.	11286	N.A.	15782

In System 3, an additional hectare of housefield or bushfield will add nothing to TGM while an additional hectare of lowland field will add 24,059 CFA to TGM. Labor periods 6 and 7, corresponding to the month of July, are binding constraints in this system. In period 6 which corresponds mainly to the weeding of grains and groundnuts, an additional hour of labor will add 22 CFA to TGM and in period 7 which corresponds to the weeding of grains only, an extra hour of labor will add 82 CFA to TGM.

In System 4, all the three categories of land are binding constraints and only labor period 8 corresponding to the first part of August is a binding constraint. In period 8 which corresponds to weeding of grain and fertilization of rice an extra hour of labor will add 11 CFA to TGM.

In all the production systems, labor is a binding constraint only in July-August. This is a rather surprising result given that through the discussions with farmers, labor was also a problem during the months of October-November (periods 13 and 14) when the bulk of harvesting takes place. One possible explanation for this unrealistic result could be that by using the maximum farm labor available each period on an average farm, we are making total labor from the model very different from the total labor use in reality. In an attempt to address this issue, in section 3 below, instead of using the total maximum available farm labor per period (i.e., $f_j = \overline{W}_j \times 35 \times L_j$ where all the symbols are the same as defined in Chapter Five, section 1.2.3.) we will use the average labor use per period in the labor supply vector (i.e., $f_j = \overline{W}_j \times \overline{H}_j \times L_j$ where f_j, $\overline{W}_j$ and L_j are the same as before and $\overline{H}_j$ is the average number of hours per worker per week).

The last four rows of Table 6.11 give us an idea on how the TGM will be affected if the production constraints are modified. In Systems 1, 2 and 3, increasing the MINFG by one hectare will have no impact on TGM whereas in System 4, TGM will be reduced by 2,123 CFA. In Systems 1, 3 and 4, increasing the MAXMAI constraint by one hectare will increase TGM by 14,223 CFA, 27,722 CFA and 52,934 CFA, respectively; increasing the MAXMAI constraint in System 2 by one hectare will have no impact on TGM. In Systems 1 and 3, increasing the MAXSOY constraint will add to TGM by 53,066 CFA and 75,435 CFA, respectively; increasing the MAXSOY constraint in System 2 by one hectare will have no impact on TGM. Soybean is not grown in System 4. In Systems 2 and 4, where okra is grown, increasing the MAXOKRA constraint will add 11,286 CFA and 15,782 CFA to TGM, respectively. However, the feasibility and profitability of relaxing production constraints should not be based only on gross margins considerations. The current levels of consumption of the enterprises concerned, the storage and other marketing problems faced by these enterprises should also be taken into account.

The major results of this section show that rice is grown by the revenue-maximizing average farmer in all the production systems studied. Furthermore, rice is entering the solution in each system under a relatively wide range of gross margins per hectare, given the model structure. One implication of this result is that it will take a big change in costs or prices for the level of rice activity in the optimal plan to change from their current levels, assuming other things remaining unchanged. So, increased rice production will necessitate improvement in the production methods for other major competing crops, which would free up labor which would allow more intensive rice production. It should be remembered here that rice was the only major crop grown in the lowland fields during the rainy season, and thus did not face any competition by other crops for this category of land.

In Systems 1 and 4, all the three categories of land were binding constraints. In System 2, however, lowland field was not a binding constraint. But in System 3, lowland field was the only binding land constraint. It should be noted that some land is left idle in Systems 2 and 3 as a result of labor conflict between crops during the months of July-August; relatively high labor demand on sorghum/millet fields during this period being the major contributing factor.

3. SENSITIVITY OF THE BASIC MODEL TO CHANGES IN SELECTED PARAMETER VALUES

Experiments with the basic model were designed to assess the impact of possible changes in the economic and technical environment of the farmers surveyed. The hypotheses elaborated in sections 1 and 2 of this chapter were tested by running five separate versions of the basic model. Version A is the case where the average labor coefficients for each production system were replaced with field specific labor coefficients. This version allowed us to test whether the opportunity cost of growing rice was lower in the average model, hence leading the farmer to produce more rice because peak labor demand was underestimated. Version B corresponds to the case where the availability of lowland was increased by 50 percent. This version allowed us to test whether the use of scarce development funds to support water control (hence more lowland available for cultivation) in the bas-fonds would lead to increased hectarage under rice in the different production systems. Version C represents the case where there is a 10 percent increase in gross margins per hectare for the S/M/C enterprise. This version also includes the case where the minimum food grain constraint (MINFG) is lowered by half, implying that farmers are more willing to rely on the market for their grain supply. Version C^1 which is a variant of Version C corresponds to the complete elimination of the MINFG constraint from the model. These two versions (C and C^1) allowed us to test whether increased productivity in S/M/C coupled with an easing of the MINFG constraint will lead to more bas-fonds rice production by the representative farmer. Version E corresponds to the case where the initial labor supply vector made up of maximum family labor available per period is replaced by a labor supply vector made up of average family labor use per period. This model allows us to test whether the fact that labor is only constraining in July-August was due to the fact that total labor availability in the model was unrealistically high by comparison to actual farm conditions. Note that in Versions B, C, C^1 and E, average labor coefficients are used.

The production strategies which maximize total gross margins (TGM) under assumptions A through E above are given in Tables 6.12 to 6.15, alongside the actual production strategy derived from the basic model (Version D).

3.1. Comparison of Optimal Production Strategies Under Different Models (A, B, C, C^1, D, and E)

The main result here is that the basic model is very sensitive to the choice of labor coefficients and the labor supply vector as defined under Versions A and E, and much less sensitive to the other parameter values as defined under Versions B, C and C^1. In System 1 under Version

TABLE 6.12

SUMMARY OF THE PRODUCTION STRATEGIES[a] WHICH MAXIMIZE TOTAL GROSS MARGINS (TGM) UNDER DIFFERENT VERSIONS OF THE BASIC MODEL, SYSTEM 1, 1980

Enterprises \ Model[b]	A	B	C	C[1]	D	E
Rice	1.100	1.65	1.100	1.65	1.100	1.10
S/M/C (HF)	.51	1.20	1.200	1.20	1.200	.51
S/M/C (BF)	.61	.61	.61	.61	.6100	
Maize	.40	.40	.400	.40	.40	.40
Groundnuts (HF)	.69					.1725
Groundnuts (BF)						
Bambera Nuts (HF)						.0609
Bambera Nuts (BF)						
Soybeans	.2400	.2400	.2400	.24	.24	.2307
Cotton						
Okra						
GN/BN (HF)						
GN/BN (BF)						
Maximized objective function value (CFA)	97645	124350	115434	129137	110646	76933

[a]Solutions in the table are expressed in hectares.

[b]In Version A, field specific labor coefficients are used in the model.
In Version B, availability of lowland was increased by 50 percent.
In Version C, gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was lowered by half.
In Version C[1], gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was dropped from the model.
Version D is the basic model.
In Version E, the family labor supply vector was made up of average family labor use per period.

TABLE 6.13

SUMMARY OF THE PRODUCTION STRATEGIES[a] WHICH MAXIMIZE TOTAL GROSS MARGINS (TGM) UNDER DIFFERENT VERSIONS OF THE BASIC MODEL, SYSTEM 2, 1980

Enterprises \ Model[b]	A	B	C	C[1]	D	E
Rice	.5291	1.2419	1.2419	1.2419	1.2419	.792
S/M/C (HF)	.800	.800	.80	.80	.80	.900
S/M/C (BF)	.3445	.3395	.3395	.3395	.3395	.3392
Maize						
Groundnuts (HF)						
Groundnuts (BF)						
Bambera Nuts (HF)						
Bambera Nuts (BF)						
Soybeans	.3555	.3605	.3605	.3605	.3605	.3008
Cotton						
Okra	.100	.100	.10	.10	.10	
GN/BN (HF)						
GN/BN (BF)						
Maximized objective function value (CFA)	59689	90233	92213	92213	90233	67760

[a]Solutions in the table are expessed in hectares.

[b]In Version A, field specific labor coefficients are used in the model.
In Version B, availability of lowland was increased by 50 percent.
In Version C, gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was lowered by half.
In Version C[1], gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was dropped from the model.
Version D is the basic model.
In Version E, the family labor supply vector was made up of average family labor use per period.

TABLE 6.14

SUMMARY OF THE PRODUCTION STRATEGIES[a] WHICH MAXIMIZE TOTAL GROSS MARGINS (TGM) UNDER DIFFERENT VERSIONS OF THE BASIC MODEL, SYSTEM 3, 1980

Enterprises \ Model[b]	A	B	C	C[1]	D	E
Rice	.428	1.500	1.00	1.5	1.0	.9743
S/M/C (HF)	1.000					.1478
S/M/C (BF)		1.603	1.6091	1.6029	1.6091	1.8849
Maize	.400	.52	.520	.52	.52	.52
Groundnuts (HF)						
Groundnuts (BF)						
Bambera Nuts (HF)						
Bambera Nuts (BF)						
Soybeans	.3835	.490	.49	.49	.49	.49
Cotton						
Okra						
GN/BN (HF)		.9123	1.1477	.9123	1.1477	
GN/BN (BF)		.5271	.5209	.5271	.5209	.2451
Maximized objective function value (CFA)	69159	128689	118999	131019	116659	112865

[a]Solutions in the table are expressed in hectares.

[b]In Version A, field specific labor coefficients are used in the model.
In Version B, availability of lowland was increased by 50 percent.
In Version C, gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was lowered by half.
In Version C[1], gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was dropped from the model.
Version D is the basic model.
In Version E, the family labor supply vector was made up of average family labor use per period.

TABLE 6.15

SUMMARY OF THE PRODUCTION STRATEGIES[a] WHICH MAXIMIZE TOTAL GROSS MARGINS (TGM) UNDER DIFFERENT VERSIONS OF THE BASIC MODEL, SYSTEM 4, 1980

Enterprises \ Model[b]	A	B	C	C[1]	D	E
Rice	.366	.6948	.60	.7311	.60	.3071
S/M/C (HF)	.050	.08	.04		.0596	.3180
S/M/C (BF)					.024	.0207
Maize	.48	.48	.48	.48	.48	.2539
Groundnuts (HF)			.0579			.1786
Groundnuts (BF)					.0396	
Bambera Nuts (BF)		.1785	.2221	.1942	.2604	.0495
Bambera Nuts (BF)			.060			.0393
Soybeans						
Cotton						
Okra	.01	.40	.40	.40	.40	.40
GN/BN (HF)						
GN/BN (BF)						
Maximized objective function value (CFA)	60664	99884	94969	101751	94829	60249

[a]Solutions in the table are expressed in hectares.

