IMPROVED SYSTEMS OF RICE FARMING IN ZAÏRE:
A COMPARISON OF UPLAND AND IRRIGATED RICE

By

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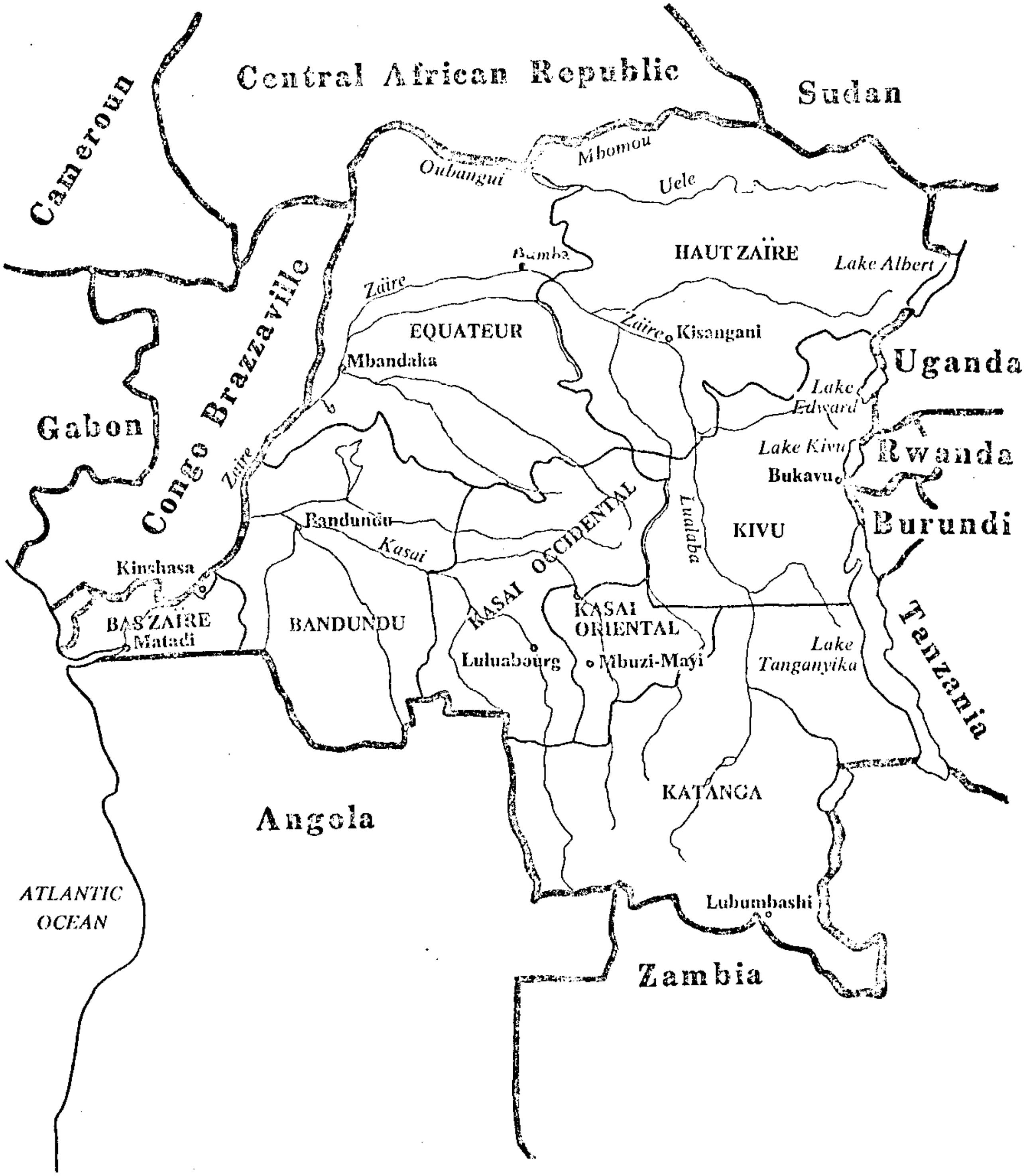
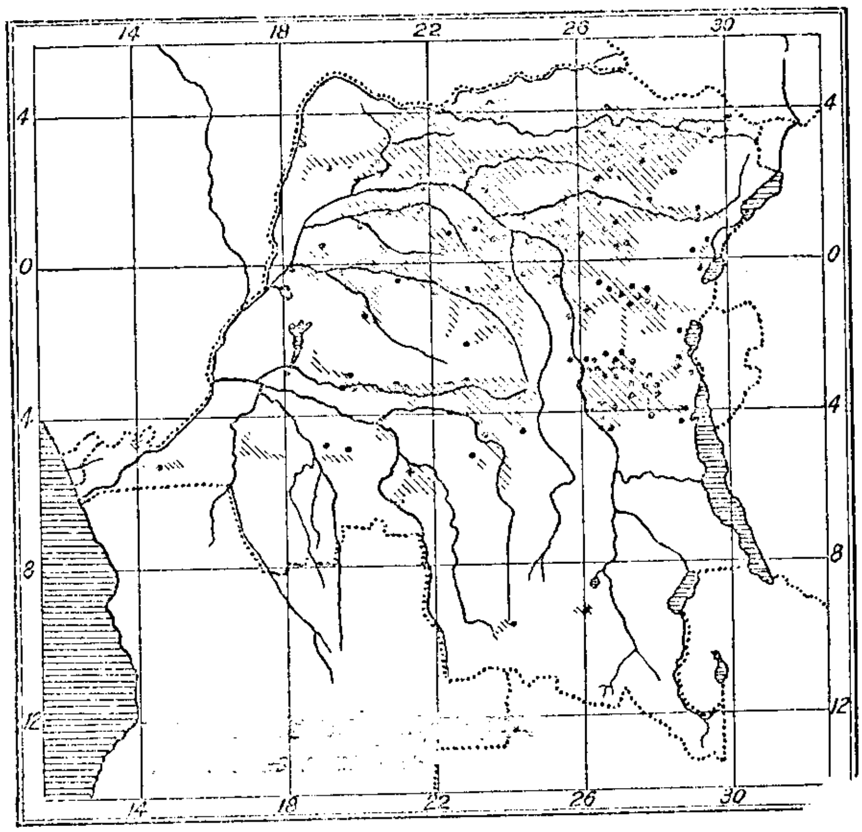


Map 1: Republic of Zaïre, Administrative Organization



Map 2: Republic of Zaïre, Rice Production Zones

INTRODUCTION

Cassava, maize, rice, groundnuts and plantains constitute the main food crops in Zaïre. Rice is a staple food in several regions though its consumption has thus been concentrated in the urban centers. The Department of Agriculture [1975] has estimated that rice consumption increased at an annual rate of 2.1 percent for the 1971-74 period and it has also predicted that this rate may reach 9.1 percent by the end of the decade. One of Zaïre's key problems is to meet its domestic demand for rice.

The government policy of fixing annual hectarage targets for rice and other crops to be achieved through the opening of new land and through exhorting farmers to grow more rice has not succeeded in closing the gap between supply and demand. The focus now is on development programs to increase the commercial production of rice, maize and other major crops. As is the case for most food crops, there is an urgent need for micro-economic research at the farm level to help guide policy makers in increasing rice production.

A generalized introduction of fertilizer and high yielding seeds at the small farm level, the adoption of a mechanical technology and the diffusion of irrigated rice system constitute major elements of improved systems of rice farming being presently contemplated in Zaïre. In contrast with the agriculture of some West African countries, fertilizer diffusion has not yet reached the vast majority of small holders in various regions of Zaïre although they have some use of improved seeds. This paper will first attempt to evaluate the impact of a fertilizer adoption at the small farm level in traditional upland rice farming in the forest zone and later deal with a comparative analysis of an improved upland rice and an irrigated rice farming systems in savannah area where both the objective of increasing rice output and the farmer's revenue are contemplated.

In Chapter I of this paper a description of the present Zaïrean rice economy and its future prospects is given with respect particularly to its place in the food-crop subsector. Then a review of some selected rice studies in Africa is undertaken in Chapter II in order to provide a background from other areas which may be relevant to the Zaïrean situation. Chapter III is devoted to a comparative analysis of four possible systems of rice farming in Zaïre: a traditional upland rice in forest zone with no fertilizer, a hypothetical improved upland rice using fertilizer in the forest zone, an improved upland rice in savannah area with fertilizer and mechanical technology and an irrigated rice system in the same area. Returns per hectare of land, returns to labor and other issues will be analyzed. Finally the implications of the study will be presented in Chapter IV which will terminate with an exploration of research priorities in the food-crops subsector of Zaïre.

CHAPTER I

CURRENT STATUS OF THE ZAÏREAN RICE ECONOMY

Rice in the Food-Crop Subsector

Rice was introduced in Zaïre in the middle of the 19th century from early contacts with Arabs in the North and North-East of Zaïre. By 1920 its cultivation had reached the northern Kasaï where it became a major staple food. Presently about 16 percent of the country's rice is grown in Equateur region and 30 percent in the Haut Zaïre region (see Map 1). Upland rice production has mostly remained in the equatorial and other ecologically suitable forest areas. Other excellent areas of rice production are located in Shaba and Bandundu regions though they are not yet used [TVA, 1975].

The successful introduction of rice in traditional agriculture is due to two factors. First government policy actively encouraged the availability of increased supplies of basic staple foods in order to sustain an increasing demand in the rapidly expanding urban and mining centers. Second and more importantly INEAC[1] engaged in the selection and improvement of rice varieties capable of high yields. The latest selection is R66 variety, still being developed on INERA stations and distributed to farmers. In rural areas rice yields have improved from

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[1] Institut National d'Etudes Agronomiques au Congo created in 1933 and renamed INERA (1971) or Institut National d'Etudes et Recherche Agronomiques.

400-700 kg per hectare to 1,200 kg and above where improved seeds regularly reach the farmers.

Rice is rarely cultivated in pure stands. In savannah areas it often comes in mixture with cassava and maize. In forest areas the composition of the mixture is usually extended to include plantains. Ntamulyango [1975] found that the mixture rice-maize-casava-plantains occupied 26.5 percent of the total crop area in forest zone (Yalibwa). In 1970 rice represented about 4 percent of the total crop hectarage for the country as a whole compared to 13 percent for maize [Kamuanga, 1973]. At 1970's prices rice accounted for 30 percent of the value of food-crops and 8 percent of the total value of crops produced including export crops. However in terms of total output, rice has been rapidly expanding in recent years.

Production and Future Trend

Upland rice cultivation is the common system of rice production in Zaïre. Major zones of production comprise Bumba in the Equateur region, Bengamisa (Haut Zaïre), Lusambo (Kasaï) and Kindu (Kivu). Equateur and Haut-Zaïre regions are the primary suppliers to the Kinshasa market (Map 2).

About 28 percent of Zaïre's rice is grown in the Ruzizi Valley, Kivu region under permanent flooding. Before 1960, this system was undertaken through a reclamation project using irrigation techniques. Van Den Abeele and Vandenput [1956] report average yields of 5,000 kg per hectare when rice cultivation was undertaken under heavy technical supervision and in village agriculture irrigated rice yielded about 3,800 kg per hectare. Currently there are very few farmers using irrigation techniques and the swamp rice cultivation is mostly limited to the Ruzizi Valley area.

Agricultural officials have hypothesized that the lack of interest in irrigated rice was due to the labor intensive method of rice cultivation which is not necessary in a country with abundant arable land while at the same time the cost of installing and maintaining the irrigation infrastructure was also considered too high to justify the adoption of this system. With the land-man ratio becoming lower in some zones of the Bas-Zaïre and Kivu regions as a result of both high rate of population growth and immigration from neighboring countries,[1] it became necessary for the Zaïre's government to envision the introduction of such an intensive system of rice production. This role is now accomplished by the Chinese Agricultural Mission (CAM) under an agreement with the Department of Agriculture to introduce and diffuse the irrigation system in rural areas where upland rice is less suitable. Since 1966-67, the CAM has introduced irrigated rice at Bumba, Equateur region and at Mawunzi, Bas-Zaïre and there seems to be a growing optimism from the pilot projects as exemplified by an increasing number of requests on the part of farmers to get their irrigated area expanded further [Tshingomba, 1976].

