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Labor Allocation and Productivity for
Upland Rice Farms: Sierra Leone,
1974-1975

by

E. Chinwe Spears

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LABOR ALLOCATION AND PRODUCTIVITY FOR UPLAND RICE FARMS:

SIERRA LEONE, 1974/1975

By

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CHAPTER I

INTRODUCTION

Sierra Leone is a West African country bordered by Guinea to the north and west and by Liberia to the southeast. Land area is approximately 27,925 square miles, lying between 6°55' and 10° north latitude and 10°16' and 13°18' west latitude.¹ The country lies completely in the tropical zone and can be divided into three different ecological regions: the interior hills and plateaus; the coastal plain and; the colony peninsula.²

The population of Sierra Leone is approximately 2.8 million people. Agriculture is the dominant sector in Sierra Leone with an estimated 75 percent of the population being engaged in subsistence farming and producing 32 percent of the gross domestic product. Sierra Leone is a major rice producing country and thus rice has an important role in the economy. Rice produces about 45 percent of the agricultural value added. Additionally, rice is an important staple food with estimates of 240 pounds of rice per capita being consumed per annum in rural areas and 150 pounds per capita in urban areas.

Since this is the case, National Development Plans have emphasized the development of this sector. The most recent Plan, in a

¹Saylor, R. G., The Economic System of Sierra Leone. Duke University Press, Durham, 1967.

²Jarrett, H. R., A Geography of Sierra Leone and the Gambia. London: Longmans and Green, 1954, p. 10.

discussion of the basic features and elements of the Plan, states:

Top priority has been given to agriculture, the growth rate of which is projected to increase from an estimated 1.6 percent during 1963/64-1970/71 to 4.6 percent. . . . Apart from acceleration of overall economic growth, rapid expansion of output in the commodity producing sectors will contribute to important objectives of the Plan relating to income distribution, foreign exchange, and the creation of conditions for sustained long-term economic growth.³

Further, the Plan contained an overall framework for the development of the agricultural sector and a section specific to rice production.⁴ A major goal of the Plan is to increase rice production to self-sufficiency. With 81 percent of Sierra Leone's farmers growing at least one rice crop per year, the importance of rice in the economy and in the Development Plan can hardly be denied.

Agriculture in the Development Process

From the introduction, it is safe to assume that Sierra Leone is a country intent on developing and has the characteristics common to the majority of the developing countries in Tropical Africa. These include:

1. Real income is low, although there may be sectors in the urban area which have high incomes;
2. Low income means low productivity and the implications of low productivity are:
 - a. Unless a country has high foreign exchange earnings, most foodstuffs must be produced domestically;

³The Government of Sierra Leone, "National Development Plan, 1974/75-1978/79," Central Planning Unit, Ministry of Development and Economic Planning, Freetown, 1974, p. viii.

⁴Ibid., see pp. 125-137.

- b. Farms are likely to be small in size;
- c. The labor to land ratio may be high;
- d. Because the productivity of labor is low, the marginal product of labor is also low;
- e. Traditional agriculture prevails.⁵

The descriptive section of this paper will show that most of these points are true of Sierra Leone. Additionally, the agricultural sector is expected to contribute greatly to the economic development of their countries. Myint suggests that the agricultural sector is expected to contribute to development in the following ways:

- 1. By increasing domestic food supply;
- 2. By providing a growing market for domestic manufactures;
- 3. By contributing to domestic savings and capital formation;
- 4. By providing foreign exchange through agricultural exports.⁶

Given the necessity of developing the agricultural sector so that it may contribute in the manner suggested by Myint, policy-making and planning are required. Although policy and planning have taken place, it has been done without a great deal of information about the sector whose development is being considered. Information gaps to be considered are:

- 1. The general insufficiency of knowledge about traditional agriculture, with some specifics being:
 - a. Resource allocation;

⁵Morgan, T., Economic Development: Concept and Strategy. New York: Harper, 1975. pp. 35 ff.

⁶Myint, H., "Agriculture and Economic Development in the Open Economy," Agriculture in Development Theory. Reynolds, ed., New Haven: Yale University Press, 1975. pp. 328 ff.

- b. The decision-making process;
 - c. Technical coefficients, i.e., input-output data.
2. Productive techniques which would affect the input-output ratios, i.e., cause an upward shift in the production function.
 3. The barriers to the adoption of new techniques.
 4. The means by which these barriers might be removed.

Purpose and Scope of the Study

The problems of planning due to lack of information can only be solved by research based on primary data. A basic objective of this study is to add to the information pool. In attempting to reach this objective the following areas will be covered:

1. Labor resources for Sierra Leone upland rice farms.
2. Use of labor over a crop year.
3. Estimation of production functions for selected inputs, including labor and an evaluation of the relative importance of the factors.
4. Allocative efficiency will be tested.