[b]In Version A, field specific labor coefficients are used in the model.
In Version B, availability of lowland was increased by 50 percent.
In Version C, gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was lowered by half.
In Version C[1], gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was dropped from the model.
Version D is the basic model.
In Version E, the family labor supply vector was made up of average family labor use per period.

A, less S/M/C is grown and groundnuts which is less labor demanding (204 hrs/ha as compared to 1,627 hrs/ha under S/M/C) enters the solution at the level of .69 ha. In System 2, labor demand is so constraining, mainly in periods 9 and 10 which correspond to the month of August that only .529 ha of rice is grown comparatively to 1.24 ha grown under the basic model (Version D). In System 3, not only is a smaller hectarage of rice and S/M/C grown, but also the mixture GN/BN does not enter the solution anymore under Version A. Finally, in System 4, less rice and okra are grown under Version A, and two enterprises (groundnuts and bambera nuts) are no longer part of the optimal solution.

One over-riding observation is that across all the production systems (except System 1) less rice is grown under Version A, confirming the hypothesis that under the basic model, the opportunity cost of growing rice is low and the use of true specific field data in the matrix results in lower hectarage of rice. It is also interesting to note that the results for Version A, which represents fairly closely current conditions, show that rice growing is compatible with a revenue maximizing strategy.

Under Versions B, C and C^1, the optimal solution to the basic model showed very little sensitivity to the parameter values under consideration. In Systems 1 and 3 under Version B, all additional lowland available was put under rice cultivation whereas in System 4, only part of the lowland made available is grown in rice. In System 2, additional lowland made available was left idle.

In Systems 1, 2 and 3 under Version C, the optimal solution to the basic model remained unchanged. But in System 4, there was a slight modification in the optimal plan: fewer hectares of S/M/C and bambera nuts were produced and groundnuts did not enter the new plan. This was probably due to increased intensity in rice cultivation under this system. Under Version C^1, the same results as in Version C occurred, except that in System 4, no S/M/C enterprise was produced and more land was put under rice cultivation (.731 ha instead of .60 ha). So the main conclusion here is that under Versions B, C and C^1, the parameter values would have to change substantially in order to affect the optimality of the solutions in Tables 6.7 to 6.10, given the model structure.

Under Version E, the optimal solution to the basic model was very sensitive to the parameter values under consideration except in System 3. In System 1, labor is so constraining during the months of September-October-November that less sorghum/millet is grown and groundnuts and bambera nuts, which are less labor demanding, enters the solution at .17 ha and .06 ha, respectively. In System 2, a smaller hectarage of rice and soybean is grown because of labor bottlenecks in June and September. Finally in System 4, less rice and maize are grown and the groundnut enterprise, which is less labor demanding than rice and maize, enters the solution at the level of .1786 ha. One over-riding observation under Version E is that labor has become constraining in period 6 (land preparation) in System 2, periods 7-9 (weeding) in Systems 1 and 2, and in periods 11-16 (weeding-harvesting) in Systems 3 and 4. This confirms the hypothesis that under the basic model (Version D), too much labor was made available with the attending result that labor turned out to be a constraining factor only in periods 7-9. However, it is interesting to note that even under Version E, both rice and S/M/C enterprises are compatible with a revenue maximizing strategy.

TABLE 6.16

SHADOW PRICES OF RESOURCES AND CONSTRAINTS USED IN THE VARIOUS MODELS, SYSTEM 1, 1980

Resources or Constraints	Shadow Prices (CFA)					
	A[a]	B	C	C[1]	D	E
Housefields (HF)	7612	26455	29100	29100	26455	0
Lowlandfields (LF)	24915	24915	24915	24915	24915	22121
Bushfields (BF)	7612	26455	29100	29100	26455	0
LAB01	0	0	0	0	0	0
LAB02	0	0	0	0	0	0
LAB03	0	0	0	0	0	0
LAB04	0	0	0	0	0	0
LAB05	0	0	0	0	0	0
LAB06	0	0	0	0	0	0
LAB07	0	0	0	0	0	1
LAB08	0	0	0	0	0	0
LAB09	40	0	0	0	0	0
LAB10	0	0	0	0	0	0
LAB11	0	0	0	0	0	0
LAB12	0	0	0	0	0	543
LAB13	0	0	0	0	0	0
LAB14	0	0	0	0	0	149
LAB15	0	0	0	0	0	0
LAB16	0	0	0	0	0	0
LAB17	0	0	0	0	0	0
MINFG	0	0	0	N.A.	0	-9158
MAXMAI	33066	14223	11573	11573	14223	23730
MAXSOY	71909	53066	50421	50421	53066	0
MAXOKRA	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

[a]In Version A, field specific labor coefficients are used in the model.
In Version B, availability of lowland was increased by 50 percent.
In Version C, gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was lowered by half.
In Version C[1], gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was dropped from the model.
Version D is the basic model.
In Version E, the family labor supply vector was made up of average family labor use per period.

TABLE 6.17.

SHADOW PRICES OF RESOURCES AND CONSTRAINTS
USED IN THE VARIOUS MODELS,
SYSTEM 2, 1980

Resources or Constraints	Shadow Prices (CFA)					
	A[a]	B	C	C[1]	D	E
Housefields (HF)	13558	7824	9951	9951	7824	13520
Lowlandfields (LF)	0	0	0	0	0	0
Bushfields (BF)	13558	7824	9951	9951	7824	13520
LAB01	0	0	0	0	0	0
LAB02	0	0	0	0	0	0
LAB03	0	0	0	0	0	232
LAB04	0	0	0	0	0	0
LAB05	0	0	0	0	0	0
LAB06	0	0	0	0	0	0
LAB07	0	0	0	0	0	0
LAB08	0	139	128	128	139	253
LAB09	64	57	64	64	57	114
LAB10	30	0	0	0	0	0
LAB11	0	0	0	0	0	0
LAB12	0	0	0	0	0	0
LAB13	0	0	0	0	0	0
LAB14	0	0	0	0	0	304
LAB15	0	0	0	0	0	0
LAB16	0	0	0	0	0	0
LAB17	0	0	0	0	0	0
MINFG	0	0	0	N.A.	0	0
MAXMAI	0	0	0	0	0	0
MAXSOY	0	0	0	0	0	0
MAXOKRA	13303	11286	9965	9965	11286	0

[a]In Version A, field specific labor coefficients are used in the model.
In Version B, availability of lowland was increased by 50 percent.
In Version C, gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was lowered by half.
In Version C[1], gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was dropped from the model.
Version D is the basic model.
In Version E, the family labor supply vector was made up of average family labor use per period.

TABLE 6.18

SHADOW PRICES OF RESOURCES AND CONSTRAINTS
USED IN THE VARIOUS MODELS,
SYSTEM 3, 1983

Resources or Constraints	Shadow Prices (CFA)					
	A[a]	B	C	C[1]	D	E
Housefields (HF)	0	0	0	0	0	0
Lowlandfields (LF)	0	24059	24041	24041	24059	0
Bushfields (BF)	0	0	0	0	0	0
LAB01	0	0	0	0	0	0
LAB02	0	0	0	0	0	0
LAB03	0	0	0	0	0	0
LAB04	0	0	0	0	0	0
LAB05	0	0	0	0	0	0
LAB06	645	22	31	31	22	434
LAB07	0	82	79	79	82	154
LAB08	0	0	0	0	0	0
LAB09	143	0	0	0	0	0
LAB10	0	0	0	0	0	0
LAB11	27	0	0	0	0	111
LAB12	0	0	0	0	0	0
LAB13	0	0	0	0	0	0
LAB14	0	0	0	0	0	0
LAB15	0	0	0	0	0	178
LAB16	0	0	0	0	0	26
LAB17	0	0	0	0	0	0
MINFG	-452369	0	0	N.A.	0	0
MAXMAI	0	27722	27633	27633	27722	31388
MAXSOY	0	75435	75521	75521	75435	76633
MAXOKRA	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

[a]In Version A, field specific labor coefficients are used in the model.
In Version B, availability of lowland was increased by 50 percent.
In Version C, gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was lowered by half.
In Version C[1], gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was dropped from the model.
Version D is the basic model.
In Version E, the family labor supply vector was made up of average family labor use per period.

TABLE 6.19

SHADOW PRICES OF RESOURCES AND CONSTRAINTS
USED IN THE VARIOUS MODELS,
SYSTEM 4, 1983

Resources or Constraints	Shadow Prices (CFA)					
	A[a]	B	C	C[1]	D	E
Housefields (HF)	0	0	13133	13133	13133	895
Lowlandfields (LF)	0	0	70126	70126	70126	0
Bushfields (BF)	22243	0	13133	13133	13133	964
LAB01	0	0	0	0	0	0
LAB02	0	0	0	0	0	0
LAB03	0	0	0	0	0	0
LAB04	0	0	0	0	0	0
LAB05	0	0	0	0	0	0
LAB06	0	0	0	0	0	0
LAB07	96	206	0	0	0	169
LAB08	0	3	11	11	11	0
LAB09	0	0	0	0	0	0
LAB10	0	0	0	0	0	0
LAB11	0	0	0	0	0	0
LAB12	0	0	0	0	0	430
LAB13	0	0	0	0	0	68
LAB14	0	0	0	0	0	22
LAB15	0	0	0	0	0	22
LAB16	0	0	0	0	0	0
LAB17	0	0	0	0	0	76
MINFG	-22490	-23340	-758	N.A.	-2123	0
MAXMAI	51844	30658	53934	30658	53934	0
MAXSOY	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
MAXOKRA	0	24495	15782	24495	15782	25468

[a]In Version A, field specific labor coefficients are used in the model.
In Version B, availability of lowland was increased by 50 percent.
In Version C, gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was lowered by half.
In Version C[1], gross margin per ha for S/M/C enterprise was increased by 10 percent and the MINFG constraint was dropped from the model.
Version D is the basic model.
In Version E, the family labor supply vector was made up of average family labor use per period.

3.2. The Opportunity Cost of Scarce Resources and Constraints to Increased TGM

The opportunity cost of a scarce resource represents the change in TGM that one extra unit of the factor could produce when employed in the most profitable fashion, given that resources are already optimally allocated and that available supplies of the factor in question have already been used. The results for Versions A through C[1] for the four production systems were given in Tables 6.16 through 6.19, alongside the opportunity costs of resources and constraints used in the basic model.