The total rice production in 1975 amounted to some 221,000 metric tons of paddy, i.e., 133,000 metric tons of clean rice at a 60 percent conversion rate. An additional 25,000 metric tons were imported bringing domestic consumption to around 158,000 tons of rice. Annual importations have also averaged 25,000 metric tons of clean

[1]Mostly from Angola and Rwanda-Burundi.

rice for the last four years [Départment de l'Agriculture, 1975] which roughly amounts to $7.5 million loss at 1975 world prices.

The 1970 govenment census showed a Zaïre population of 21.6 million; with a 2.8 percent per year growth rate, it is estimated that the population will reach 28.5 million in 1980. A 6 percent per year growth rate in urban centers is projected until 1980. Income elasticity estimates for cereals (rice and maize) range from 1.2 in the low income group, 1.2 to 0.9 in the middle income group and 0.7 to 0.2 in the upper income group, the average being around 0.84 [TVA, 1975]. With the above information and hypothesizing a 1.5 percent increase in per capita income, the TVA estimates indicate that rice needs would amount to 328,900 metric tons of clean rice in 1980 (i.e., 11.5 kg per capita) if the 1970-74 trend continues. The Department of Agriculture projections of rice production for the 1977-80 period which take the expansion of irrigated rice into account are shown in Table 1 below. More than 500,000 metric tons of paddy is expected to be produced on an expanded

Table 1. Projections of Rice Production 1977-1980

		Area (ha)	Production (Tons)	Yields (T/ha)	Number of Rice Farmers
1977	Rain fed	310,000	310,000	1.0	620,000
	Irrigated	10,000	40,000	4.0	50,000
	TOTAL	320,000	350.000	--	670,000
1980	Rain fed	390,000	429,000	1.1	780,000
	Irrigated	20,000	120,000	6.0	100,000
	TOTAL	410,000	549,000	--	880,000

SOURCE: Départment de l'Agriculture - Kinshasa, 1975.

area and an ever increasing number of rice growers. If such objectives are realized domestic needs for rice would be more than satisfied leaving an exportable surplus. This would require on the part of the Government tremendous efforts in extension and an intensive resource mobilization for rice production.

There is now a growing awareness that increases in rice production as well as in other food crops will not always be sustained through opening of new areas and an increase in the number of rice growers. The traditional sector which provides about 3/4 of the basic food stuffs has to increase its productivity if it is to keep up with structural changes in the country. The introduction and the adoption of fertilizer and improved seeds at the small farmer level is a contemplated government objective particularly in view of the fact that Zaïre while possessing one of the largest agricultural potential in tropical Africa is, however, the smallest consumer of fertilizer with less than 1 kg per head compared to over 10 kg per head in most West African countries [Tollens, 1975].

Most economic research on rice production in Africa has been conducted in West Africa. The next chapter is a brief review of some of these rice studies in order to provide some basic comparable data and achievements in terms of policy objectives in countries where efforts to expand production have already been undertaken.

CHAPTER II

REVIEW OF SELECTED RICE STUDIES IN AFRICA

Technical Change in Perspective

For most low income countries an important component of development programs is the aim at increasing output per unit of input (land, labor). This conceptually can be achieved either through (a) reshuffling production resources within a given production possibility curve, (b) the use of added resources or (c) by shifting the production surface. T.W. Schultz's thesis of "efficient but poor" farmers is now being questioned by some authors including E. Clayton [1961] and empirical evidence contradicting it has also appeared in D.K. Dessai [1973][1] thus indicating that possibilities may still exist in a traditional farming for optimal allocation of resources that would increase profit. The third possibility namely shifting of the production function will be explored as relevant for changes proposed in this paper. The shift of the production surface occurs by changing the parameters of the production function through a technological change involving the introduction of new inputs or the combination of existing inputs in so far an unknown way.

To follow Hayami and Ruttan [1971] technology in agriculture can be separated into two kinds: labor-saving and land-saving. A

[1]Dessai [1973] using a LP approach showed that traditional farmers in West India allocate resources inefficiently.

mechanical technology is labor saving and designed to facilitate the substitution of power and machinery for labor, while a biological chemical technology is land-saving and designed to facilitate the substitution of labor and/or industrial inputs for land. From these definitions it is clear that in countries such as Zaïre where the price of labor is low and the price of machinery high, there should be little economic incentive for large-scale mechanization of field operations, though small scale mechanization may be profitable. The leading force in greater use of mechanical equipment in agriculture, it is recognized, was the drive to reduce labor costs.

Improved seeds, fertilizer, water control (as an important element of the irrigation technique) constitute a group of inputs being contemplated for rice farming development in Zaïre and which fall broadly in the category of biological-checmical technology. One of the advantages of land-saving technology is that it does not lead toward a radical reorganization of the agricultural production systems as would a generalized mechanical technology. In addition the fertilizer component of a biological-chemical technology presents the characteristic of being a divisible input such that farmers with limited capital may purchase only enough of it for a light application to part of his land. If returns are higher the farmer would increase his average rate of application year after year, plowing back the returns into wider application until he reaches the optimum level of application.

Some features of the African agriculture may make the adoption of a land-saving technology questionable. In fact as land-labor ratio in Africa and Zaïre in particular is very high and capital use minimal, labor becomes the dominant factor of production. A biological chemical technology though land-saving, may be appropriate in such a situation because of the seasonal nature of the labor constraint: increases in output per hectare may largely exceed increases in labor requirement at the peak-season thus making the technology relatively labor saving.

The implication for efficiency, output, employment, and income distribution of new and alternative technology packages have never been the object of detailed studies in the republic of Zaïre. As in Nigeria, Ghana, Sierra Leone, Liberia in West Africa Zaïre has the urgent need for microeconomic research for all food production systems to help guide government agricultural policy.

Some Results from West Africa

Rice has become one of the most studied single food crops in Africa and an abundant literature on the economics of rice is building up. This chapter will briefly review some comparative data for the traditional, semi-traditional and improved systems of rice production especially as they refer to labor requirements and economic returns. Alternative policies for increasing rice production pursued in some West African countries will be estimated. Because of the difficulty of dealing with intercropping it is assumed that data refer to both rice as a major crop in a mixture and as a single crop where pure stands will be mentioned.

Rice production systems can be classified into five broad categories: (1) The traditional upland rice is a rain-fed system with no requirement for standing water. It is the most widespread among African small holders and the least productive in terms of yields per unit area. The age of bush cleared for upland rice cultivation varies between regions, but it takes in general 7 to 10 years for soil fertility to be restored. In forest zones, the average age of the fallow is 10 to 15 years. (2) Upland rice cultivation can be improved with fertilizer and high yield seeds. Mechanical technology can also be introduced though it is difficult to adopt it for bush or forest fallow agriculture. (3) Rice is also grown under different flooding conditions. Bottomland rice in northern Ghana is still a rain fed system with water standing in the field for some period during the planting season. A detailed description of this system is given by Winch [1976]. Swamp rice cultivation is undertaken in a lowland usually saturated with water from a river flood. Both systems are traditionally tilled with no water control. (4) With fertilizer, improved seeds, mechanical operations and water control, rice production under flooding conditions will constitute a fourth system usually more productive than the rain fed system in terms of yields per unit area. (5) Irrigated rice using fertilizer and improved seeds is a fifth system recently being promoted in tropical Africa under Chinese and AID schemes. This system offers higher yields per acre and the possibility of two crops per year.

In his study[1] of Sierra Leone rice farmers Spencer [1975] has shown that the average traditional upland rice farmer cultivates about 0.85 to 2.22 hectares depending on the region and soil conditions. In four enumeration areas the labor requirement on the average amounted to 247 man-days per hectare of which 29 man days were hired labor. Harvesting was found the most labor demanding (63 man-days per

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[1]All comparative data have been directly converted to the metric system, yield in kilogrammes per hectare, and returns will be commonly expressed in dollars (U.S.) per hectare.

hectare) followed by weeding (37 man-days). Where soils were good and pest control effective the highest yield was found to be 1,420.3 kg per hectare in one enumeration area. The gross margin[1] per hectare in five enumeration areas was respectively $19.90, $23.43, $54.13, $45.20 and $54.33 though this included in each case the value of other crop sales (13 percent of value of rice produced), rice being a major crop in the mixture. Assuming a zero opportunity cost for land, Spencer estimated that the highest return to family labor and management per man-day was $0.79 in one enumeration area; the lowest amounted to $0.28 in another area.

Spencer and Byerlee [1976] in a more recent survey compared labor utilization and yields in rice production under traditional and improved technologies in Sierra Leone. The results are shown in Table 2.

The IADP package of fertilizer, seed and water control was used for improved swamp rice cultivation. This system has the highest labor use per hectare though the yield is about 30 percent higher than traditional swamp and is twice that of traditional upland rice. In their enterprise budget the five systems were ranked for the gross margin per acre as follows: $113.63 for the improved swamp, $103.51 for traditional swamp, $57.86 for traditional upland. In the Bolilands, mechanical and hand cultivation systems, respectively had $57.09 and $56.21 in gross margin indicating no significant differences. These returns have been calculated with subsidized prices of fertilizer and mechanical ploughing. Returns to the limiting factor, family labor, have shown a different pattern: $0.14 for traditional swamp, $0.11 for

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[1]Converted from 1 Leone = $1.10 at 1974-75 equivalence rate.

Table 2.[a] Labor Input and Yields in Sierra Leone Rice Production Systems

	Labor Input Per Hectare (in man-hours)			Yield
	Family	Hired	Total	kg/ha
IADP[b] Area				
1. Traditional Upland	2,184	148	2,354	896
2. Traditional Swamp	1,722	96	1,818	1,415
3. Improved Swamp	2,779	632	3,441	1,947
Bolilands				
4. Hand Cultivation	667	116	783	964
5. Mechanical Cultivation	378	99	477	1,132

SOURCE: Spencer and Byerlee, American Journal of Agricultural Economics, December 1976.

[a]Converted to per hectare.

[b]Integrated Agricultural Development Project

improved swamp, while traditional upland had the lowest return per man-hour of family labor ($0.06). The adoption of fertilizer, seeds and water control has resulted in increased returns to land, but because of the added labor required, returns per unit of labor are lower than under traditional swamp cultivation systems. When unsubsidized costs are used, the gross margin per man-hour did significantly change only in the Bolilands: mechanical cultivation which previously yielded the highest return per man-hour[1] ($0.37) of all the systems was ranked as

[1]Spencer and Byerlee reported that this was also partly due to a higher level of fertilizer application than was the case for hand cultivation in Bolilands.

low as the traditional upland ($0.07). Spencer and Byerlee thus concluded that neither the biological chemical technology of the IADP area nor the mechanical technology of the Bolilands was particularly successful as measured by returns to the limiting factor--labor. In other comparison, the improved swamp system has the highest cost of production[1] ($0.03 per lb. of rice), followed by traditional upland in the IADP area and mechanical cultivation of the Bolilands ($0.02 per pound). The cost of production was $0.013 for the hand cultivation system of Bolilands while the lowest cost was found for the traditional swamp ($0.01 per pound).

There are few West African countries where mechanization efforts in agriculture have been so intensely pursued as in Ghana. State farms in Ghana constitute now a known experience in mechanization undertaken in the 1960s together with the opening of new land through government tractor-hire services in an attempt to expand domestic food production.