One interesting result that emerges from this analysis is that the family labor profile and the labor supply levels are critical in determining the maximum level of TGM attainable by the farmer from his cropping activities. This result is not surprising since family labor is the major input in farming in the EORD. The use of chemical fertilizer or insecticides or herbicides is extremely uncommon. Even animal traction was uncommon in 1980 in the survey area. Hence the intensity and timing of total family labor use are important factors in determining attainable gross farm incomes. The labor coefficients in periods 9 for System 1, 9 and 10 for System 2, 6 and 9 for System 3, and 7 for System 4 are critical in determining the maximum level of attainable TGM under Version A. Under Version E, in addition to the labor periods that are constraining under Version A, labor is also a binding constraint for all systems during at least one period between periods 11-15. Consequently, greater availability of labor in these periods would permit increases in the maximum level of attainable TGM if families were willing to devote more time to farm work. Presumably the fact that it is not the case at the present time is because of incentive problems, the desire for increased leisure, and the preference for pursuing other activities. Under Versions B, C and C^1, the opportunity costs of resources and constraints used are only slightly different from the results under the basic model in Table 6.11.

4. SUMMARY

Several interesting results emerge from the modeling exercise. First, except for System 4, the cultivation of low-yielding sorghum/millet is compatible with a revenue-maximizing strategy. Even when we do not impose a minimum food grain production constraint, the S/M/C enterprise is still competitive enough to appear in the optimal plan, given the current costs and returns structure and the production constraints imposed to reflect either the market limits or the soil conditions. Second, investment in water control to expand the rice land available to farmers will only induce farmers to grow more rice in Systems 1, 3 and 4. In System 2 where investment comes entirely from local initiative without any government assistance, an additional hectare of lowland made available will add nothing to TGM. So land expansion as a strategy to expand rice production in this system will have a very limited potential. In Systems 1 and 3, a land expansion strategy would have some potential to the extent that the increase in lowland availability is compatible with labor bottlenecks in periods 6, 11, 14 and 15. In System 4, increasing rice production through land expansion should be undertaken with caution since lowland appears to be less of a constraint here. When the lowland available was increased to .9 ha in the model, only .7 ha is used in the optimal plan (Table 6.15). Third, except in System 2, there is evidence that increased productivity in the S/M/C enterprise coupled with the elimination of the minimum food grain constraint will lead to increased hectarage under rice; the logic here being that with less acreage under S/M/C, labor is freed up and can now be used in rice production, which is relatively more attractive in terms of gross margin per hectare. Fourth, current levels of rice growing under the different systems are pretty stable within a wide range of variations of gross margins per hectare given the model structure, implying that in the model, price policy alone may not be enough to bring about expanded rice production. But it is quite conceivable that the improvement in the technological package may result in higher yields and justify further investment in water control, for it should be kept in mind that improved water control may have an impact either on the land under cultivation or on the intensity of farming. Fifth, for groundnuts and bambera nuts to be competitive in the various production systems, tremendous efforts in terms of yield increases and marketing outlets are still needed. Gross margins per hectare for these two enterprises will have to be increased at least by ten-fold. Sixth, from the modeling perspective, the labor profile using field specific labor coefficients and the labor supply vector using average labor use per period yielded results which were fairly close to reality, i.e., labor being a binding factor during land preparation, weeding and harvesting.

CHAPTER SEVEN

SUMMARY, POLICY RECOMMENDATIONS, AND FURTHER RESEARCH

The purpose of this chapter is to present the summary of findings and the policy implications of the study, to draw conclusions and to make suggestions for further studies.

1. SUMMARY

The current vagaries of weather in Upper Volta, increasing food imports in general and rice imports in particular, and the need for agriculture to play a greater role in the socio-economic development of the country have intensified interest in increasing food production in the country. The country is divided into eleven ORDs (Regional Development Office), one for each of the ten departmental subdivisions of the country, with one department subdivided into two ORDs. The Eastern Region of Upper Volta has a large surplus agricultural production potential and it has a natural terrain which is suited to rice production in bas-fonds (saucer swamps). But relatively little information is available on the costs and returns of producing rice in these bas-fonds.

This study focuses on the Eastern ORD (EORD) and is designed to generate farm level data to estimate the relative profitability of different crops for the four major rice production systems in the Eastern

Region of Upper Volta in 1980. This study further investigates whether and how rice cultivation can be increased in the EORD.

The research approach employed for this study was described in Chapter Two. Three major sources of information on farmers' circumstances were used:

(1) background information on the farmer's environment from secondary sources (research institutes, government reports, meetings, etc.);

(2) field survey involving structured interviews with farmers by enumerators; and

(3) personal observations in farmer's fields and environment to obtain information on the agricultural production processes. It was anticipated that the most important input would be labor, so detailed data on family, hired, and communal labor utilization was collected, using an "activity" or modified cost route survey method. The cost route method of interviewing farmers once or twice a week over the whole length of the agricultural calendar was not used in this study because of the doubt about its cost effectiveness and the difficulty of maintaining interest of farmers during repeated interviews. Instead an activity approach was used to collect input-output data on each of the major activities--clearing-burning-ploughing-weeding-mulching-spraying-fertilization-cutting-threshing-winnowing-bagging-transport--involved in the production processes during the period running from June 1980 through February 1981. The activity approach consisted of interviewing farmers once for each of the major field activities (altogether 12 to 14 activities depending on the type of production system), on a plot by plot basis soon after its completion.

The sample size of 116 farmers was determined by the number of the farmers producing bas-fond rice in the EORD and by the number of farmers that an enumerator could effectively handle. Typically each enumerator covered 30 farmers. Later inputs were recorded only at the end of each major field activity, but enumerators visited farmers at weekly intervals to check on their progress since detailed information on the cropping calendar of sample farmers was not available to the researcher at the beginning of the survey.

The activity approach which was used in this study as a method to generate information on small farmers' conditions looks promising in terms of (1) maintaining the farmers' interest in rural surveys, and (2) avoiding collection of too much information. However, this approach may not reduce survey costs unless there is detailed information available on the cropping calendar since farmers have to be interviewed to see if an activity is completed. But data processing costs are reduced in the sense that there are fewer survey forms to be coded and key punched with the attending result that data files created are much smaller than otherwise, and the researcher can benefit from insights gained through informal and personal interviewing. While the data collected using the activity approach can be used for budgeting, some difficulties are encountered when programming models are the intended analytical tool; more specifically, conversion of labor coefficients derived by using data collected on an activity by activity basis into calendar week coefficients proved to be a painful process. Furthermore, it will be very difficult to define the family labor supply on an activity by activity basis.

Chapter Three describes the agricultural production systems in the Eastern Upper Volta. An overview of agricultural production in the Eastern Upper Volta shows that the agricultural sector is based primarily on subsistence agriculture: over 90 percent of farmers meet their food requirement needs by growing staple food crops under shifting cultivation. A wide variety of crops are grown, both for domestic consumption (e.g., sorghum, millet, maize, peanuts, etc.) and for export (e.g., cotton). Farmers generally grow more than one crop but on different plots. Fifty-seven percent of the cultivated land was sole cropped, and all but 1 percent of the rice fields was sole cropped.

There are numerous factors that constrain the expansion of agriculture in the EORD; these factors include: capricious weather, poor soils, water management deficiencies and/or costs, lack of improved seeds, poor extension services, poor marketing infrastructure, etc. Rainfall has a skewed distribution toward the end of the growing season. The main constraint is not the lack of rainfall, but poor management of available water. Agricultural research is nonexistent in the EORD and the extension system is crippled by the low level of training of extension agents coupled with the high turn-over of the ORD personnel.

Four production systems were defined based on the degree of water control. System 1 represents the traditional bas-fonds or unimproved swamps. No attempt is made in this system to control water in the bas-fonds. System 2 is based on semi-traditional bas-fonds; in this system water control improvements are rudimentary (based on the use of dikes) and are all done by farmers without any government intervention. In System 3, the improvement consists of the building of dikes to retain water longer on the plots than otherwise. The topographic mapping and dike building are done with heavy government assistance. System 4 represents the system based on irrigated bas-fonds; here the degree of water control is higher than in any of the previous systems. The dam structure here is built and managed by the government, and irrigation is done by gravity.

On the average, farms were made up of eight fields, with an average area of .45 hectares per field. Rice represented on the average only 11 percent of the total cultivated area, varying from 3 percent in System 3 to 31 percent in System 1. Three main categories of labor were identified in the research sites: family labor, hired labor and social labor. Finally, it was found that on the average, 67 percent of household heads were involved in at least one non-farm activity.

In Chapter Four, the relative profitability of different crops was estimated for each of the four major rice based production systems. Financial enterprise budgets were constructed from survey data, and for each enterprise budget, the net cash income (or gross margins) was derived. Other performance measures that were derived using the budgets included: net margin per hectare, net financial returns to land, family labor and management, and costs of production.

It was found in System 1 that gross margin ranged from 1,671 CFA/ha to 79,521 CFA/ha depending on the crop. The soybean enterprise had the highest gross margin and the groundnut and bambera nut enterprises had the lowest gross margin. For all the six enterprises (rice, S/M/C, maize, groundnuts, bambera nuts and soybeans) in System 1, the returns per field hour of family labor varied from 97.6 CFA for rice to 13.9 CFA for bambera nuts. This result suggests that it may be profitable in some instances for family members to seek employment in urban areas where the minimum guaranteed wage is 90 CFA/hr. However, for the rice enterprise, the returns of 97.6 CFA/hr of family labor suggest that there is no financial advantage of family members seeking wage employment in urban areas when they are needed on their rice fields. It was found that the weighted average net return per hour of family labor across all enterprises in System 1 was 47.4 CFA, which is only about half of the minimum urban guaranteed wage. However, it should be kept in mind that whenever the return per hour of family labor is less than the minimum urban guaranteed wage, this will not necessarily lead to rural exodus because of relocating the job search costs that may be so high that the farm worker decides to remain in agriculture. Among the six enterprises comprising System 1, maize showed the lowest total cost of production, 22.8 CFA/kg, and bambera nuts had the highest cost of production, 182.8 CFA/kg. Rice showed the second lowest total cost of production, 33.6 CFA/kg of paddy. Using 47 CFA/hr as the opportunity cost of family labor, three enterprises in System 1 realized a negative return to land and management; they are groundnuts, bambera nuts and S/M/C.