Winch [1976] has examined costs and returns of six alternative rice production systems in Ghana: (I) farmers hiring tractor services and using traditional seeds; (II) tractor hire system and improved seeds; (III) tractor hire and mixed varieties (i.e., improved and traditional); (IV) tractor owners using traditional seeds; (V) tractor owners with improved seeds and (VI) upland rice farming system with bullock plow and traditional seeds. The first five systems refer to bottomland rice farming in northern Ghana. Table 3 summarizes Winch's characterization of the six rice production systems as it refers to labor utilization and returns using farmer private costs (financial analysis).

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[1]Subsidized at 67 percent for fertilizer and 85 percent for mechanical ploughing with hired labor and a 20 percent opportunity cost in interest charge.

Table 3.[a] Summary of Budget Enterprises of Six Alternatives Rice Production Systems in Northern Ghana

Production Systems / Characteristics	I Tractor Hire Trad. Seeds	II Tractor Hire Improved Seeds	III Tractor Hire Mixed Seeds	IV Tractor Owned Trad. Seeds	V Tractor Owned Improved Seeds	VI Bullock Plow Trad. Seeds
Average farm size (Ha)	5.18	8.58	6.84	16.84	48.30	0.41
Percent mechanically harvested	20	14	3	12	77	0
Mean labor use (man-h/ha)	286.5	255.9	543.4	219.3	93.4	1,563.5
Yields (kg/Ha)	1,050.8	1,252.9	1,677.4	1,313.6	1,434.8	1,515.7
Capital-labor ratio	1.9	3.8	2.0	4.4	8.5	0.4
Gross income ($ per farm)	694.78	1,371.30	1,464.35	2,821.74	8,838.26	104.65
Gross margin ($ per farm)	277.32	375.65	706.96	1,010.00	3,417.30	64.09
($ per hectare)	53.54	67.09	103.36	60.00	70.75	156.31
Net return per family labor[b]	0.23	0.51	0.30	0.88	2.57	0.11
Financial cost of production ($ per ton)	115.65	97.4	95.65	97.4	90.43	156.65
Economic cost of production ($ per ton)	143.48	150.43	122.61	143.48	167.83	180.00

SOURCE: F. Winch [1976].

[a]Data have been converted to per hectare basis; currency exchange rate: cedi 1.15 = $1.00

[b]At subsidized costs.

Fertilizer was used in all six systems with however different rates of application in each case. For all the systems, harvesting was the most labor demanding activity with 70 percent of total labor per hectare on the average; this is due to the mechanization of cultivation. The traditional upland with bullock plow (system VI) had the highest cost of production ($155.65 per ton) which is due to the large quantity of labor input for this system (the opportunity cost of family labor made up 57 percent of total cost) (p. 84).

A comparison of net returns per man-hour of family labor using private costs reveals also that system VI has the lowest return. For all bottomland systems (I to V) this return was higher than the average wage rate paid to hired labor thus indicating as Winch asserts that there was little financial advantage in family member seeking wage employment on other rice farms. The combination of other characteristics and efficiency measures finally reveals that system III of tractor hire and mixed seeds was the most profitable (the highest yield per hectare, the lowest economic cost per ton and a relatively higher gross margin).

There are few studies to date on the economics of irrigated rice in tropical Africa. Recent experiences with Chinese scheme have not yet been the object of detailed studies to evaluate financial and economic returns. However, the possibility of achieving higher yields and performing two harvests in one crop year constitute the main advantages of irrigated rice. In Gambia, the Chinese mission helped bring 2,500 acres of irrigated rice under cultivation from 1966 to 1971. A brief description of the Chinese irrigated rice project in Gambia is given in an IBRD appraisal report of the Agricultural Development

Project (pp. 8-9). Farmers cultivate about one acre of rice and do most of the leveling and bund construction by hand with only a small amount of final land clearing done by tractor. Farmers are also provided with improved seeds in the first year and every second year thereafter at a rate of 45 to 56 kg per hectare and nearly 500 kg of compound fertilizer is applied per hectare.

It is also reported that labor requirement to develop and cultivate one acre of rice under the Chinese scheme evolves as follows: 100 man-days for initial land clearing and leveling, 30 man-days for land preparation, 5 man-days for nursery, 20 for transplanting, 15 for weeding and fertilizing and 20 for harvesting and threshing. With a 6 hour man-day rate used in the Gambian project, the total labor allocation per hectare can be converted as follows:

	First Year	Subsequent Year
-- initial land clearing and leveling	1,482	
-- land preparation	444	741
-- nursery	74	148
-- transplanting	296	593
-- weeding and fertilizing	222	444
-- harvesting and treshing	296	593
TOTAL	2,814	2,519

The total labor input is reduced to 2,520 man-hours during successive campaigns as there is no longer need for larger labor input in initial field work and other activities increase their labor input.

Typical costs and returns per hectare[1] for swamp rice and irrigated rice were also compared. In Table 4 below, an enterprise budget for swamp rice is compared with an irrigated rice using data from the 1972 crop pattern in Gambia.

In other comparisons of different rice production systems, Van Santeen [1975] has asserted that traditional upland and swamp rice cultivation in Liberia require the same amount of labor day per acre, 84 and 80 days respectively (197 and 207 per hectare) with land development operation included. He also showed that irrigated rice requires about 20 percent more labor compared to rain fed cultivation (70 and 57 man-days per acre respectively); this is due to additional labor use in nursing and transplanting. His estimates of yields and variable costs per acre are converted to metric system in Table 5.

A general pattern can be drawn from the above case studies (and in fact for much of the literature not cited here) that yields per hectare generally increase with the importance accorded to the water element and yields are higher for an improved rice farming system compared to a traditional system. There is in general a lot of variation in labor use between different systems of rice production. This is due to the kind of technology adopted (labor saving and/or land saving technology) while the average farm size and the difference in labor between farms of similar size also contribute to the wide variation of labor use among different systems. However, for improved systems with a higher degree of mechanization, the labor input per hectare is substantially lower compared to systems with little emphasis on

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[1] Converted from a one acre basis.

Table 4. Enterprise Budget for Swamp and Projected Irrigated Rice Plan Agricultural Development Project--Gambia

	Swamp Rice	Irrigated Rice
Labor input	1,495.3 man-hr.	2,520 (man-hr.)
Cash cost[a]	0	\$ 85.80
Yields	909 kg/ha	7,859.1 kg/ha[b]
Gross income	\$ 44.1	\$ 478.15
Gross margin (per ha)	\$ 55.1	\$ 392.35
Gross margin per man-hr. of family labor	\$ 0.037	\$ 0.16

SOURCE: IBRD, International Development Association, Agricultural Development Project, Gambia, 1972.

[a]Cash costs have been converted into dollars (U.S.). (The 1972 conversion rate was 1 dalasi = \$0.52.) They include the cost of sprayers, thresher, pump spare pieces and repair, fuel, fertilizer, pesticide plus an additional charge for the demonstrator.

[b]The yield was about 7,000 lbs. per acre for one crop season.

Table 5. Yields and Variable Cost Per Hectare of Different Rice Production Systems in Liberia

Rice Production Systems	Yields (kg/ha)	Variable Cost (\$/ha)
Traditional upland	1,122.7	3.50
Traditional swamp	1,571.8	10.00
Improved upland	2,245.5	31.00
Improved swamp	2,337.7	250.00
Irrigated rice	3,929.5	500.0

SOURCE: C. E. Van Santeen [1975].

mechanical operations. Winch's system V of tractor-owners using improved seeds and combine harvesters (77 percent of the cultivated area) had the lowest man-hours of labor input per hectare (see Table 3). Mechanical cultivation in Sierra Leone's Bolilands was the least labor intensive of all the five systems (see Table 2).

Estimates of returns to man-hour of family labor constitute a good measure of efficiency between different systems of rice production. In comparing the irrigated rice to traditional swamp rice for Gambia's Agricultural Development Project, it was shown that the former had a return to man-hour four times higher than the latter (Table 4). In fact increases in yield per hectare and hence in gross margin outweighed the relative increase in per hectare labor requirement for irrigated rice. Returns to labor for a mechanical cultivation system and a hand cultivation system in Sierra Leone's Bolilands was higher in the former case partly because fertilizer application was higher on mechanical farms [Spencer and Byerlee, 1976]. In all cases, however, traditional upland rice has shown the lowest return per man-hour though sometimes it has presented a higher gross margin per unit of land area.

The case studies in Ghana and Sierra Leone also revealed two critical elements for the economic analysis of different rice production systems. The degree of combine harvesting and its influence on the capital intensities of alternative rice production systems in Winch's study was determinant in the evaluation of economic costs per ton as a measure of efficiency. On the other hand government subsidies for fertilizer and mechanical ploughing in Sierra Leone partly explained the non-success of biological and mechanical technologies when measured by returns to labor.

Policy Objectives and Production Strategies

The above technical results have to be completed with outcomes of different production strategies undertaken in the framework of specific policy objectives pursued by African Governments in agriculture. African governments are giving high priority to agriculture in order to gain self sufficiency in food production. Increased food production can be obtained through the opening of new land since Africa generally has an abundance of land. Hence more attention is being given to mechanization to overcome seasonal labor bottlenecks. Many authors including Clayton [1971], Winch [1976], Byerlee and Eicher [1972], Green [1971] have agreed that Government policy in Africa of encouraging farmers to expand farm size with the adoption of subsidized capital intensive and labor saving production practices results in artificially high incomes that do provide incentives to farmers though distortion of factor prices through duty-free machinery and fuel imports, credit at low or negative real interest rates make these production systems uneconomic from the national point of view.

Another issue usually raised refers to the trade off that occurs in contrasting a small-scale versus a large-scale production system in Africa. In his study of six alternative rice production systems in Ghana, Winch [1976] has compared one small-scale, labor intensive production system to a large-scale, capital intensive system. His results showed that in both approaches, returns to management from a financial point of view were high and costs of production were the lowest of all systems studied. From an economic point of view, however, capital requirements and costs of production were lower for the small-scale production system than they were for the large-scale system thus indicating that the small scale approach was more profitable.

An attempt will be made in the coming chapter to analyze different rice production systems in Zaïre on the basis of available data. The study is not aimed at drawing conclusions, rather at providing a background for suggesting policies to improve the economics of rice farming and identification of urgent areas of future research.

CHAPTER III

IMPROVED RICE FARMING IN ZAÏRE: FERTILIZER INTRODUCTION FOR UPLAND RICE AND THE IRRIGATED RICE SYSTEM

Different rice production systems can be defined on the basis of the technology used and ecological conditions in Zaïre: (1) traditional and improved upland rice systems in forest zones, (2) traditional and improved upland rice in savannah areas, (3) swamp rice[1] production and (4) the irrigated rice system when water is mechanically supplied. An attempt is made in this chapter to put together comparative characteristics of the economics of rice at the farm level for alternative production systems through the use of a partial budget analysis.

Economics of a Traditional Upland Rice Farming in Northern Zaïre

This section is essentially drawn upon a set of primary data from a one year cost-route survey of rice farmers of Yalibwa village, Haut Zaïre region during 1974-75. The survey was organized by the department of Agricultural Economics, Yangambi at the Faculty of Agriculture, National University of Zaïre and partly served as a framework for senior students' theses. This author participated in the groundwork of the survey and occasionally visited Yalibwa as the survey went on.

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[1]This system will not be covered in this study for lack of data.

Source of Data

Yalibwa is among the best rice producing villages of the Turumbu Collectivity and most of its farmers are members of the great Cooperative of Turumbu where they sell their rice produce. Yalibwa also serves as a multiplication site for the development of INERA selected rice varieties.

A systematic sample of 20 rice farmers was obtained from the cooperative membership list of 220 farmers of which three were dropped. Activity recording was done by two enumerators who interviewed farmers at least twice a week. All farmers retained in the sample did not use hired labor though mutual help between families was common at peak season.

Field acreages were measured for all sampled farmers. Ntamulyango [1975] found that on the average most farmers had two fields though some farmers claimed more fields than they actually owned. Enumerators recorded the number of hours of labor worked on a particular task. Some farmers had their children record work information on a form provided by enumerators. Men, women and children's labor were separately recorded.

The yield plot method with crop density counts helped estimate yields. Density squares were $9m^2$ for rice, $25m^2$ for maize, groundnuts and other annual food crops, $200m^2$ for cassava, plantains and other pluri-annual crops. Also recorded were the distance travelled by farmers from their residences to fields, the family composition, crop mixtures per farm as well as relative densities of individual crops.

Rice Farming in a Forest
Type Agriculture

Crop farming at Yalibwa exemplifies the traditional forest agriculture. The climate is classified as Af Köppen type with average temperature of about 25.5° C and an annual precipitation averaging 1,835 millimeters. A short dry season from late December to early February separates the two rainy seasons: the first runs from September to December, and the second with less precipitation starts in March to reach its maximum in May.

The agricultural calendar as described by Tshibaka [1975] displays the staggered nature of agricultural activities in a traditional farming system such as at Yalibwa. January, February and March because of low precipitation are devoted to field preparation activities with tree felling usually undertaken by men the most labor demanding activity. The field burning period usually extends from March through April when the debris are dry and before the soil becomes too wet in May. Seeding is done from April to September depending on the success and the rapidity with which field burning has taken place. Sometimes extended delays in getting seeds explain latter sowing activities usually resulting in low yields particularly for rice. Seeding is mainly done by women. The first weeding occurs at three weeks after rice plants have emerged and in general weeding and crop maintenance extend from May to July and may be repeated thereafter as the need occurs though from August to September weeding is usually done for the benefit of cassava and plantains.

Rice is planted in April-May and ripens in August-September when harvesting begins. Harvesting is continued to December and January. Maize has also the same vegetative cycle with however a shorter harvest period. Because of its perennial nature on the fields, plantain planting and harvesting is continuous throughout the year. The same is also true for cassava.

It is difficult to dissociate rice from other crops because of the intercropping practice. Ntamulyango [1975] has noted a total of 15 different crops grown on fields at Yalibwa of which rice, maize, cassava, plantains remained the most important and commonly found. Other crops grown were yams, sugarcane, sweet potatoes, cucumber, coffee, palm tree, etc. Rice is essentially grown as a cash crop. The average fallow age is about 8 to 10 years in the region [Jurion and Henry, 1967].

Characteristics of the Rice Enterprise

Different aspects of the economics of rice farming at Yalibwa have been compiled from this sample.[1] Tshibaka [1975], looked at labor utilization, Ntamulyango [1975] explored the intercropping pattern while Ngoy [1976] provided a detailed study of the capital input. The following analysis constitutes an effort to put together all the information related to the rice enterprise. It has not been possible to check the accuracy of all the information; however my acquaintance with the surveyed area and personal understanding of some cultural practices have helped correct some figures which appeared inconsistent.

Fields and Average Area Cultivated

Only five farmers out of 18 surveyed had three crop fields. The average is reported to be two fields per farmer for the village in general. The first field usually is planted to rice, maize and other annual food crops and generally is taken as the unit from which crops can be sold. The second field represents a subsistence unit that is

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[1]Senior theses, Départment d' Economie Agricole, Université National du Zaïre, Yangambi.

mostly planted to cassava and plantains. The average distance separating the residence and the farmers' field n°1 was found to be 831.9 m travelled in an average 11.52 minutes while the second was located at an average distance of 1,159.5 meters and reached after 1.56 minutes on the average (see Appendix A). I have not counted the time spent to get to the fields as part of labor input for two reasons: (1) to avoid the problem of its allocation between crops and activities and (2) the average of 15 minutes is a negligible magnitude relative to the man-hour unit.

The total crop area for each farmer was measured; this is approximately the farm size if one neglects the area planted to minor and occasional crops. The data reveal that the average crop acreage was 12,148 m^2 or 1.21 hectares with a standard deviation of 0.77 ha. The average area planted to rice amounted to 2,184.85 m^2 or about 0.22 hectare with a s.d. of 0.16 ha. The relative size of the rice enterprise was estimated by relating it to the total crop acreage for each farmer. The results show that for the sample as a whole 16.7 percent (s.d., 7.2) of the crop area was planted to rice by each farmer (Appendix B).

Intercropping is so widely practiced that it is often difficult to find single crop fields in the northern region. Ntamulyango [1975] estimated the relative importance of different crop mixtures found in the sampled area. 46.56 percent of total crop mixtures were occupied by cassava and plantains mixtures which are in fact subsistence crops for the region. The relative importance of other crops is shown in Table 6.

Table 6. Relative Share of Crop Mixtures on Fields at Yalibwa

Mixtures[a]	Percentage
R + B	46.56
R + M + C + B	26.45
R + B + M + C	7.69
M + C + B	6.83
R + C + B	5.77

SOURCE: Ntamulyango, 1975.

[a]From left to right in order of their relative density: R = rice; M = maize; B = plantains; C = cassava.

Individual crop hectarages were estimated from a procedure that takes into account the relative importance of a crop in field with mixed cropping. Following ONCDE [1968], Ntamulyango [1975] used the following approach:

$$S_i = S \frac{a_i}{\sum_{i=1}^{n} a_i}$$

in which S_i = area planted to crop i

S = total area occupied by the crop mixture

a_i = coefficient of soil utilization for crop i and a_i is defined as the ratio $\frac{d_i}{D_i}$ where d_i is the density of crop i per unit of area in the given crop mixture and D_i is the density of crop i when planted in pure stands. There are n different crops in the mixture. This formula has some merits and can be justified in comparison with other approaches to the intercropping problem.[1] Estimates of individual crop areas on sampled fields are provided in Appendix A. The area cultivated to maize appeared the lowest of all crops grown which reflects the minor role that maize plays either as a cash crop or a dietary staple for the Turumbu. As expected cassava and plantains account for a large part of crop acreages at Yalibwa.

Average Yields Per Hectare

Rice outputs per farm are given in Appendix C. When converted to per hectare basis, the average yield of the sample was 1,678.6 kg per hectare (s.d. = 607.3). The relatively high yield at Yalibwa can be explained by the availability of improved seeds provided by INERA and a possible upward bias from density plots estimates. In villages where there is no access to INERA selected seeds, farmers use their own seeds taken out of previous harvest. The poor quality of seeds in general gives yields of only about 1,000 kg per hectare.

The low standard deviation for the average yield at Yalibwa clearly reveals that individual values were more concentrated about the mean. It can be said in general that average characteristics of rice farming will differ a little across farms as the system of shifting cultivation with modest capital being used by farmers does not present wide variations in resource use and product combination.

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[1]A detailed discussion of intercropping in Africa is provided by D. W. Norman [1971].

Labor Use

Labor input measurement constitutes a main feature of cost-route surveys in traditional African farming because the land input can be measured once and the capital input is usually very low. The labor input in this survey is expressed in man-hours of work. Following Tollens [1975] an appropriate conversion scale for the forest zone should give equal weight for men's and women's labor because the adult female is as efficient as the male in performing physical work in forest agricultural activities. Hence I utilize a weight of 1 for both adult male and female labor. On farms where children's[1] hours of work were reported I corrected their labor input using a 0.5 scale for conversion in man-hours. The details on labor input per farm, crop grown and activity are shown in Appendices C through F. Table 7 gives the summary of labor allocation per activity per hectare.

Table 7. Average Labor Input Per Hectare Rice Enterprise--Farm as A Whole (man-hour per Ha)[a]

Rice Enterprise	Field Preparation	Sowing	Weeding[b]	Harvesting	Post harvest	Total
	292.7 (45.5)	1,007.6 (780.3)	1,187.7 (455.7)	837.8 (636.8)	170.8 (144.9)	3,496.6
Farm	Field Preparation	Agricultural Activities			Post harvest	Total
	277.8	1,833.8			68.6	2,180.1

SOURCE: Calculations (Kamuanga)

[a]Standard deviations in parantheses.

[b]Include crop maintenance.

[1]Are considered as children, all youngsters between 7 and 15 years of age.

Total labor input on each farm is allocated between field preparation, agricultural activities (i.e., the sum of seeding, weeding and crop maintenance and harvesting time) and post harvest treatment (Appendix C). The sum of individual figures is divided by the total area planted to crops and adjusted to a per hectare basis to obtain average data.[1] The results in Table 7 show that the labor input amounted to 277.8 man-hours per hectare for field preparation, 1,833.8 man-hours per hectare in agricultural activities and only an average of 68.6 man-hours per hectare was devoted to post harvest treatment of the produce. The overall average labor input was 2,180.1 man-hour per hectare per farm. However labor input per hectare for all crops are not useful in showing the relative labor intensity of one enterprise compared to other enterprises.

Although data on labor input in seeding, harvesting and post-harvest treatment were available per crop [Tshibaka, 1975] I felt uneasy interpreting per crop labor input for field preparation and weeding as a global figure evenly allocated to each crop. Hence I allocated the global figure in proportion to the estimated hectarage planted to each crop under the simple assumption that weeding and land preparation were in proportion to the area of that crop. Corrected per crop figures are shown in Appendix D for all farmers.

Weeding, followed by harvesting constitute the most labor demanding activities. In forest agriculture, the rapid rate of weeds regeneration and the traditional method of hand and machet weeding make labor inputs in weeding the largest of all field activities. The

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[1]Standard deviations cannot be calculated using this approach.

labor input will also be a function of the vegetative period and the area planted to each crop. Harvesting time is also made longer because crops are harvested as they ripen, thus necessitating frequent visits to the fields. Jurion and Henry [1967] concede that in forest zones, farmers stagger the work of the harvest by spreading the sowing over a fairly long period. In the savannah zones harvesting methods are similar but the work is completed more quickly particularly for maize, rice and other grain crops because the possible sowing season is shorter.

Post harvest operations have the lowest labor input of all activities per farm and per crop. For rice the work mainly refers to threshing and winnowing. The number of man-hours of post harvest treatment is also reduced because of numerous cases where no data was reported on this activity (Appendix D). In Table 7 the average labor input per hectare of rice enterprise is higher than the overall average labor input per hectare for all crops grown on the average farm, thus indicating that farmers at Yalibwa devoted relatively more of their labor to grow rice than they did on the average for all crops considered. This can be partly explained by the fact that the rice enterprise demands more labor for harvest and post-harvest operations than other crops.

Capital

In a traditional agriculture capital is usually restricted to reproducible resources whose indirect usage in production activities contributes to the farmer's revenue period after period. In current usage however the word capital in a traditional agriculture is limited to production tools that are either on-farm produced or acquired from the outside market.

Ngoy [1976] used the same sample of rice farmers to assess capital input. He counted a total of 496 different tools used in agricultural and related activities. However the value of agricultural tools at their market price amounted to only $13.17. A straight line depreciation allowance for these tools was estimated at $3.91 per crop year. As the capital tools can be used for different crop enterprises at the same time, it is difficult to estimate its appropriation for each crop taken individually.

Gross Margin Analysis for the Rice Enterprise at Yalibwa

As rice constitutes the main cash crop, estimates of return from the rice enterprises will constitute a large portion of the total farm gross margin. The approach will use average farm data because as mentioned above, there is not too much variation in resource use among farmers in a given traditional agricultural environment when capital use is of little economic importance.

Gross margin analyses excluded fixed costs of production which in this case refer mostly to the capital-tools and farm's small equipment. I have already shown that the annual depreciation of capital is small and these tools can be alternatively used for different crops making it difficult to allocate the capital charge to any particular enterprise. Except for a few densely populated areas with a land shortage problem, land has no market price in most parts of Zaïre territory. As far as agricultural production is concerned land acquisition price and salvage price are both zero. For these reasons, returns to land, family labor, management and working capital becomes returns to family labor, management and working capital.