In System 2, the gross margins ranged from 2,119 CFA/ha to 42,711 CFA/ha, depending on the crop. The rice enterprise had the highest gross margin and groundnut and cotton enterprises had the lowest gross margin. However, all enterprises in this system were able to cover their variable costs as in System 1. Returns per field hour of family labor in the system ranged from 1.4 CFA for cotton to 45.5 CFA for soybeans. For the rice enterprise, the return per field hour of family labor was only 18.7 CFA. If the present costs and returns structure continues, the following shifts could be expected: a) farmers will likely put more of their land and labor into soybeans, okra, S/M/C and rice in that order; and b) low returns per field hour of family labor for the cotton enterprise may force farmers to abandon this enterprise despite the heavy government support of this export crop. However, the return per hour to family labor alone cannot determine the change in enterprise mix. Other factors that can affect the farm re-structuration include: (1) the fixity of some inputs to some enterprises, e.g., lowland fields during the rainy season can only be used to grow rice; (2) the family size and the division of labor within the family; and (3) the labor requirements of different crops as well as their market potentials, e.g., currently the market potentials of soybeans and okra are very limited and their home consumption level is very low. Four out of seven enterprises (rice, maize, groundnuts and cotton) realized a negative return to land and management. Among the seven enterprises, S/M/C had the lowest total cost of production, 27.8 CFA/kg and cotton had the highest cost of production, 133.2 CFA/kg. The second highest total cost of production was found for the groundnut enterprise, 93.1 CFA/kg, probably due to the low yield of groundnut (215 kg/ha) in this system. Rice showed the second lowest total cost of production, 44.1 CFA/kg of paddy.

It was found that in System 3, gross margin ranged from 6,502 CFA/ha to 78,254 CFA/ha, depending on the crop. The soybean enterprise had the highest GM and the groundnut/bambera nut mixture had the lowest GM. For all the five enterprises (rice, S/M/C, maize, groundnuts/ bambera nuts, soybeans) comprising this system, except for soybean and maize, the return per field hour of family labor was less than the minimum wage rate paid to unskilled urban labor, i.e., 90 CFA/hr. For the maize and soybean enterprises, returns per field hour of family labor were 116.0 CFA and 450.2 CFA, respectively. For the rice enterprise, returns per field hour of family labor were 51.4 CFA. As a result, if the present costs and returns structure persist, farmers will likely put more of their land and labor into soybeans and maize if the minimum sorghum needed for home consumption is attained. Low returns per hour of family labor under rice may force farmers to abandon this crop since as a grain, it is not yet an important part of the diet. Some incentive structure must be urgently found if rice growing is to survive in this system where some important investments in water control have already been made. Except for soybeans and maize, all enterprises in this system realized a negative return to land and management. Among the five enterprises, maize showed the lowest total cost of production (19.1 CFA/kg), and GN/BN showed the highest total cost of production (228.3 CFA/kg). Rice showed the third lowest total cost of production (69.4 CFA/kg).

In System 4, the variation in GM ranged from 13,655 CFA/ha to 74,109 CFA/ha, depending on the crop. The rice enterprise had the highest gross margin and the S/M/C enterprise had the lowest GM; but all the GMs were positive. In all the six enterprises (rice, S/M/C, maize, groundnuts, bambera nuts, and okra) comprising System 4, except for okra, the returns per field hour of family labor was less than the minimum wage rate paid to unskilled urban workers, i.e., 90 CFA/hr. For okra, returns per field hour were 198.2 CFA, while for rice it was only 24.1 CFA. This low return per hour for rice may be enough to discourage farmers from further rice cultivation. All enterprises except maize and okra realized a negative return to land and management. Among the six enterprises comprising System 4, maize showed the lowest total cost of production, 11.4 CFA/kg. The second highest cost of production was found in bambera nuts, 94.0 CFA/kg. Okra showed the second lowest total cost of production (16.2 CFA/kg), followed by rice (56.8 CFA/kg).

Among the four different rice enterprises, the labor utilization ranged from 302 hours per hectare in System 1 to 3,054 hours per hectare in System 4. So, the highest the level of water control, the more labor intensive is the rice cultivation. The contribution of family labor to total labor on rice plots varied from 76 percent in System 3 to 97 percent in Systems 2 and 4. In System 1, family labor contribution to total labor was 81 percent.

The financial analysis of the different rice production techniques showed that System 4 yielded the highest gross margin per hectare (74,109 CFA) but the second lowest returns per field hour of family labor (24.1 CFA) due to the high labor requirement of this system (irrigated bas-fonds). The traditional bas-fond (System 1) yielded the lowest gross margin per hectare (24,915 CFA) but the highest returns per field hour of family labor (97.6 CFA). The most expensive way to grow rice was found in System 3 (69.4 CFA/kg of paddy), probably due to water costs coupled with low rice yields and the least expensive way of producing rice was found in System 1 (traditional bas-fonds), i.e. 33.6 CFA/kg of paddy.

An economic analysis of the different rice enterprises from the society's perspective showed that the least cost technique for producing rice remains the traditional cultivation or unimproved swamps (System 1). The introduction of water control to date does not compete effectively with this basic system, and total costs per kilogram of paddy rise in every case. However, the possibility of increasing rice production within traditional cultivation is limited. The most efficient means of producing rice under "secure" water control appears to be by partial water control (System 2). Production on irrigated bas-fonds with complete water control and fertilizer use is the second most expensive with cost per kilogram of paddy some 173 percent above the least expensive, traditional bas-fonds, and 96 percent above the more attractive improved alternative (System 2). When considering whether rice production in the EORD should be increased by promoting a particular technique of cultivation, only production in traditional bas-fonds will be economically justifiable under current technologies and yield levels.

In Chapters Five and Six, a linear programming model for the four rice-based production systems was presented and results from the basic model discussed. In addition, several experiments with this basic average-coefficient model were designed to assess the impact of possible changes in the economic and technical environment of the sample farmers. These changes involved varying land availability, labor coefficients, and supply and some production constraints. The goal of this exercise was to provide direction to policy makers rather than attempting to recommend improved plans for individual farmers.

The major results of the models show that rice is grown by the revenue-maximizing average farmer in all the production systems studied. Furthermore, rice is entering the solution in each system under a relatively wide range of gross margins per hectare given the model structure, except in System 2. It can therefore be concluded that it will take a big change in costs or prices for the level of rice activity in the optimal plan to change from their current levels, assuming other things remaining unchanged. As a result, increased rice production will necessitate improvement in the production methods for other major competing crops, which would free up labor which would allow more intensive rice production. It should be remembered here that rice was the only major crop grown in the lowland fields during the rainy season, and thus did not face any competition by other crops for this category of land.

In Systems 1 and 4 all the three categories of land were binding constraints. In System 2, however, lowland field was not a binding constraint. But in System 3, lowland field was the only binding land constraint. It should be noted that some land is left idle in Systems 2 and 3 as a result of labor conflict between crops during the months of July-August; relatively high labor demand on sorghum/millet fields during this period being the major contributing factor.

In all the production systems studied, labor is a binding constraint only in July-August. This is a rather surprising result given that farmers identified labor as a problem during the months of October-November (periods 13 and 14), when the bulk of harvesting takes place. One possible explanation for this unrealistic result could be that by using the maximum farm labor available each period on an average farm, we are making total labor from the model very different from the total labor use in reality.

Several interesting results emerge from the modeling exercise with labor supply based on average labor use. First, the cultivation of low-yielding sorghum/millet is compatible with a revenue-maximizing strategy in Systems 1, 2 and 3. Even when we do not impose a minimum food grain production constraint, the S/M/C enterprise is still competitive enough to appear in the optimal plan, given the current costs and returns structure and the production constraints imposed to reflect either the market's limits or the soil conditions. Second, the investment in water control to expand the rice land available to farmers will only induce farmers to grow more rice in Systems 1, 3 and 4. In System 2, where investment comes entirely from local initiative without any government assistance, an additional hectare of lowland made available will add nothing to TGM. So land expansion as a strategy to expand rice production in this system will have a very limited potential. In Systems 1 and 3, a land expansion strategy would have some potential to the extent that the increase in lowland availability is compatible with labor bottlenecks in periods 6, 11, 14 and 15. In System 4, increasing rice production through land expansion should be undertaken with caution since lowland appears to be less of a constraint here. When the lowland available was increased to .9 ha in the model, only .7 ha was used in the optimal plan. Third, except in System 2, there is an evidence that increased productivity in the S/M/C enterprise coupled with the elimination of the minimum food grain constraint will lead to increased hectarage under rice; the logic here being that with less acreage under S/M/C, labor is freed up and can now be used in rice production which is relatively more attractive in terms of gross margin per hectare. Fourth, the family labor profile and the labor supply levels are critical in determining the maximum level of total gross margin (TGM) attainable by the farmer from his cropping activities. The labor coefficients in periods 9 for System 1, 9 and 10 for System 2, 6 and 9 for System 3 and 7 for System 4 are critical in these respective systems in determining the maximum level of attainable TGM when field specific labor coefficients are used. This result is not surprising since the family labor is the major input in farming in the EORD. The use of chemical fertilizer or insecticides or herbicides, is extremely uncommon. Even animal traction was uncommon in 1980 in the survey area. Hence the intensity and timing of total family labor use are important factors in determining attainable gross farm incomes. Consequently, greater availability of labor in these periods would permit increases in the maximum level of attainable TGM if families were willing to devote more time to farm work. Presumably the fact that it is not the case at the present time is because of incentive problems, the desire for increased leisure and the preference for pursuing other activities. Fifth, current levels of rice growing under the different systems are stable within a wide range of variations of gross margins per hectare, given the model structure, implying that in the model price policy alone may not be enough to bring about expanded rice production. But it is quite conceivable that the improvement in the technological package may result in higher yields and justify further investment in water control, for it should be kept in mind that improved water control may have an impact either on the land under cultivation or on the intensity of farming. Sixth, for groundnuts and bambera nuts to be competitive in the various production systems, tremendous efforts in terms of yield increases and marketing outlets are still needed. Gross margin per hectare for these two enterprises will have to be increased at least by ten-fold. Seventh, from the modeling perspective, the labor profile using field specific labor coefficients and the labor supply vector using average labor use per period yielded results which were fairly close to reality, i.e., labor being a binding factor during land preparation, weeding and harvesting.