As fertilizer and other model inputs are still not used at Yalibwa, the only variable costs are labor and seeds. Direct data on rice seeds quantities per farm were not available. I then utilize the INERA recommended quantity of 30 kilogrammes of seeds per hectare for the average farm. Seeds were provided at a price of 10 K (Makuta) per kilogramme. The price of rice used in 1975 was 8K per kilogramme of paddy. Estimates of returns are shown in Table 8 where monetary units are expressed in dollars.[1]

The results in Table 8 reveal that at current farm gate price of $93.60 per metric ton of paddy and despite a relatively higher yield per hectare, farmers at Yalibwa have a negative return to management and capital on their rice enterprise. The opportunity cost of $11.7 per man-month is apparently the lowest wage in most parts of the Haut-Zaïre region. The cost of production ($104/ton) is the ratio of total variable cost of production to the output. It also constitutes a measure of efficiency that will be compared to other rice production systems to be considered later in this paper.

Impact of Fertilizer Introduction in Traditional Rice Farming in the Forest Zone

The importance of the diffusion of a fertilizer technology in traditional farming has recently been recognized in Zaïre. Historically fertilizer use has been limited to plantation agriculture in European hands and in agricultural experimentation. Recent implementation and reactivation of some large scale government owned agricultural projects

[1]The 1976 conversion rate was 1 Zaïre (=100K) = 1.17 U.S. dollar (Zaïre Magazine, March 1976).

Table 8. Gross Margin Analysis: Average Farm at Yalibwa (per ha) (average size of rice enterprise: 0.22 ha)

			Value
Gross value of output:			
Average yield (kg/ha)	:	1,679	
Price per kg	:	9.4¢	
Total value	:		$ 157.15
Variable costs			
Seeds (kg/ha)	:	30	
Price per kg	:	11.70¢	
Total value			$ 3.51
Family labor (man-hours/ha)			
Field preparation		292.7	
Seeding		1,007.6	
Weeding		1,187.7	
Harvesting		837.8	
Post-harvest		170.8	
Total		3,496.6	
Gross margin:			$ 153.64
Return per man-hour of family labor			$ 0.044
Cost of production ($/ton) at $0.049/man-hr.[a]			$ 104.
Return to management and capital			$ -17.69

[a]There is practically no hired labor in farm activities at Yalibwa. I assumed an opportunity cost of Z10 per man-month for family labor. This is the wage commonly paid to a non-fed domestic servant at Yangambi and Ngazi. Hence for a 8-hour work day, a man-hour would be charged 4.9¢.

has created a strong need for diffusion of fertilizer at the farm level. In fact in some project areas such as Gandajika, Kasai Oriental, an increasing demand for fertilizer has been reported. The main difficulty in getting fertilizer to the small holder is its high cost relative to prices of agricultural products and this may explain in part the decrease in the level of usage from 20,000 metric tons in 1971 to 11,000 in 1974 [TVA, 1975] while world price of fertilizer also increased in this period. In areas where fertilizer has been introduced, no attempt has been made to assess private and economic costs for the individual small holder.

In this section an attempt is made to evaluate the probable effect on returns of a fertilizer introduction in traditional rice farming in the forest zone. A partial budget approach will be used on the basis of the average farm data from our survey. Some elements of the following analysis such as average physical data on yields and labor inputs are realistic while others including opportunity cost of labor are essentially estimated in order to make the analysis more complete. In general budgeting consists of projecting the costs and the returns associated with a particular adjustment into the future and calculating the probable effect on net earnings of the individual or average farmer. The real job therefore is one of making more accurate predictions.

Proposed Changes

Few data are available on response of rice to applied fertilizer in Zaïre. In 1958 at INEAC-Yangambi fertilizer application in controlled experimentation gave the results shown in Table 9.

Table 9. Rice Response to Fertilizer - INEAC - Yangambi 1958

Trial	Rough rice kh/ha
No fertilizer	2,036
100 kg triple sup-phosphate + 10.5 kg N[a]	4,017
65 kg ammonium metaphosphate	4,217
75 kg calcium metaphosphate + 10.5 kg N	4,298

SOURCE: TVA, 1975

[a]As ammonium sulfate 21-0-0

Recently most experimentations at the farm level on the package fertilizer-improved seeds have been conducted by the "Programme National Maïs" in various zones of the Shaba region. For rice there has only been scattered trials around the country all showing yield improvements as a result of fertilizer introduction but still performed under direct technical supervision (e.g., Mawunzi, Bas-Zaïre).

Yield response would be difficult to isolate if rice is still grown in an intercropping pattern with other crops even when improved seeds are used, because other crops will also benefit from fertilizer application. Let us assume for the purpose of analysis that rice will be planted in pure stands on some parts of the farmers' fields.[1]

Following TVA [1975] I assume that 30 kg of N and 30 kg of P_2O_5 will be used per hectare of the planted area. With the R66 variety the

[1]A complete conversion of all their fields to pure stands of rice would be a drastic step in a traditional agriculture. This would also assume that all crops have some fertilizer response.

expected yield increase per hectare will be in the order of 600 kg of rough rice.[1] This is an acceptable rate of fertilization that can be initially adopted by farmers.

Partial budget analysis involves two major steps: identification of added receipts and reduced costs on the revenue side, and identification of added costs and reduced receipts on the expenditure side. In exploring these steps, I shall introduce and explain some basic concepts usually ignored in partial budgeting.

Added Receipts

The first concept in relation with added receipts is the net yield[2]. This is defined as the measured yield per hectare in the field minus harvest and storage losses. I have taken the sample yield average of 1,679 kg per hectare as a gross yield for the Yalibwa rice farmer. With an estimated increase of 600 kg per hectare, the gross yield will amount to 2,279 kg. There will be losses at harvest and storage estimated at about 8 percent [INEA, 1958]. The field price of output is defined as the value to the farmer of an additional kilogramme of rice in the field prior to the harvest [CIMMYT, 1975]. In practice it is taken as the market price minus storage and transportation cost per unit of output. The farm gate price of rice is ¢9.4 (8K). Assuming that there are no significant cost per kilogramme of paddy before it is sold, the farm gate price of ¢9.4 is a net field price as well. The product of net yield and field price

[1]Each kilogramme of N and P_2O_5 would increase rice yield by 10 kg per hectare.

[2]For practical purposes however comparisons here will only refer to gross yields.

constitutes the gross field benefit. As paddy straw, whose production would increase as a result of fertilizer application, has no economic value to the farmer, the gross field benefit only comes from the grain.

Added Costs

The first category of costs to be incurred is an increased labor requirement for different activities. It is unlikely that sowing time will be significantly increased as a result of fertilizer use and for practical purposes I assume no change in labor input for weeding. The application of fertilizer will take approximately 10 man-hours per hectare. With an increase in output, the increase in labor requirement at harvest time is obvious. With 36 percent increase in rice output the additional labor requirement at harvest time will increase by about 22 percent per hectare.[1] I maintain the same percentage increase for post-harvest treatment. Hence the increment would amount to 184.3 man-hours for harvesting activity and 37.6 man-hours for post-harvest operations.

The next category of variable cost is the cost of fertilizer itself at the farm level. It can be estimated from the price of fertilizer such as practiced at the delivery port of Lisala, Equateur region on the Zaïre River. Sources of nitrogen and phosphates are urea and diamonium phosphate respectively. TVA [1975] estimates of prices on per nutrient basis range as follows: \$0.36/kg for N and \$0.26/kg for P_2O_5. After adjustment for transport cost Lisala-Yangambi

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[1]In his budget for fertilizer use on upland rice in Sierra Leone, Spencer [1975] estimated that farmers would use half a man-day per acre to apply fertilizer and 40 percent more labor at harvest time to harvest an additional yield increase of 65 percent (p. 37).

and Yalibwa, it is likely that these prices would average \$0.41/kg for N and \$0.29/kg for P_2O_5. Using these unsubsidized prices the total cost per hectare of paddy is estimated at \$21.00. This constitutes the field price of fertilizer. I have not assumed a significant change in the quantity of seeds required so that its cost would remain unchanged.

Summary and Partial Budget

In Table 10, returns to family labor, management and working capital are assessed using the above assumptions on possible outcomes of a fertilizer use for upland rice. As expected the gross margin per hectare is higher and returns to management and working capital show a significant improvement over the without fertilizer case. The increase in output is however counterbalanced by an increase in total labor requirement per hectare such that the gross margin per man-hour does not show a large improvement. A direct implication of this comparison is that the producer price for rice though recently increased from 4K to 8K per kg ought to be increased further to provide a secure margin for the use of fertilizer.

It is not possible to consider all the changes that are likely to happen as a result of fertilizer use. It is recognized that disregard for some details has been an important factor in explaining the non-adoption of technologies promoted as being profitable [CIMMYT, 1975]. In areas where there are no available off-farm employment, the opportunity cost of family labor may be lower, but it is never equal to zero. The opportunity cost is an important element in the estimation because the value in terms of money as a cost to the farmer may include

Table 10. Rice Enterprise Budget With Fertilizer Use at Yalibwa

			Value
Grass field benefit			
Average gross yield (kg/ha)	:	2,279	
Field price per kg	:	9.4¢	
Total value	:	21,422.60¢	$ 214.23
Variable costs			
Seeds (kg/ha)	:	30	
Value (11.7¢ x 30)			$ 3.51
Fertilizer (per ha)			
30 kg N ($12.30) + 30 kg P_2O_5 ($8.70)			$ 21.00
Labor (man-hours)			
Field preparation	:	292.7	
Seeding		1,007.6	
Weeding and fertilizing		1,197.7	
Harvesting		1,022.1	
Post harvest		208.4	
TOTAL		3,728.5	
Gross margin (per ha)			$ 189.72
Gross margin per man-hour			$ 0.051
Return to management and capital[a]			$ 7.02
Cost of production (per metric ton of paddy)			$ 91.00

[a]Assuming an opportunity cost of $0.049 per man-hour.

his subjective valuation of the additional pain in undertaking the task himself. In general high opportunity costs of farm labor and scarce financial resources are also major constraints that may result in low rates of adoption of any new technology.

In Section 4 a similar analysis is undertaken in comparing an improved upland rice farming and the irrigated rice system in a savannah zone of Zaïre. Section 5 will synthetize the four different systems of rice farming.

The Irrigated Rice System versus Improved Upland Rice Farming at Mawunzi, Bas Zaïre

As pointed out earlier in this study the need for an expansion of irrigated rice farming in Zaïre was not strongly felt until recently because of the relative land abundance and the belief that upland rice of the forest zones would sufficiently cover domestic needs. In 1966 however Zaïre signed a contract with the Chinese Agricultural Mission (C.A.M.) for the introduction and diffusion of irrigation technology in regions such as Bas-Zaïre with rising population density. There has already been at Mawunzi, Bas-Zaïre an appropriate agricultural infrastructure[1] on which to base a pilot rice project. Fertilizer and mechanical services were already introduced in an upland rice development project.

The adoption of irrigated rice has followed a successive number of steps. Initial infrastructure was financed by the Government through the services of the center. Tractor services, fertilizer and pesticide are also provided on a subsidized basis. All subsidies will

[1] Existing since the establishment of a paysannat settlement under G.E.R. (groupe d'Economie Rural) back before 1960.

be progressively removed as farmers become capable of supporting the total cost of irrigated rice.

Current Standing

Experimental trials by the CAM[1] in 1967 for irrigated rice resulted in average yields of 6 to 7 metric tons per hectare with the use of Chinese varieties (Taichung 65, Tainan 5, and IR 8) [Department of Agriculture, CAM, 1975].

Currently the program supervises some 130 farmers in Zamba and Kiloanga villages on a total area of 43 hectares of irrigated rice. Each farmer is accorded one or more 10-are plot of which he holds a property right. As for upland rice, subsidized tractor services, fertilizer and pesticide are also provided to farmers who in turn are required to deliver in kind 30 percent of their harvest in partial payment of all services. These include mechanical ploughing, harrowing and levelling and maintenance work for the irrigation infrastructure.

Upland Rice and Irrigated Rice Systems: Costs and Returns

My source of data for this evaluation has come from the 1975 annual report of the Department of Agriculture, Zaïre, a three month socioeconomic survey[2] of irrigated rice at Mawunzi by Tshingomba [1976], various documents on the agriculture of the region as well as my personal judgment.

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[1]Formerly with the Taiwan Mission was handed over to People's Republic of China in 1973.

[2]Unpublished senior thesis, Department of Agricultural Economics, Yangambi-Zaïre.

Upland rice cultivation in savannah area of Bas-Zaïre suffers from scarcity of water supply especially when the dry season (June-September) takes longer than usual. This is also one of the reasons which motivated irrigation trials in that region long before 1960 [Vandenput and Van Del Abeele, 1956]. From 1968 to 1973 average yields have remained stable in all neighboring villages (Appendix G). The calculated average yield was 2,304 kg per hectare. This figure is taken as the average yield at the farm level. Only two villages, Zamba and Kiloanga, are involved in irrigated rice farming. An arithmetic mean from averages of two time series of annual yields from 1968 to 1975 will serve as the average farm yield. The average at Zamba is 4,279.93 kg per hectare (s.d. = 372.9) and the average at Kiloanga over the same 7 year period is 4,145.70 (s.d. = 446.26). My test of the null hypothesis $\overline{X}_1 - \overline{X}_2 = 0$ against the alternative $\overline{X}_1 - \overline{X}_2 \neq 0$ was not rejected at the 5 percent level ($Z = .845 < 1.96$). Hence the arithmetic mean of the two averages of 4212.8 kg/ha is as representative as each of them. Clearly irrigated rice yields are twice as high as upland rice in village agriculture where both farming systems are subsidized. Tshingomba [1976] asserted that for 8 years however averages yields in both cases have not improved at all which he attributes to soil conditions, seed degeneration and perhaps a lack of aptitude on the part of farmers to adequately perform all required tasks for an improved farming system.

In the following analysis, I have assumed that the farmer would pay the totality of variable costs for his rice enterprise. As labor requirements were not available for both systems I have used approximative figures based on similar rice production systems in

West Africa. For upland rice labor input estimates for harvest and post harvest activities amount to about 1130 man-hours per hectare and 80 man-hours per hectare for weeding, seeding and ferilizing.[1] Land preparation is included in the total cost of the tractor hire services. For the irrigated rice figures on labor inputs per activity are taken from the Gambian Agricultural Development Project [IBRD, 1972].[2] Estimates of total labor requirements per hectare amounted to 120 six-hour man-days when land preparation is not included.

The actual cost of tractor, fertilizer and pesticide services of which farmers partially pay 30 percent in kind from the harvest [Tshingomba, 1976] is detailed for each case in Table 11. Labor is charged $0.33 per man-day at the CAM center. This is taken as the opportunity cost of family labor ($0.041 per man-hour).

A complete enterprise budget is shown in Table 11. The gross value of output for the irrigated rice system approaches twice that of upland rice as a result of a significant difference in yields. The gross margin per hectare constitutes the returns to land, family labor, management and capital because land has an opportunity cost in a region such as Bas-Zaïre. The analysis would be more complete however if depreciation and interest charge on the irrigation infrastructure as

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[1] F. Winch's study of 14 upland rice farmers in Northern Ghana using bullock plow shows an average of 457.1 man-hours per acre for harvest activities (hand harvesting (p. 76). On farms using tractor hire, improved seeds and combine harvesting (System II), the mean labor input for weeding, seeding and fertilizing was 31.8 man-hours per acre (p. 65).

[2] "Projected costs and benefits of developing and operating one acre of irrigated rice" were based on the Chinese scheme of irrigated rice in Gambia. Agricultural Development Project (1972).

Table 11. Estimates of Costs and Returns for Upland and Irrigated Rice Systems, Case of Mawunzi (per ha)

Improved Upland Rice		Irrigated Rice	
Family labor (man-hour)		Family labor (man-hour)	
Pre-harvest activities (seeding, weeding fertilizing):	80	Nursery	148
Harvest activities (threshing, winnowing, and post-harvest treatment):	1,130	Transplanting	593
		Weeding and fertilizing	447
		Harvest activities	593
TOTAL	1,210	TOTAL	1,781
Operating expenses (per ha)		Operating expenses (ha)	
Labor service; 114 man-days x $0.33	$ 37.62	Labor service	$ 37.62
Tractor services; ploughing ($7.99) + harrowing ($3.43) + line making $(2.28) TOTAL	13.70	Tractor services; ploughing ($7.99) + harrowing ($3.43) + leveling $15.91) TOTAL	27.33
Pesticide	1.17	Pesticide	1.17
Fertilizer (150kg x $0.41)	61.50	Fertilizer (150kg x $0.41)	61.50
Bags and bagging (40 x $0.29)	11.60	Bags and bagging (70 x 0.29)	20.30
Seeds (70kg x $0.177)	8.19	Seeds (60kg x $0.117)	7.02
TOTAL Operating costs	$134.78	TOTAL Operating costs	154.94
Gross value of output (2,304kg x $0.094)	$216.57	Gross value of output (4,212 x 0.094)	$396.00
Returns to land, labor, management and capital	81.79	Returns to land, labor, management and capital	241.06
Gross margin per man-hour	0.068	Gross margin per man-hour	0.135
Returns to land, management and capital (at $0.041/man-hour)	32.18	Returns to land, management and capital (at $0.041/man-hour)	168.04
Cost of production (per ton of paddy)	80.00	Cost of production (per ton of paddy)	54.1

well as maintenance charge could be obtained. In that case, difference between returns for the two systems would be less.

Comparison and Appraisal of the Four Systems of Rice Production

This section puts together the findings of my analysis of the four alternative rice production systems in two different ecological zones of Zaïre. The discussion will mainly concern their alternative costs and returns under the set of assumptions presented above. A summary of costs of production and returns for all four rice production systems is provided in Table 12.

Table 12. Summary, Costs and Returns of Alternative Systems of Rice Production in Zaïre

	I	II	III	IV
Average yield (kg/ha)	1,679	2,279	2,304	4,213
Average labor input (man-hour/ha)	3,496.6	3,728.4	1,210	1,781
Pre-harvest	2,488.0	2,498.0	80	1,188
Harvest and post-harvest	1,008.6	1,230.4	1,130	593
Gross income ($/ha)	157.15	214.23	216.50	396.00
Gross margin $ per ha	153.64	189.72	81.79	241.06
$ per man-hours	0.044	0.051	0.068	0.135
Returns to management and capital ($)	-17.70	7.03	32.18	168.04
Unit cost of production ($/ton)	104	91.00	80.00	54.1

The traditional system (I) of upland rice farming in forest zone was analyzed using sample data from a survey of Yalibwa rice farmers. Though the results apply only to one village, it is my contention that the main features of this system have been reflected. The total labor input per hectare is close to 3,500 man-hours with weeding and crop maintenance being the most labor demanding activity (34 percent of total labor input). Kline, C. K. et al. [1969] have also recognized this as a constraint limiting the area that can be effectively cultivated by the small holder in equatorial Africa. The average yield per hectare of 1,680 kg of paddy is relatively high but can be attributed to the use of improved seeds (R66) provided by INERA. In comparison with data from West Africa, Spencer and Byerlee [1976] estimated that traditional upland rice in Sierra Leone required 2,354 man-hours per hectare (Table 2) with an average yield of about 900 kg of paddy per hectare. Traditional upland rice in Liberia yielded about 1,200 kg of paddy per hectare [Van Santeen, 1975] (Table 5).

Return to family labor, management and capital was $154 per hectare and 4 cents per man-hour. With an opportunity cost of 4.9 cents per man-hour of family labor, return to management and capital was negative (-$17.70). With the same opportunity cost the unit cost of production amounted to 10 cents per kg of paddy or $104 per ton.

For the contemplated improved upland rice (II) in forest zone, there is no doubt that labor requirement especially at harvest and post harvest time will increase. My approximation comes close to 3,730 man-hours per hectare in total labor input. With an estimated gross yield of 2,279 kg of paddy per hectare, the gross margin would be improved by about 20 percent ($190) with the return per man-hour of family labor showing a 14 percent improvement over the without fertilizer case (5.1 cents and 4.4 cents per man-hour respectively). With the same opportunity cost as before, return to management and farmer's capital have shown a significant improvement from $-17.70 to $7.03. The cost of production per ton of paddy decreases slightly to $91 compared to $104 for System I. A tentative conclusion here is that the adoption of a fertilization rate of 60 kg of N-P_2O_5 per hectare would, at current prices of fertilizer and paddy, result in an increase in the gross margin per hectare and large improvement in return to management and capital with relatively minor change to the return per man-hour and the unit cost of production.

Finally an improved upland rice with mechanical services, fertilizer and pesticide (III) was compared to the irrigated system (IV) in a savannah zone of Zaïre. The idea was to assess the relative merits of both the introduction of tractor hire services and the irrigation technology. My assumptions on labor requirement per hectare were 1,210 man-hours for the upland rice and 1,781 for irrigated rice. By all efficiency measures, and using unsubsidized costs,[1] the irrigated rice system performs better than upland rice. The gross margin is positive and the highest of all four systems. Return per man-hour has significantly improved, 14 cents per man-hour and 6 cents for the upland rice. Return to land, management and capital is about six times higher for

[1]Tshingomba [1976] reports that farmers are required to pay in kind 30 percent of their harvest in partial payment of tractor service, fertilizer and pesticide, thus implying that farmers who grow irrigated rice cover 77 percent of their operating expenses, while upland rice farmers cover only 47 percent (i.e., they are subsidized at 53 percent of their operating costs).

the irrigated system than upland system ($168 and $32) and the unit cost of production is $54 per ton, the lowest of all four systems.

The apparent profitability of the irrigated rice over upland systems however should be weighted to the social cost of irrigation infrastructure financed by the government. But the possibility of two crops a year will double the gross margin and the return to management, capital and land, which is a real advantage as far as the farmer is concerned.

CHAPTER IV

SUMMARY--IMPLICATIONS OF THE STUDY AND POSSIBILITY OF FUTURE RESEARCH

This study was initially designed to evaluate, using a partial budget approach, the impact of a fertilizer adoption in a primarily traditional rice farming in northern Zaïre. With the availability of some secondary data on rain fed and irrigated rice at Mawunzi, Bas-Zaïre, the paper was reoriented toward a comparative economic analysis of current and prospective rice production systems. This chapter is aimed at drawing some of the implications of the findings of the study and I shall also explore areas for further research in this domain.

Summary

In Chapter I a review of the rice economy in Zaïre was undertaken to stress the importance of that cereal as a dietary staple food. Rice consumption has been increasing at an annual rate of 2.1 percent and with an expected Zaïre population around 28.5 million in 1980 and a 6 percent per year growth rate in urban population, it was estimated that domestic rice needs would rise to about 330,000 metric tons for a 1.5 percent increase in per capita income.

Chapter II introduced the economics of rice at the farm level by reviewing some selected rice studies in West Africa where that cereal has long been a major food crop. The different case studies referred to Sierra Leone [Spencer, 1975 and Spencer and Byerlee, 1976] Ghana [F. Winch, 1976], Liberia [Van Santeen, 1975] and the Gambia [IBRD, 1972]. It was shown in most cases that rice yields per hectare generally increase with the importance accorded to the water element and also that yields are higher for an improved system than a traditional one. Although there is some variation in total labor input, labor use per hectare was substantially lower on farms with high degree of mechanization. Returns per man-hour and cost of production constituted good criteria for efficiency measure. In general returns per man-hour were lower for the traditional upland system and increased from the improved swamp rice to the irrigated rice system. In regard to production strategies and policy objectives, the Ghanaian experience confirmed the view that subsidized capital-intensive and labor-saving production systems were uneconomic from the national point of view and in contrasting small-scale and large-scale production units, the former was shown to be economically more profitable.