2. POLICY IMPLICATIONS AND STRATEGY TO IMPROVE THE PERFORMANCE OF RICE PRODUCTION IN THE EORD

Several policy implications can be derived from the findings of this study as they relate to (1) the improvement of the four major rice based production systems in the EORD; and (2) the identification of an appropriate bas-fond rice production strategy which could assist with the increase of rice production in the EORD. The improvement of economic profitability of the different types of rice cultivation can come either through the improvement of the efficiency of resources already committed to rice production or the introduction of improved inputs or through appropriate pricing policies, or a combination of all the above alternatives. This study provides policy makers in Upper Volta some of the data required to identify the trade-offs among investment levels in water control for alternative rice production systems. Four basic systems of water control are employed in rice farming in the EORD. System 1 represents the unimproved swamps with yield of .458 ton of paddy per hectare on the average. Systems 2 and 3 rely on uncertain surface flooding, and water is controlled in these two systems by using dikes. Yields in these two systems averaged .5 and 1.2 ton of paddy per hectare in Systems 3 and 2, respectively. The main difference between System 2 and System 3 is that the investments in water control in System 2 come entirely from local initiative whereas in System 3 water control is achieved with government assistance in terms of topographic mapping and building of dikes. System 4 represents the system with complete water control, based on dam irrigation and with yield of 1.7 tons of paddy per hectare on the average. The survey data have permitted a detailed analysis of the farm-level relative position of rice in the four production systems studied. However, we do not have marketing and other macro-economic data to rigorously trace the direct and indirect implications of these alternative production systems for the Eastern Region of Upper Volta and the national economy. Nevertheless, this study will pose major policy issues facing GOUV policy makers and then conclude with some recommendations as to how to improve the performance of rice production in the EORD.

2.1. Major Policy Issues and Reorientation

Key policy issues which GOUV policy makers should consider include:

Capital investment. Capital investment in the agricultural production systems was found to be low. With regard to durable capital, the present study shows clearly that the predominant capital item among survey farmers is hand-tools, mainly cutlasses and hoes. However, it should be kept in mind that historically, the development of mechanical technology suitable for small farmers has proved to be more difficult than advances along biological lines (improved seeds and fertilizers). It is important that adaptative research trials be directed toward divisible and low cost technology given the low resource levels of farmers in the EORD. Policy measures should also aim at developing much required skills in small scale rural industries both as an additional source of income and as a support to the farm sector technology. It is suggested here that the operations of ARCOMA-COREMMA should be reviewed in order to help this institution play a vital role in the rural equipment which will help lessen the human energy requirements associated with hand-tools.

Research priorities. Even though the results of the modeling exercise suggest that current levels of rice growing in the different production systems are stable within a wide range of variations of gross margin per hectare, implying that price policy alone may not be enough to bring about expanded rice production, it is quite conceivable that improvement in the technological package of rice growing may result in higher yields, thus increasing rice production without any expansion in the area under rice cultivation. With the S/M/C enterprise still the major crop mixture in the cropping systems of EORD farmers, this enterprise which absorbs most of the family labor, will have to be looked at concurrently. Unfortunately, these two enterprises fall under the jurisdiction of two different research institutes: IRAT for the S/M/C enterprise and CERCI for the rice enterprise. So, it is recommended that trials on farmers' fields be jointly planned and carried out by CERCI and IRAT. This recommendation ensures that technological packages will be formulated and refined under actual farmers' management practices, while also meeting consumer's preferences.

Land expansion/Levels of investments in water control. High marginal value productivities found for the lowland fields in Systems 1, 3 and 4 seems to indicate insufficient lowland fields in these systems and thus suggest a land expansion strategy. But there are a number of unfavorable medium- and long-term consequences of this strategy. Increasing rice production can be achieved either by improving yields (increased intensity of farming) or by expanding the area under production, or both. However, the higher level of investment in water control necessary for expanding area or increasing yields can only be profitable if increased costs are more than offset by increased revenues. The economic analysis showed that the costs of improved water control in the EORD are very high and cannot be covered by the returns under existing technology. With current average yields of .5 ton of paddy per hectare in System 3, the expansion of rice land available to farmers should be discouraged. In System 4, lowland availability to farmers appears to be less of a constraint, and a rice farming intensity strategy rather than a land expansion strategy should be promoted. However, in order to draw definitive conclusions regarding the returns to land improvement under partial or complete water control, there is a need for studies on the utilization of the irrigated areas during the dry season.

Paddy pricing. The present official farm gate price of 63 CFA per kilogram of paddy is rarely followed by market participants. Actual observed farm gate prices per kilo of paddy were 61, 42, 66 and 52 CFA in Systems 1, 2, 3 and 4, respectively. The economic costs of production per kilogram of paddy were 34, 44, 69 and 57 CFA in Systems 1, 2, 3 and 4, respectively. So, except in System 1, the economic cost of production was greater than the farm gate price received by sample farmers. The marketing of domestic rice is further complicated by its poor quality because of its higher percentage of brokens, with the attending result that domestic rice is less desired by consumers. If the policy objective is agreed upon as being to satisfy consumer's demand through domestic production and imports while providing some incentives to rice farmers, possible policy instruments available to the GOUV policy makers to achieve this objective include: (1) floor pricing in order to allow farmers to cover their cost of production; and (2) a tax on imports of rice in the short run and subsidization of rice research in-country with the tariff revenues. Here it is suggested that measures should be taken to make sure that the farm gate price of paddy in the EORD is at least equal to the import parity price of paddy, i.e., 56.4 CFA per kilogram. The "Caisse de Pèrèquation" of the Ministry of Commerce could play a vital role in the implementation of such policies. However, further investigation will be needed to determine the exact magnitude of these policy instruments. The problem of the poor quality of domestically produced rice should also be addressed at the same time that the pricing of paddy is being discussed.

Extension services. The problem of high turn-over of the EORD personnel was identified. The personnel policy of the EORD as well as that of the other institutions involved in the development of the Eastern Region (e.g., CERCI, FDR, ONBI) will have to be revised to ensure some continuity in the implementation of various rice programs. In addition, given the relatively high profitability of other crops such as soybeans and okra and the importance of the S/M/C enterprise in the cropping system of the EORD farmers, more attention should be given to these crops through a personnel redeployment.

2.2. Identification of an Appropriate Bottomland Rice Production Strategy in the EORD

Two major components of an appropriate bas-fond rice production strategy are identified below for the evaluation of GOUV policy makers.

2.2.1. Small Scale Irrigation Using Dikes

The EORD should de-emphasize major investments in dam irrigation and give priority to partial water control and rainfed agriculture. Reasons for this recommendation include:

(1) Dam irrigation appears to be too costly to be profitable under current technologies and yield levels.

(2) Managerial and maintenance problems continue to persist, making demands on scarce administrative talent and reducing the profitability of these operations. In fact rice production with dam irrigation created the highest net economic losses among the four types of rice cultivation.

(3) Even though from the strict economic sense only rice production in traditional bas-fonds is justifiable, partial water control has potential for bas-fond rice production. Economic losses per hectare in System 2 are only about 5,000 CFA. Furthermore, farmers in this system can play a more active role in both the investment in and operation of the system, thereby reducing the need for government control, supervision and expenses, while creating more employment.

2.2.2. Improved Production Practices

Our analysis showed that not only yields achieved in various systems under study are low, but also most farmers are not following recommended production practices (seed rates, fertilizer use and/or rates, pesticide use, use of animal traction, etc.). The main reason for this situation is that most recommendations from CERCI and IRAT have been so far based on experiment station trials, sometimes discounted to approximate responses under farm-level conditions. This approach is a poor substitute for FSR approach, with the attending result that yield-increasing technology, especially for food crops, is still lacking. Therefore, there is an urgent need to get Farming Systems Research (FSR) underway in the EORD in order to test and to assess new technologies with farmers and to evaluate with them what the tangible benefits of improved production techniques can be. This recommendation will call for a close collaboration between CERCI, IRAT and ICRISAT which are the main research institutions of importance to the EORD.

3. SUGGESTIONS FOR FURTHER STUDIES

This study has generated a data base on the economics of bas-fond rice production and the relative profitability of the different levels of water control in the EORD. However, there is a need for studies on the utilization of the "irrigated" areas during the dry season which will be helpful for an accurate assessment of the returns to land improvement under partial (Systems 2 and 3) or complete water control (System 4). In addition, the author recognizes the need to integrate this farm level study with other important components of the sub-sector such as marketing, trade policy, tax on consumers in some areas, etc. These complementary studies will provide the missing link between farm-level trade-offs and macro-level policies. Finally, there is now a need to initiate on-farm trials as we mentioned above. This will call for a much more close collaborative effort from IRAT, CERCI and ICRISAT.

Further investigations are also needed into alternative data collection methods. The assessment of the activity approach used in this study was presented in Chapter Two and in the Summary of Findings. In order to address some of the shortcomings of this approach, it is still necessary to identify various data gathering shortcuts which could be useful in any future evaluation of existing cropping systems, particularly if resources of the study are more limited.

APPENDIX A

SURVEY FORMS USED FOR THE STUDY

APPENDIX A

SURVEY FORMS USED FOR THE STUDY

BF1 - Plot inventory

BF2 - Household inventory

BF3 - Family labor use

BF4 - Non-family labor use

BF5 - Purchase of non-labor inputs

BF6 - Use of non-labor inputs

BF7 - Harvest records

BF8 - Sales records

BF9 - Inventory of tools and equipment

BF10 - Family labor spent on non-family fields

BF11 - Price information records

BF12 - Off-farm employment records

BF13 - Plot area measurement

BF14 - Yield plot records

BF15 - Livestock inventory

BF16 - Labor use in livestock activities

BF17 - Estimated costs and returns in livestock activities

BF18 - Qualitative data information

*Measurement units used to collect information on output

*Assessment of the quality of data gathered by the enumerators

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/ / / / / / / / /
Fiche Zone Ménage

FICHE BF1: Recensement initial des parcelles sous culture cette année par ménage

IDENTIFICATION: NOM DU MENAGE ____________________ ZONE __________

ENQUETEUR ____________________ DATE D'ENTRETIEN __________

Nom et n° des parcelles	Responsable de la parcelle (2)	Méthode de labour de la parcelle (3)	Localisation de la parcelle (4)	Culture principale (5)	Culture secondaire (6)	Autre culture (7)	Culture de bordure (8)	Type de sols (9)	Topographie (10)	Nbre d'anées sous culture (11)	Utilisation du fumier ou engrais (12)	Acquisition--Méthode (13)	Acquisition--Cout: en espece ou nature (14)	Temps nécesaire: Maison-parcelle (15)	Superficie