Chapter III constituted the core of this paper. In section 1, an economic study of a traditional upland rice system in forest zone provided basic data upon which a budget was constructed to assess the impact of a possible fertilizer adoption in traditional farming. The rest of the chpater was an attempt to compare on the basis of costs and returns the merit of the four rice production systems as they were defined. The comparison between traditional upland and a contemplated improved system using fertilizer in northern Zaïre showed a 19 percent increase in gross margin for the latter. In the first case return to management and farmer's capital was negative after an opportunity has been assigned to family labor while the difference was less pronounced for return to man-hour. Tractor services, fertilizer and pesticide are provided to farmers for both the irrigated and upland rice in neighboring villages of the Mawunzi Center, Bas-Zaïre. Unsubsidized costs are used and with my assumptions on labor input per hectare in both systems, the irrigated system turned out to be the most profitable of all systems as long as the irrigation infrastructure remains a cost to the government.

Implications of the Study

Some primary data from a small sample of rice farmers at Yalibwa, Haut-Zaïre and a set of secondary data on rice farming at Mawunzi, Bas-Zaïre have constituted the basic sources of information from which this study was derived. It is hence very premature to draw up general conclusions concerning alternative rice production systems in Zaïre. The following implications have thus to be regarded as suggestive views on increasing rice production in Zaïre.

Upland rice is the most common system of rice production in Zaïre and its potential is very great. If yields are generally low in village agriculture (750 kg to 1,000 kg/hectare) as a result of poor quality of seeds, the example of Yalibwa (above 1500 kg/ha) and other zones that can be reached by INERA is quite convincing of the necessity of supplying farmers with improved seeds in traditional farming. If data on response of upland rice to fertilizer could be made available for various areas, yield increases can be expected even where local varieties are used.[1] As pointed out in Section 1 of Chapter III

[1] In Sierra Leone, fertilizer demonstrations results of yield responses on upland rice when traditional varieties were used showed increases in yields from 30 to 70 percent at different rates of application in various regions [Spencer, 1975].

fertilizer is a divisible input and farmers with capital limitation may well purchase initially just enough for a light application; further increases in returns will permit him to reach optimal doses of fertilizer that will increase his returns even more. In order however to get farmers to adopt fertilizers and improved varieties, the Government of Zaïre will need to direct more resources for upland rice farming.

The relative merits of irrigated rice are already recognized: yields per hectare could go as high as 4,500 kg, and the possibility of two crops per year (though this is also theoretically possible for upland rice in equatorial forest zones; Van Den Abeele and Vandenput, 1956). The Government of Zaïre will have to balance the social cost of subsidized extended irrigation infrastructures at the farmer level and the annual cost of rice imports. In 1975 however only 10,000 metric tons of rice were imported compared to 25,000 metric tons average of the 1971-74 period [USDA, 1976]. This may be suggestive of the impact of recent development programs to increase the commercial production of rice.

With current structure of rice production assumed stable at least in the short run and fertilizer prices less susceptible to a decrease, the government-fixed farmgate price of rice remains one of the variables that can be manipulated. My estimates of costs and benefits indicate that a farmgate price increase from the present 8 makuta to 9 makuta per kilogramme (9.4 to 10.5 cents) would be sufficient to turn return to management and capital for the upland rice at Yalibwa (I) from $-17.70 to a positive $2.30. Returns in other systems would be improved even more. Producer prices of most agricultural products in Zaïre have always been kept low to preserve the purchasing power of urban consumers and this cannot encourage the much-needed production for the market. Recent action of the National Cereal Office (ONACER) in raising the minimum farmgate price for maize from 8 to 15 makuta per kilogramme [USDA, July 1976] ought to be extended to the rice subsector as well. On the other hand substantial hikes in farmgate prices of paddy would certainly result in higher prices of clean rice in urban centers, a situation that usually facilitates competition with imported rice.[1] A downward trend in world prices of rice begun in 1974. The estimated average price was $315 per ton (1975) in government to government contract [FAO, 1976] and expectations were for $206 by February 1976. On per kilogramme basis, these are competitive prices for domestic clean rice traded in Zaïre's urban centers at about 29 cents (25 makuta)[2] per kg [Tshingomba (p. 53), 1976].

Research Priorities in the Food-Crop Subsector and Rice in Particular

There are few African countries where the need for agricultural economics research is so acute as in the republic of Zaïre. Since agriculture has become the "priority of priorities,"[3] conception and implementation of a sound agricultural development policy increasingly depends on the availability of research data from various subsectors of agriculture. Agricultural economic research areas in the Zaïrean

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[1]Tollens and Kamuanga [1974] looked into the mechanism by which farmgate price increases result in higher competition of imported and domestic grains for the maize subsector.

[2]A producer price of 8 K per kg of paddy is equivalent to 12 K per kg of clean rice for a 2/3 conversion rate thus indicating that the marketing margin is very high in urban centers trading.

[3]President Mobutu's speech, December 5, 1972, Kinshasa.

food-crops subsector have been recently identified by some authors including Jurion and Henry [1967], Tollens [1973], Perrault [1973], Miracle [1966] and Linsenmeyer [1974]. This last section explores some of the research needs in the short and intermediate run for the food-crops subsector and its rice component in particular. It will terminate with a brief outlook of the rice study which the author proposes to undertake in northern Zaïre.

(a) Farm level microeconomic data are urgently needed for all basic staple foods particularly maize, rice, cassava and plantains. These will include labor allocation and other input combinations on farms, revenues and expenditures, current production techniques, local prices and market practices, etc., all of which are necessary in designing optimal production systems and appropriate pricing policies for each basic food crop.

(b) For rice as a staple food and following the scheme presented in this paper, different systems of production as defined in Chapter III can be investigated to reveal their relative economic profitability at the farm level and more importantly their relative merits as to which system can be pushed forward at low cost to increase the rice output at the national level.

(c) A whole farm approach is also preferable in different agricultural zones of Zaïre particularly where it is not possible to single out a major economic crop. In this respect data needs would comprise estimates of input-output coefficients, factor proportion ratios, crop combinations and other descriptive material on the farming pattern, economic and social constraints. Such information is helpful for a better understanding of farmers' decision making process and for planning the reallocation of existing resources. Analyses of crop mixtures, improved seeds and fertilizer response studies, possibilities of price responses can also be investigated to complete whole farm research results.

(d) In a country such as Zaïre any effort to increase market supplies of agricultural commodities has to be coupled with realistic attempts to improve the efficiency of the marketing system for both farm products and farm inputs. Since 1960 Zaïre has experienced considerable changes in the ownership and orientation of its agricultural marketing systems with consequences on the reliability and the stability of performance standards of the system. Data are hence needed on transportation costs, handling and transit costs, pricing, marketing margins and competition. Income elasticities for demand in the subsector of basic staple foods need also to be estimated in order to guide future production decisions and for planning.

Fertilizer plays an important role for the future of Zaïrean agriculture. Data are therefore needed on the mechanism underlying fertilizer pricing in order to reduce their cost at the small farmer level. For the past few years in fact, high import prices, high transportation costs and unfavorable commodity pricing and taxation have contributed to make fertilizer use uneconomic at the small-holder level.[1] The structure and the organization of the delivery system need also to be reviewed for detection of its outstanding deficiencies.

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[1]A detailed study by TVA (USAID) on the possibility of building a fertilizer production plant in Bas-Zaïre was completed in 1975. This is a major step being considered in order to reduce fertilizer cost and imports.

(e) Other areas of urgent research are found at the macro-economic level. Pricing and trade policies in general, the structure of import duties, quotas, taxation and related legislation affect the development of the food-crop subsector and rice in particular. Alternative policy measures and their consequences ought also to be examined in order to assess their ultimate results at the national level.

Among research alternatives explored above, one of the most critical priorities is the issue of whether the Government of Zaïre should pursue its efforts in exapnding the irrigated rice technology at the small holder level or exploit the great potential represented by upland rice development in forest zones if improved technology could be successfully diffused. This writer proposes to examine in more details the consequences of two such production policies through a comparative economic analysis of irrigated rice and upland rice production systems in the equatorial zone of northern Zaïre. A certain number of visits at Bumba, Equateur will be needed to collect reliable primary and secondary data on irrigated rice development. The writer also proposes to extend the Yalibwa experience to a limited number of rice producing villages in Equateur or Haut-Zaïre region.[1]

Finally in exploring the economics of upland rice production system in forest zone, consideration will also be given by this writer to a reassessment of the intercropping pattern[2] as to contribute to our better understanding of farmers' decision making process and more

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[1] Details on survey methodology, sampling and analytical techniques will be explored in a forthcoming research proposal by this author.

[2] Idem for intercropping analysis.

importantly to improve our approach in evaluating labor and other inputs allocations per enterprise in a crop mixture pattern of farming.

Summary

Through a partial budget approach with available and assumed data, this paper has shown the need for and the importance of various micro-level data for an in-depth study of rice farming systems in Zaïre. Our brief exposé of short-run research priorities implicitly reveals the importance of joint micro and macro-level studies for future development in the cereal subsector and the opportunities these studies can provide to policy makers in guiding their decisions.

APPENDICES

APPENDIX A

Area Planted (square meters)

Farm	Distance--Residence --Fields (m) (minutes)				Field Areas				Area Planted to Each Crop			
	01 dist.	time	02 dist.	time	01	02	03	Total	R	M	B	C
02	87	2	1,478	24	R+M+B 1,782.5	C+B 8,210.0		9,992.5	825.30	319.07	7,046.04	1,802.09
04	607	19	1,364		R+M+B+C 13,050	C+B 6,757.5	B+M+R+C 7,637	27,444.5	5,841.15	2,417.78	10,116.081	9,069.481
05			688	9	B+R+C 4,305	C+B 5,972.5		10,277.5	1,851.15	--	3,527.98	4,898.36
06	564	8	18	1	B+M+C 3,505	3,255		6,760.0	--	918.94	2,809.53	2,056.33
07	1,092	15	987	12	B+M+R+C 17,485	C+B 18,740		3,6225	5,997.355	524.55	16,617.35	13,085.74
08	991	12	946	13	B+M+R+C 9,955	C+B 7,387.5		17,342.5	3,265.24	736.67	6,501.35	6,839.24
09	248	5	102	2	B+M+C 4,560	C+B 1,335		5,895	--	638.40	2,299.03	2,957.57
10	1,027	13	896	12	B+M+R+C 4,737.5	C+B 3,807.5		8,545	1,369.138	1,203.325	4,062.38	1,910.16
11	938	16	1,125	13	R+B+M+C 4,640	C+B 4,916.9		9,456.9	1,936.81	342.16	4,763.35	2,414.50
12	1,862	28	1,152	14	B+M+C 2,910	C+B 7,158.5	B+M+R+C 1,042.5	11,111.0	505.61	256.44	7,438.88	2,910.07
13	1,002	10	981	12	B+M+R+C 3,982.5	C+B 3,807.5		7,790.0	1,266.43	103.54	5,075.71	1,344.31

APPENDIX A (Continued)

Farm	Distance--Residence --Fields (m) (minutes)				Field Areas				Area Planted to Each Crop			
	01 dist.	time	02 dist.	time	01	02	03	Total	R	M	B	C
14	964	13	1,904	24	B+M+R+C 4,432.5	C+B 4,647.5	B+R+C 575	9,653.00	2,391.62	487.57	3,451.318	3,324.488
15	1,262	14	1,986	27	B+M+F+C 3,902.5	C+B 4,937.5		8,840.00	920.99	359.03	4,183.88	3,376.10
16	1,018	14	2,103	28	B+M+F+C 4,667.5	C+B 7,805		12,472.5	2,063.03	452.75	6,596.271	3,360.447
17	799	10	2,045	27	B+R+C+M 2,907.5	C+B 4,245	M+B+C 900	8,052.5	1,197.89	184.63	5,224.81	1,445.18
18	614	10	732	13	C 2,625	C+B 4,895	R+C+B 5,245	12,765.00	1,594.48	--	5,496.27	5,674.25
19	480	6	1,582	25	B+M+R+C 6,715	C+B 1,535		8,250	3,001.605	611.06	2,709.42	1,927.9
20	1,000	10	803	7	R+C+M 2,145	C+B 5,640		7,785.00	928.78	332.47	3,760.18	2,763.6
Averages	831.9	11.52	1,159.5	15.6				12,147.99				
Standard deviation	393.4	5.4	612.8	9.04				7,768.23				

SOURCE: Field Survey, Ntamulyango and Tshibaka, 1974-75. Yalibwa, Zaire

R = rice; B = plantains; M = maize; C = Cassava

APPENDIX B

Relative Size of the Rice Enterprise

square meter (m^2)

Farm	Area Planted to Rice	Total Area Cultivated
02	825.30	9,992.5
04	5,841.15	27,444.5
05	1,851.15	10,277.5
06	--	6,760.0
07	5,997.355	36.225.00
08	3,265.24	17,342.50
09	--	5,895.00
10	1,369.138	8,545.00
11	1,936.81	9,456.90
12	505.61	11,111.00
13	1,266.43	7,790.00
14	2,391.62	9,655.00
15	920.99	8,840.00
16	2,063.03	12,412.50
17	1,197.89	8,052.00
18	1,594.48	12,765.00
19	3,001.605	8,250
20	928.78	7,785

SOURCE: Field survey by Ntamulyango [1975]; estimated data by Kamuanga.

APPENDIX C

Total Labor Input Per Farm and Average Per Hectare

Farm	Male	Fem.	Child.	Field Preparation	Agricultural Activities	Post-harvest Operation	Total Labor	Total Crop Area (m^2)
02	1	1	1	249	1,674	69	1,992	9,992.5
04	8	4	14	997	8,408	166.5	9,571.5	27,444.5
05	2	1	4	342	2,011	97	2,450	10,277.5
06	1	1	3	380	1,490.5	85	1,955.5	6,760.0
07	1	4	0	612	3,426	194	4,232.	36,225.00
08	2	1	4	157	3,567.5	52	3,776.5	17,342.5
09	1	2	1	81	991	97	1,169	5,895.00
11	4	2	6	773.5	1,511	41.5	2,326	9,456.90
12	2	2	2	165	1,966.5	63	2,194.5	11,111.00
13	2	2	-	209	2,007	85	2,301	7,790.0
14	1	1	1	148	2,217	152	2,517	9,655.00
15	1	2	2	332	1,142	33.5	1,507.5	8,840.00
16	2	2	4	332	2,135.5	61.5	2,529	12,472.5
17	1	2	2	212.5	2,227.5	86	2,526	8,052.5
18	1	1	5	351	1,174.5	67	1,592.5	12,765.00
19	2	2	2	264	1,634.5	51.5	1,950	8,250.00
20	3	1	5	231	947.5	39	1,217.5	7,785.00
				Σ=5,836	Σ=38,531.00	Σ=1,440.5	Σ=45,807.5	Σ=210,114.90
Average per ha				277.8	1,833.8	68.6	2,180.1	

SOURCE: Corrected from Tshibaka [1975].

[a]Include seeding, weeding, and crop maintenance, harvesting.

APPENDIX D

Labor Input (hours) Per Crop

Farm		Field Preparation	Agricultural Activities			Post-harvest	Total
			Sowing	Weeding	Harvest		
02	R	20.6	36	93.7	8	5	163.3
	M	8.0	7	36.2	13	2	66.2
	C	44.9	11	204.7	362	62	684.6
	B	175.6	14	800.3	88	--	1,077.9
04	R	212.2	533	1,162.1	665	239	2,811.3
	M	87.8	214	481	480	--	1,262.8
	C	329.5	220	1,804.4	1,191	2	3,546.9
	B	367.5	251	2,012.6	93	--	2,724.1
05	R	61.6	247	198	316	83	905.6
	C	163.0	23	523.8	290	14	1,013.8
	B	117.4	11	377.3	25	--	530.7
06[a]	C	115.6	24	355.3	74	--	568.9
	M	51.7	53	158.8	60	85	408.5
	B	157.9	35	485.4	85	--	763.3
07	R	101.3	34	323	373	142	973.3
	M	8.9	15	28.3	10	--	62.2
	C	221.1	51	704.8	698	52	1,726.9
	B	380.7	163	895	131	--	1,469.7
08	R	29.6	399	512.9	338	57	1,336.5
	M	6.7	23	115.7	18	--	163.4
	C	61.9	20	1,074.2	180	--	1,336.1
	B	58.9	107	1,021.2	22	--	1,209.1
09	M	8.8	4.1	48.3	61	--	122.2
	C	40.6	19.1	223.7	429	97	809.4
	B	31.6	14.8	173.9	17	--	237.3
11	R	158.4	--	207.1	--	7	372.5
	M	28.0	43	36.6	12	--	119.6
	C	197.5	26	258.1	367	38	886.6
	B	389.6	70	509.2	25	--	993.8
12	R	7.5	--	61.7	--	--	69.2
	M	3.8	23	31.3	28	--	86.1
	C	43.2	27	354.9	469	63	957.1
	B	110.5	86	907.2	7	--	1,110.7

APPENDIX D

(Continued)

Farm		Field Preparation	Agricultural Activities			Post-harvest	Total
			Sowing	Weeding	Harvest		
13	R	34	120	185.2	256	17	612.2
	M	2.8	39	15.1	63	25	144.9
	C	36.1	58	196.6	270	43	603.7
	B	136.2	30	742.1	32	--	804.1
14	R	36.7	190	329.2	133	90	778.9
	N	7.5	22	67.1	29	4	129.6
	C	51	62	457.6	418	58	1,046.6
	B	52.9	10	475.1	24	--	562
15	R	34.6	28	93.6	5	5	166.2
	M	13.5	11	36.5	30	--	91
	C	126.8	2	343	133	31	635.8
	B	157.1	14	425.0	52	--	648.1
16	R	54.9	167	210.2	101	37	570.1
	M	12.1	42	46.1	28	--	128.2
	C	89.5	40	342.4	369	29	869.9
	B	175.5	39	672.2	90	--	976.7
17	R	31.6	256	174.8	156	34	652.4
	M	4.9	52	26.9	13	5	101.8
	C	38.1	49	762.4	555	50	1,454.5
	B	137.9	30	210.9	64	--	442.8
18	R	43.8	438	67.1	216	37	801.9
	C	156.0	7	238.7	91	57	549.7
	B	151.1	14	231.2	26	--	422.3
19	R	96	117	502.1	54	19	788.1
	M	19.6	23	102.2	8	2	154.8
	C	61.7	26	322.5	77	37	524.2
	B	86.7	8	453.2	26	--	479.2

APPENDIX D

(Continued)

Farm		Field Preparation	Agricultural Activities			Post harvest	Total
			Sowing	Weeding	Harvest		
20	R	27.6	--	49.4	31	3	111
	M	9.9	27	17.7	56	3	113.6
	C	82.0	15	147	409	33	686
	B	111.6	29	200	7	--	347.6

SOURCE: Field survey, corrected data from Tshibaka [1975].

[a] 06: man-hours in field preparation don't add up to 380 reported in Appendix C because the remaining labor input was allocated to coffee not entered here.

[b]The total labor in weeding was obtained from fields 01 and 02; this figure allowed for the estimation of man-hours in sowing that was not available.

APPENDIX E

Labor Input for the Rice Enterprise Per Farm (man-hours)

Average size of rice enterprise: 0.22 hectare

Farm	Field Preparation	Seeding	Weeding	Harvest	Post Harvest	Total
02	20.6	36	93.7	8	5	163.3
04	212.2	533	1,162.1	665	239	2,811.3
05	61.6	247	198	316	83	905.6
07	101.3	34	323	373	142	973.3
08	29.6	399	512.9	338	57	1,336.5
11	158.4	--	207.1	--	7	372.5
12	7.5	--	61.7	--	--	69.2
13	34	120	185.2	256	17	612.2
14	36.7	190	392.2	133	90	778.9
15	34.6	28	93.6	5	5	166.2
16	54.9	167	210.2	101	37	570.1
17	31.6	256	174.8	156	34	652.4
18	43.8	438	67.1	216	37	801.9
19	96	117	502.1	54	19	788.1
20	27.6	--	49.4	31	3	111

SOURCE: Field survey--corrected data from Tshibaka [1975].

APPENDIX F

Labor Input Per Hectare for the Rice Enterprise

Farm	Field Preparation	Seeding	Weeding	Harvest	Post Harvest	Total
02	249.6	436.2	1,135.3	96.9	60.6	1,978.6
04	363.3	912.5	1,989.5	1,138.5	409.2	4,813
05	332.8	1,334.3	1,069.6	1,707.1	448.4	4,892.2
07	168.9	56.7	538.6	621.9	236.8	1,622.9
08	90.7	1,222	1,570.8	1,035.2	174.6	4,093.3
11	817.8	--	1,069.3	--	36.1	--
12	148.3	--	1,220.3	--	--	--
13	268.5	947.6	1,462.4	2,021.4	134.2	4,834.1
14	153.5	794.4	1,639.9	556.1	376.3	3,520.2
15	375.7	304.0	1,016.3	54.3	54.3	1,804.6
16	66.1	809.5	1,018.9	489.6	179.4	2,763.5
17	263.8	2,137.1	1,459.2	1,302.3	283.8	5,446.2
18	274.7	2,747	420.8	1,354.7	232.1	5,029.3
19	319.8	389.8	1,672.8	179.9	63.3	2,625.6
20	297.2	--	531.9	333.8	32.3	1,195.7
	$\bar{X}$=292.7	$\bar{X}$=1007.6	$\bar{X}$=1187.7	$\bar{X}$=837.8	$\bar{X}$=170.8	$\bar{X}$=3432.3
	sd=45.4	sd=780.3	sd=455.7	sd=636.8	sd=144.9	sd=1271.0

SOURCE: Calculations by Kamuanga.

APPENDIX G

Average Yields on Upland Rice at Mawunzi

1968-73 (M.A.C.)

Seasons	Location	Yields kg/ha
Feb-July 68	Makuta	2,800
Feb-July 69	Makuta	2,500
70	Kiloanga B	2,500
	Yanda-Kondo	2,000
71	N'Salu	3,250
	Kumbi II	1,915
	Kiloanga B	2,400
	Kiloanga C	2,100
	Makuta	2,350
	Yando-Kondo	2,250
	Kinsumbu	2,455
	Centre Noa	2,150
72	Kiloanga B	2,315
	Kiloanga C	2,005
	Makuta	2,300
	Yanda	2,200
	Kisama	2,654
	Kinsumbu I	2,400
	Kinsumbu II	1,750
	Noa	2,000
Average		2,304
S.D.		0.142

SOURCE: Tshingomba [1976].

APPENDIX H

Average Yields on Irrigated Rice at Mawunzi (M.A.C.) (1968-1975)

Season	Zamba	Kiloanga A
Feb 68 - Jul 68	4,980	3,600
Sept 68 - Jan 69	4,780	--
Feb - Jul 69	4,300	4,950
Sept 69 - Jan 70	4,100	--
Feb - Jul 70	3,950	4,250
Sept 70 - Jan 71	--	4,150
Feb - Jul 71	4,280	4,050
Sept 71 - Jan 72	3,950	4,100
Feb - Jul 72	4,350	4,555
Sept 72 - Jan 73	3,950	3,900
Feb - Jul 73	3,640	4,200
Sept 73 - Jan 74	4,561	4,561
Feb 74 - Jul 74	4,578	4,578
Sept 74 - Jan 75	4,000	3,500
Feb - Jul 75	4,500	3,500
Average	4,2799.93	4,145.70
S.D.	372.9	446.26

SOURCE: Tshingomba [1976].

$$Z = \frac{134.230}{158.945} = 0.845 < 1.96 \text{ at } \alpha = 0.05$$

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