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Ménage

FICHE BF2: Recensement initial de la taille des ménages

IDENTIFICATION: NOM DU MENAGE________________ ZONE________

ENQUETEUR________________ DATE D'ENTRETIEN________

Noms et Prénoms	Lien de parente avec chef du ménage (2)	Sexe (3)	Année du naissance (4)	Niveau d' instruction (5)	Résidence principale		Activité principale (8)	Autres activites importantes (9)	Temps ou période nécessaire pour cette activité en (9) par an (10)	Si Inactif préciser raison (11)
					Hivernage (6)	saison sèche (7)				

ETUDE AGRO-ECONOMIQUE DES BAS-BONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/

Fiche Zone Menage

<u>FICHE BF3</u>: Temps de travail fourni par les membres du ménage

<u>IDENTIFICATION</u>: NOM DU MENAGE ____________________ ZONE __________

ENQUETEUR ____________________ DATE D'ENTRETIEN __________

Nom et N° de la parcelle ______________________________

Culture (s) plantée (s) sur cette parcelle ______________________________

(commencer par la culture la plus importante en terme de densité)

Activités (1)	Culture	Nbre d'exécutions de cette activité sur toute la parcelle (2)	Date d'execution de cette activité (3)	CATEGORIE DES MEMBRES AYANT PARTICIPE A CETTE ACTIVITE					
				HOMMES (4)		FEMMES (5)		ENFANTS (6)	
				Nbre de personnes	Heures totales par personne	Nbre de personnes	Heures totales par personne	Nbre de personnes	Heures totales par personne

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Menage

FICHE BF4: Temps de travail fourni par les membres hors du ménage et dépenses totales engagées

IDENTIFICATION: NOM DU MENAGE____________ ZONE____________

ENQUETEUR____________ DATE D'ENTRETIEN____________

Nom et nº de la parcelle	Cultures	Activité	Daté d'exécution de cette acvité	Type de travailleurs	CATEGORIE DES MEMBRES AYANT PARTICIPE A CETTE ACTIVITE						DEPENSES TOTALES			
					Hommes (4)		Femmes (5)		Enfants (6)		Espéce	Nature		
					Nbre de personne	Heures totales/personnes	Nbre de personne	Heures totales/personnes	Nbre de personne	Heures totales/personnes		Type	Quantité	Unite de measure

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Menage

FICHE BF5: Dépenses totales pour les facteurs de production autres que la main d'oeuvre.

IDENTIFICATION:

NOM DU MENAGE______________________ ZONE__________

ENQUETEUR______________________ DATE D'ENTRETIEN__________

Date d'achat ou de location (1)	Nature de la dépense (2)	Quantité		Source d'approvisionement (4)	Cout par unité
		Nbre	Unité		

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/

Fiche Zone Menage

FICHE BF6: Utilisation de facteurs de production autre que la main-d'oeuvre
(Uniquement pour les facteurs non-durables)

IDENTIFICATION: NOM DU MENAGE________________ ZONE________

ENQUETEUR________________ DATE D'ENTRETIEN________

N^{o} de la parcelle	Cultures plantées	Nature du facteur utilisé	Date d'utilisation	Quantité		Source d'approvisionnement	Prix courant ou de remplacement
				Nbre	Unité		

Facteurs non-durables

- Semences, Engrais, Pesticides, Autres

/__/__/ /__/__/ /__/__/

Fiche Zone Ménage

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS
DE L'O.R.D. DE L'EST, RHV

FICHE BF7: Registre des recoltes

IDENTIFICATION:

NOM DU MENAGE ______________________ ZONE ______________

ENQUETEUR ______________________ DATE D'ENTRETIEN ______________

Date	N° de la parcelle	Type de produit	QUANTITE RECOLTEE			UTILISATION ENVISAGEE			
			Forme (4)	Nombre	Unités	Consommation	Ventes	Stockage	Autre Usages

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Menage

FICHE BF8: Registre des Ventes

IDENTIFICATION: NOM DU MENAGE________________ ZONE__________

ENQUETEUR________________ DATE__________

Date	Type de produit	Origine* de produit	QUANTITES VENDUES			Prix total	Prix/ Unité	Lieu de vente	Type d'a-cheteur	Cout de vente
			Forme	Nombre	Unités					

*N'engregistrer que les produits de la saison 1980-81.

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Menage

FICHE BF9: Inventaire du cheptel mort et materiel agricole

IDENTIFICATION: NOM DU MENAGE__________ ZONE__________

ENQUETEUR__________ DATE D'ENTRETIEN__________

Type de matériel (1)	Nombre total	Age du matériel	Prix d'achat unitaire	Prix actuel au marché	Vie utile du matériel

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/

Fiche Zone Menage

FICHE BF10: Temps de travail fourni par les membres du menage dans les champs d'autrui et paiement recu

IDENTIFICATION: NOM NU MENAGE ______________________ ZONE ______________

ENQUETEUR ______________________ DATE D'ENTRETIEN ______________

Nom et nº de la parcelle	Cultures	Activité	Date d'exécution de cette acvité	Type de travailleurs	CATEGORIE DES MEMBRES AYANT PARTICIPE A CETTE ACTIVITE						PAIEMENT RECU			
					Hommes (4)		Femmes (5)		Enfants (6)		Espèce	Nature		
					Nbre de personne	Heures totales/personnes	Nbre de personne	Heures totales/personnes	Nbre de personne	Heures totales/personnes		Type	Quantité	Unite de measure

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/

Fiche Zone Menage

FICHE BF11: Prix aux marchés locaux

IDENTIFICATION: NOM DU MARCHE________________ DATE DU MARCHE________________

NOM ENQUETEUR:________________

Produits (1)	Forme (2)	Unité de Mesure (3)	Prix Unitaire	Nombre de Vendeurs (4)

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Menage

FICHE BF12: Couts et revenus provenant d'occupation non-agricoles

IDENTIFICATION: NOM EU MENAGE______________________ ZONE______________

ENQUETEUR______________________ DATE D'ENTRETIEN______________

	CATEGORIE DES MEMBRES DU MENAGE PARTICIPANT A CETTE OCCUPATION												DEFENSES TOTALES				GAINS BRUTS			
	HOMMES				FEMMES				ENFANTS					Nature				Nature		
Nature de l'occupation non-agricole	Nbre	Mois de l'année ou il est engagé dans cette occupation	Jour total par mois	Heures totales par jour	Nbre	Mois de l'année ou il est engagé dans cette occupation	Jour total par mois	Heures totales par jour	Nbre	Mois de l'année ou il est engagé dans cette occupation	Jour total par mois	Heures totales par jour	Espèces	Type	Quantité	Unité de mesure	Espèces	Type	Quantité	Unité de mesure

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Menage

FICHE BF13: Mesurage des superficies des parcelles cultivées cette saison

IDENTIFICATION: NOM DU MENAGE ________ ZONE ________

ENQUETEUR ________ DATE DE MESURAGE ________

CULTURES PRESENTES ________

N° de cote	Azimuth	Longueur	N° de cote	Azimuth	Longueur

Distance de la concession ________ km

CROQUIS DE LA PARCELLE

Erreur de fermeture ________%

Superficie /__/__/__/__/__/ ares

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Menage

FICHE BF14: Carres de densites

IDENTIFICATION: NOM DU MENAGE ______________________ ZONE ______________

ENQUETEUR ______________________ DATE DE MISE EN PLACE DES CARRES ______

Nom et n° de la parcelle	Cultures présentes (par ordre d'importance)	Emplacement des cultures sur la parcelle	N° de carré	Nbre de poquets	Nbre de pieds

Surface totale des carrés __________/m2
Nombre de poquets au total __________/
Nombre de pieds au total __________/

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/

Fiche Zone Menage

FICHE BF15: Inventaire du cheptel vif

IDENTIFICATION: NOM DU MENAGE________________ ZONE________________

ENQUETEUR________________ DATE D'ENTRETIEN________________

Espece (1)	Categorie (2)	Sexe (3)	Age (4)	Nbre d'animaux (5)

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/ / / Fiche   / / / Zone   / / / Menage

FICHE BF16: Temps de travail fourni par les membres du ménage dans le domaine de l'élevage

IDENTIFICATION: NOM DU MENAGE ______________________ ZONE ______________________

ENQUETEUR ______________________ DATE D'ENTRETIEN ______________________

			CATEGORIE DES MEMBRES AYANT PARTICIPE A CETTE ACTIVITE											
			HOMMES				FEMMES				ENFANTS			
Espèce d'animaux	Nombre d'animaux	Type d'activités	Nbre	Mois de l'année ou il est engagé dans cette activité	Jour total par mois	Heures totales par jour	Nbre	Mois de l'année ou il est engagé dans cette activité	Jour total par mois	Heures totales par jour	Nbre	Mois de l'année ou il est engagé dans cette activité	Jour total par mois	Heures totales par jour

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS DE L'O.R.D. DE L'EST, RHV, 1980-81

/__/__/ /__/__/ /__/__/
Fiche Zone Menage

FICHE BF17: Dépenses totales et gains bruts dans le domaine de l'élevage

IDENTIFICATION: NOM DU MENAGE__________ ZONE__________

ENQUETEUR__________ DATE D'ENTRETIEN__________

DEPENSES TOTALES				GAINS BRUTS DES VENTES				
NATURE			Espèces	Type d'animal	Nombre	Forme	Prix de vente unitaire	Prix total
Type	Quantite	Unité de mesure						

ETUDE AGRO-ECONOMIQUE DES BAS-FONDS
DE L'O.R.D. DE L'EST, RHV, 1980-81

/ / / / / / / / /
Fiche Zone Ménage

FICHE BF18: Informations générales sur les différents systémes de production.

IDENTIFICATION:

Nom du ménage ____________________

Zone ____________________

Date d'entretien ____________________

A. PROBLEMES FONCIERS ET UTILISATION DES DIFFERENTES PARCELLES.

1. Quel nombre de catégories de tèrres exploitables avez-vous à votre disposition?

_______ Terres libres (Tinjali)

_______ Terres en Jachère (Kuawaogu)

_______ Terres de Sorgho ou de mil (Kuanu)

_______ Petits lopins de terre (Liloli)

2. Si vous voulez accroitre vos superficies cultivées, pourriez-vous trouver du terrain?

_______ oui _______ non

2.1. Si non, pourquoi?

_______ Pas de terres disponibles dans la région

_______ Main d'oeuvre familiale limitée

_______ Main d'oeuvre salariée limitée

_______ Manque d'argent pour acquérir terrain

_______ Manque d'argent pour les intrants agricoles (semences engrais, ... etc)

_______ Autres raisons (préciser) ____________________

____

____

2.2 Si oui,

Quelles cultures vous aimeriez voir les superficies augmentées?

____

____

- A quelle distance de la maison compterez-vous trouver de terrain?

______ Moins d' un km

______ Moins de 2 kms

______ Plus de 2 kms

3. Avez-vous l'intention d'augmenter vos superficies en riz?

______ oui ______ non

3.1. Si oui,
Quand? ______

Pourquoi voulez-vous augmenter vos superficies en riz?

______ besoins alimentaires

______ besoins en argent

______ Prestige

______ Recommandé par ORD

______ Autre raisons (précicer)

______

______

______

3.2. Si non,
pourquoi? ______

______

______

4. Dans votre ménage, pour quels produits la superficie a-t-elle augmentée et pour quels produits a-t-elle diminuée durant les 5 dernières années

______	Mil-sorgho	1 = augmentée
______	Riz	2 = diminuée
______	Arachide	3 = pas de changement
______	Niébé/haricot	
______	Soja	
______		
______		

Raisons pour chaque cas:

______

______

______

5. Est-ce que la rotation des cultures augmente vos rendements?

    ____________________oui ____________________non

6. Quel type de rotation avez-vous trouvé très bénéfique?

____

____

____

7. Pourquoi faites-vous des associations de cultures?

    ______________________________ Manque de terrain
    ______________________________ Pour diminuer le travail
    ______________________________ Pour diminuer le nombre de champs
    ______________________________ Pour réduire les problémes avec les insectes
    ______________________________ Pour conserver le sol
    ______________________________ Par tradition
    ______________________________ Autres raisons (préciser)

____

____

B. DISPONIBILITE DE LA MAIN D'CEUVRE ET PROBLEMES Y AFFERANT

1. Pendant quelle (s) période (s) de l'annéc avez-vous des problémes de main d'oeuvre?

____

____

2. Pendant ces périodes de pointe, quelles cultures sont considérées comme les plus importantes et recoivent en priorité la main d'oeuvre disponible? (Préciser cultures et opérations dans l'ordre des priorités.)

____

____

3. Est-ce qu'un champ de riz demande plus de travail qu'un champ de sorgho/mil?

    ____________________oui ____________________non

    mais?

    ____________________oui ____________________non

Commenter____

____

C. INVITATION DE CULTURES ET AUTRES ACTIVITES COMMUNALES

1. Quelles sent les activités communales auxquelles vous participez régulièrement?

_______________ Invitation de culture

_______________ Construction de route

_______________ Construction de case

_______________ Autre (préciser)

2. Pour chaque activité préciser les periodes de l'année et les membres de votre famille y participant

3. Commenter sur le role et l'importance des activites communales

4. Est-ce que vous etes obligé de fournir du travail ou de la nourriture aux membres de la communauté qui ont eu un faible rendement à cause de maladie ou d'autres raisons (à specifier)?

D. SECURITE ALIMENTAIRE ET PROBLEMES GENERAUX

1. Quelles cultures sont plantées pour faire face à la famine en cas de mauvaise saison?

2. En cas de déficit céréalier, quelles mesures sent prises pour réduire la consommation ou obtenir de la nourriture d'ailleurs?

3. Dans la famille, qui est responsable du stock alimentaire et de sa distribution? ______________________________

4. Avez-vous eu des problèmes particuliers avec certaines de vos parcelles cette saison?

   ____________ oui ____________ non

   Si oui

Nom parcelle	Problèmes

Problemes:

1 = Invasion d'insecte
2 = maladie
3 = sècheresse
4 = inondation
5 = domages causès par animaux
6 = autre raison (à prèciser)

E. COMMERCIALISATION DES PRODUITS

1. Quelles circuits commerciaux sont disponsibles à vous pour

   a) vos cultures de rente?

   ____

   ____

   b) Pour le surplus alimentaire

   ____

   ____

   c) Pour le riz

   ____

   ____

2. A quelle distance de votre maison se trouvent les marchès

   a) Pour les cultures de rente

   ____

   ____

   b) Pour le surplus alimentaire

   ____

   ____

c) Pour le riz

F. INNOVATIONS ET CONTACTS AVEC LES SERVICES DE VULGARISATION

1. Pendant les cinq dernières années, mentionne un changement ou une innovation importante que vous avez introduit dans votre exploitation dans les domaines suivants:

- cultures vivrières

- cultures perennes ou de rente

- élevage

- transformation des produits agricoles

- commercialisation

- moyens de stockage

- équipements agricoles

2. Quand avez-vous pour la dernière fois consulté un encadreur agricole ________________________________?
   un agent d'élevage____________________________?

3. Quelles utilisations faites-vous de vos parcelles de bas-fonds pendant la saison sèche?

____

____

____

4. Par rapport aux trois années précédentes la récolte 1980 a été:

   1 = très bonne

   2 = bonne

   3 = moyenne

   4 = mauvaise

   5 = très mauvaise

Sorgho ______	______
Petit mil ______	Pois de terre ______
Coton ______	Manioc ______
Riz ______	Haricot ______
Mais ______	Soja ______
Patate ______	Sésame ______

POIDS DES UNITES DE MESURE UTILISEES

IDENTIFICATION: Nom du menage____________________

Zone____________________

Date____________________

Unite de mesure	CULTURE PESEE			POIDS EN KGS	
	Cult.	Var.	Forme	Poids de la tare	Poids du recipient rempli

EVALUATION SUBJECTIVE DE LA QUALITE DES DONNEES

(A REMPLIR PAR LES ENQUETEURS)

CHEF DE MENAGE:____

ZONE:____

DATE:____

Comment évaluez-vous les résponses du Chef du ménage aux types de données suivantes:

TYPE DE DONNEES	QUALITE ET PRECISION	ESTIMATIONS	RAISONS DE LA SOUS OU SUR-ESTIMATION
Composition de son ménage			
Age des membres du ménage			
Temps de travail des membres du ménage			
Nombre de parcelles sous culture			
Temps de travail des membres en dehors du ménage			
Quantités récoltées de chaque parcelle			
Composition du cheptel mort			
Composition du cheptel vif			

AUTRE COMMENTAIRES: ____

____

____

____

____

APPENDIX B

FIELD SPECIFIC FAMILY LABOR PROFILE FOR CROPS OTHER THAN RICE IN ALL THE FOUR PRODUCTION SYSTEMS STUDIED

TABLE B.1

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO S/M/C ENTERPRISE, SYSTEM 1, 1980

Labor Periods	Hours per Hectare			
	Average	Field Reference		
		2/2	6/2	24/2
1 (18)	47			
2 (2)	76		173	88
3 (2)	48			288
4 (2)	73	50		
5 (2)	124	256	242	
6 (2)	127			
7 (2)	127	72	135	231
8 (2)	144		290	385
9 (2)	176	475	155	
10 (2)	139	33		
11 (2)	131	333	508	692
12 (2)	43		198	58
13 (2)	46	17		
14 (2)	33	33	58	
15 (2)	76		76	185
16 (2)	86	103		115
17 (4)	17			88
Total (hrs/ha)	1513	1372	1835	2409
Area (ha)	.429	.36	.62	.23

TABLE B.2

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO MAIZE ENTERPRISE, SYSTEM 1, 1980

Labor Periods	Hours per Hectare		
	Average	Field Reference	
		5/9	5/9
1 (18)	3		
2 (2)			
3 (2)			
4 (2)			
5 (2)	185		
6 (2)	34	56	140
7 (2)	104	22	56
8 (2)	40		
9 (2)	23		
10 (2)			
11 (2)	105		
12 (2)	31	167	421
13 (2)	13		
14 (2)			
15 (2)			
16 (2)			
17 (4)			
Total (hrs/ha)	538	244	618
Area (ha)	.079	.09	.036

TABLE B.3

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO GROUNDNUT ENTERPRISE, SYSTEM 1, 1980

Labor Periods	Hours per Hectare		
	Average	Field Reference	
		2/7	23/4
1 (18)			
2 (2)			
3 (2)	3		
4 (2)			
5 (2)	15		
6 (2)	18	123	
7 (2)	27		
8 (2)	24	123	248
9 (2)	15		
10 (2)	17		
11 (2)	16		177
12 (2)	6		
13 (2)	4		
14 (2)	29	46	106
15 (2)	10		
16 (2)	4		
17 (4)	5		
Total (hrs/ha)	193	308	532
Area (ha)	.319	.132	.336

TABLE B.4

FAMILY LABOR PROFILE FOR FIELDS BELONING TO
BAMBERA NUTS ENTERPRISE, SYSTEM 1, 1980

Labor Periods	Hours per Hectare		
	Average	Field Reference	
		21/5	20/7
1 (18)			
2 (2)			
3 (2)			
4 (2)			
5 (2)	12		
6 (2)	2		
7 (2)	31		
8 (2)	9	138	
9 (2)	10		962
10 (2)			
11 (2)	17		704
12 (2)			
13 (2)	1		
14 (2)	11	12	
15 (2)	12		
16 (2)	2		235
17 (4)			
Total (hrs/ha)	107	150	1901
Area (ha)	.476	.26	1.41

TABLE B.5

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO SOYBEANS ENTERPRISE, SYSTEM 1, 1980

Labor Periods	Hours per Hectare		
	Average	Field Reference	
		4/6	4/6
1 (18)			
2 (2)			
3 (2)			
4 (2)	11		
5 (2)			
6 (2)	34	196	107
7 (2)	276	173	95
8 (2)	32	46	25
9 (2)	219		
10 (2)	157		
11 (2)	135		
12 (2)	128	123	67
13 (2)	68	108	59
14 (2)	65	15	8
15 (2)			
16 (2)			
17 (4)			
Total (hrs/ha)	1125	662	362
Area (ha)	.252	.26	.476

TABLE B.6

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO
S/M/C ENTERPRISE, SYSTEM 2, 1980

Labor Periods	Hours per Hectare				
	Average	Field Reference			
		28/1	46/2	55/2	44/1
1 (18)	11			150	
2 (2)	51	93		112	78
3 (2)	14				
4 (2)	62	230			144
5 (2)	34		192	156	
6 (2)	40	44		217	
7 (2)	72	121			51
8 (2)	57	35		94	148
9 (2)	29	20		71	42
10 (2)	23	19		6	38
11 (2)	41	102	54		9
12 (2)	20	48			
13 (2)	1				
14 (2)	2				44
15 (2)	22		47	15	134
16 (2)	61	153			
17 (4)	11	57			
Total (hrs/ha)	551	922	293	823	689
Area (ha)	1.574	3.1	.59	.48	1.49

TABLE B.7

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO MAIZE ENTERPRISE, SYSTEM 2, 1980

Labor Periods	Hours per Hectare				
	Average	Field Reference			
		52/4	42/8	29/3	34/5
1 (18)					
2 (2)					
3 (2)	45				
4 (2)	22				
5 (2)	49			736	
6 (2)	155	264	333		
7 (2)	357	956	222		490
8 (2)	237	185	222	273	
9 (2)	103				
10 (2)	71				89
11 (2)	15			9	
12 (2)	66	179	111	64	67
13 (2)	12				
14 (2)	5				
15 (2)	3				
16 (2)					
17 (4)					
Total (hrs/ha)	1140	1585	889	1082	646
Area (ha)	.049	.39	.009	.11	.045

TABLE B.8

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO GROUNDNUTS ENTERPRISE, SYSTEM 2, 1980

Labor Periods	Hours per Hectare					
	Average	Field Reference				
		55/7	52/9	41/8	32/4	46/8
1 (18)						
2 (2)						
3 (2)						
4 (2)						
5 (2)	6					
6 (2)	26					
7 (2)	228	538	150	2267		
8 (2)	138			267	27	
9 (2)	32	200		400		274
10 (2)	49	8	75	133		274
11 (2)	22				27	
12 (2)	4					
13 (2)						
14 (2)	202	38	1050	1133	32	390
15 (2)	60				114	
16 (2)	13					
17 (4)						
Total (hrs/ha)	780	785	1275	4200	200	939
Area (ha)	.070	.13	.04	.015	.37	.095

TABLE B.9

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO SOYBEANS ENTERPRISE, SYSTEM 2, 1980

Labor Periods	Hours per Hectare			
	Average	Field Reference		
		48/11	40/6	46/7
1 (18)				
2 (2)				
3 (2)				
4 (2)				
5 (2)	47			
6 (2)				
7 (2)	248		1075	629
8 (2)	211	206		
9 (2)	13		75	321
10 (2)	41			126
11 (2)				
12 (2)	23	175		
13 (2)				
14 (2)	80	69		217
15 (2)	65			
16 (2)	94	28	175	
17 (4)				
Total (hrs/ha)	822	478	1325	1293
Area (ha)	.131	.32	.04	.14

TABLE B.10

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO OKRA ENTERPRISE, SYSTEM 2, 1980

Labor Periods	Hours per Hectare				
	Average	Field Reference			
		52/28	40/5	37/5	52/17
1 (18)					
2 (2)					
3 (2)					
4 (2)					
5 (2)	23				
6 (2)	157		333	133	171
7 (2)	80	104			
8 (2)	113				
9 (2)	53		667		171
10 (2)	83	104		133	
11 (2)	157	62			171
12 (2)	23		167		
13 (2)	17			67	
14 (2)	127	563	167	67	171
15 (2)	50		167	133	85
16 (2)					
17 (4)					
Total (hrs/ha)	883	833	1500	533	769
Area (ha)	.011	.048	.006	.015	.012

TABLE B.11

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO COTTON ENTERPRISE, SYSTEM 2, 1980

Labor Periods	Hours per Hectare		
	Average	Field Reference	
		45/8	52/5
1 (18)			
2 (2)			
3 (2)			
4 (2)			
5 (2)			
6 (2)			
7 (2)	184	300	150
8 (2)	190		229
9 (2)	22		
10 (2)	56		56
11 (2)	273	1443	
12 (2)	22		48
13 (2)			
14 (2)			
15 (2)	25	133	
16 (2)			
17 (4)	32		28
Total (hrs/ha)	804	1776	511
Area (ha)	.277	.21	.50

TABLE B.12

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO S/M/C ENTERPRISE, SYSTEM 3, 1980

Labor Periods	Average	Hours per Hectare		
		Field Reference		
		65/2	82/1	69/5
1 (18)	39		177	28
2 (2)	38	274		35
3 (2)	70		366	55
4 (2)	24			
5 (2)	147			
6 (2)	204	679	763	168
7 (2)	124	48	321	120
8 (2)	136	119	468	37
9 (2)	152	190	361	46
10 (2)	118		395	37
11 (2)	61	60	229	32
12 (2)	23	71	34	
13 (2)	5		86	
14 (2)	28	60		14
15 (2)	29		23	
16 (2)	121	71	214	111
17 (4)	28		366	
Total (hrs/ha)	1347	1571	3803	683
Area (ha)	.707	.419	.524	.926

TABLE B.13

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO MAIZE ENTERPRISE, SYSTEM 3, 1980

Labor Periods	Hours per Hectare			
	Average	Field Reference		
		61/14	83/3	59/4
1 (18)				
2 (2)				
3 (2)	1			
4 (2)	16			
5 (2)	31			
6 (2)	27			50
7 (2)	50	562	56	55
8 (2)	49	812		89
9 (2)	16		71	
10 (2)	34			
11 (2)	9	37		5
12 (2)	20	12	50	25
13 (2)	21	250		268
14 (2)	1			
15 (2)				
16 (2)				
17 (4)				
Total (hrs/ha)	275	1675	175	492
Area (ha)	.431	.08	.28	.23

TABLE B.14

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO GROUNDNUTS/BAMBERA NUTS ENTERPRISE, SYSTEM 3, 1980

Labor Periods	Hours per Hectare			
	Average	Field Reference		
		66/12	68/18	69/9
1 (18)				
2 (2)				
3 (2)	2			
4 (2)	3			115
5 (2)	15			
6 (2)	25			229
7 (2)	73	429	77	179
8 (2)	57	175		40
9 (2)	52	159	19	50
10 (2)	34	349	9	25
11 (2)	23	159		
12 (2)	16			15
13 (2)	29			60
14 (2)	109	32		
15 (2)	21		71	523
16 (2)	10	63		284
17 (4)	11			
Total (hrs/ha)	480	1365	177	1520
Area (ha)	.582	.308	.31	.578

TABLE B.15

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO SOYBEANS ENTERPRISE, SYSTEM 3, 1980

Labor Periods	Hours per Hectare			
	Average	Field Reference		
		64/6	72/12	68/12
1 (18)				
2 (2)				
3 (2)				
4 (2)				
5 (2)	2			272
6 (2)	2			
7 (2)	34	258	994	99
8 (2)	39		110	62
9 (2)	29	545		74
10 (2)	31	136	2017	173
11 (2)	8			
12 (2)	5			
13 (2)	7			
14 (2)	8	15		99
15 (2)	4		138	49
16 (2)	1			
17 (4)				
Total (hrs/ha)	170	955	3260	827
Area (ha)	.494	.466	.149	1.96

TABLE B.16

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO S/M/C ENTERPRISE, SYSTEM 4, 1980

Labor Periods	Average	Hours per Hectare		
		Field Reference		
		91/1	102/13	112/3
1 (18)	2		86	
2 (2)	13			
3 (2)	20			
4 (2)	21	18		7
5 (2)	48		29	
6 (2)	44	18	129	6
7 (2)	198	170	471	145
8 (2)	235	134	329	131
9 (2)	171	177	257	55
10 (2)	243	114	286	124
11 (2)	212		329	57
12 (2)	27		57	
13 (2)				
14 (2)	14		429	
15 (2)	28	16		44
16 (2)	160	108	129	14
17 (4)	2			
Total (hrs/ha)	1,438	737	2529	583
Area (ha)	.766	2.05	.14	.87

TABLE B.17

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO MAIZE ENTERPRISE, SYSTEM 4, 1980

Labor Periods	Hours per Hectare			
	Average	Field Reference		
		105/2	116/2	107/2
1 (18)				
2 (2)				
3 (2)				
4 (2)	3			
5 (2)	40			158
6 (2)	87	30	162	
7 (2)	180	15		167
8 (2)	70	7		63
9 (2)	107		59	
10 (2)	115		59	126
11 (2)	71			506
12 (2)	155	59	176	
13 (2)				
14 (2)	12			
15 (2)				
16 (2)		222		
17 (4)				
Total (hrs/ha)	840	333	456	1022
Area (ha)	.093	.27	.068	.095

TABLE B.18

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO GROUNDNUTS ENTERPRISE, SYSTEM 4, 1980

Labor Periods	Average	Hours per Hectare		
		Field Reference		
		94/7	113/2	101/4
1 (18)				
2 (2)				
3 (2)	3			
4 (2)				
5 (2)	10			
6 (2)	36	73		89
7 (2)	94	55	250	
8 (2)	62	55		
9 (2)	37		83	
10 (2)	80		250	35
11 (2)	17	291		
12 (2)	4			
13 (2)	90	873		
14 (2)	224			53
15 (2)	22			
16 (2)				
17 (4)				
Total (hrs/ha)	679	1345	583	177
Area (ha)	.118	.055	.48	.11

TABLE B.19

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO BAMBERA NUTS ENTERPRISE, SYSTEM 4, 1980

Labor Periods	Hours per Hectare			
	Average	Field Reference		
		110/4	102/7	105/4
1 (18)				
2 (2)				
3 (2)				
4 (2)				
5 (2)	30		326	
6 (2)	140	714		
7 (2)	80		217	103
8 (2)	380	2071	326	68
9 (2)	100	429	217	
10 (2)	50			
11 (2)				
12 (2)				
13 (2)				
14 (2)		1143	2609	547
15 (2)	740			
16 (2)				
17 (4)				
Total (hrs/ha)	1520	4357	3696	718
Area (ha)	.042	.014	.0092	.058

TABLE B.20

FAMILY LABOR PROFILE FOR FIELDS BELONGING TO
OKRA ENTERPRISE, SYSTEM 4, 1980

Labor Periods	Hours per Hectare				
	Average	Field Reference			
		114/4	110/10	107/8	103/5
1 (18)					
2 (2)					
3 (2)	5				
4 (2)	10				
5 (2)	15	167		107	370
6 (2)	33	83	273		123
7 (2)	22	167	182	71	123
8 (2)	12	83		36	123
9 (2)	17	167	91		123
10 (2)	3	83			
11 (2)	3	167			
12 (2)	3	167			123
13 (2)	20	167	273	36	
14 (2)	1				
15 (2)					
16 (2)					
17 (4)					
Total (hrs/ha)	144	1250	818	250	988
Area (ha)	.065	.012	.011	.028	.016

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