This paper has six chapters. Chapter two reviews literature which is relevant to rice production in Sierra Leone. Chapter three is descriptive of the physical environment and the upland rice farm activities in Sierra Leone. Chapter four describes farm characteristics, labor resource availability and the use of labor over a crop year. Chapter five is more analytical in nature, containing the theoretical framework, an estimation of production functions for selected inputs, including labor, and an evaluation of the relative

importance of the inputs. Also included in this chapter is a test for allocative efficiency. The final chapter will summarize the results and discuss the possible implications for productivity improvement.

Data Source

Data used for this study were collected in crop year 1974/1975 for the farm management component of the African Rural Employment Project.⁷ The data were collected by an integrated twice-weekly enumeration of a sample of rural households over a period of twelve months beginning January 1974. The sampling procedure was as follows:⁸

- a. The country was divided into nine agricultural resource regions.
- b. Three census enumeration areas (consisting of 80-100 households) were chosen at random from each region (excluding urban areas).
- c. Twenty households were chosen at random in each enumeration area to give a total sample of approximately 500 households in about 25 enumeration areas (see Figure 1).

Data Collection

The research program had been divided into five integrated micro-level studies. For the purpose of this study it is the farm level

⁷Byerlee, D. and Eicher, D.K. "Rural Employment, Migration and Economic Development: Theoretical Issues and Empirical Evidence from Africa." African Rural Employment Paper No. 1, East Lansing: Department of Agricultural Economics, Michigan State University, September, 1972.

⁸Byerlee, D. and Eicher, C.K., 1972, op. cit., p. 42.

Figure 1. Sierra Leone Rural Enumeration Areas and Urban Areas

portion which is of interest. The methodology used in the farm level study had been developed by Spencer in an earlier work on rice production.⁹ It is a modification of the cost-route method of collecting farm data. The chosen households are visited repeatedly for at least one crop season and the enumerator questions the farmer as to the farm business activities.

⁹Spencer, D.S.C., "Micro-Level Farm Management and Production Economics Research Among Traditional African Farmers: Lessons from Sierra Leone." African Rural Employment Paper No. 3, Department of Agricultural Economics, Michigan State University, September, 1972, p. 5.

CHAPTER II

LITERATURE REVIEW

The inadequacy and lack of up-to-date data on agriculture in Sierra Leone, until recently, has been noted. The National Development Plan lists the lack of data as "one of the factors influencing the pace and pattern of future development."¹⁰ Research on rice production was scanty until the 1970s.

One of the earliest published articles was by Roddan in 1942.¹¹ Methods of rice production in the mangrove swamps of the northern province were studied. In this study an attempt was made to estimate the economic farm size given the observed labor input. This was determined to be five acres.

Little published two works on the Mende in 1951 and 1967.^{12,13} The earlier work was concerned with the cost of operating rice farms and while not a comprehensive economic analysis, this study did itemize farm expenditures, including such factors as labor, consumption items such as food and clothing as well as equipment for farm use. The latter work was based on anthropological field work undertaken in 1945.

¹⁰Ibid., p. 128.

¹¹Roddan, G. M., "The Cultivation of Swamp Rice in Sierra Leone," Tropical Agriculture, Vol. XIX:5, May 1942.

¹²Little, K., "The Mende Rice Farm and Its Cost." Zaire, Vol. 5.3, March 1951.

¹³Little, K. The Mende of Sierra Leone. London: Rowledge and Paul, 1967.

Because of the importance of rice farming in the Mende economic life, Little describes the economic, social, and cultural roles of rice. Some information on rice production was provided by this study.

In the 1960s, studies concerning measures to encourage production were published. The study by Jordan was primarily descriptive of the different types of rice cultivation in Sierra Leone and the measures the government had undertaken to encourage rice production.¹⁴ The measures included communal clearance, mechanical plowing, improved seed for distribution, fertilizer subsidies and controlling rice prices. The results of these measures varied but Jordan observed that in some areas the measures helped farmers to attain a standard of living which was above the average for the rural population.

Jedrej's analysis was based on the Bonthe District and was concerned with mechanically cultivated farms.¹⁵ This analysis is important not only because it describes the effects of a technological change but also how the technological change induced institutional change. A cooperative organization was formed after the introduction of mechanical plowing and subsequently modifications in the land tenure system were necessary in the areas which the cooperatives controlled.

Crauford and Carpenter were investigating partial mechanization and rice varieties in the Boliland area.¹⁶ The study was

¹⁴ Jordan, H.D., "Rice in the Economy of Sierra Leone," World Crops, Vol. 17:4, December 1965.

¹⁵ Jedrej, M.C., "Sociological Aspects of Mechanical Cultivation in Southern Province of Sierra Leone." Mimeo, School of Development Studies, Mjala University College, Mjala, Sierra Leone, April 1967.

¹⁶ Crauford, R.Q. and Carpenter, A.J., "Partial Mechanization of Rice in Sierra Leone," World Crops, Vol. 20:1, March 1967.

inconclusive as to recommendations in regard to tractor use because the costs of mechanized plowing varied among sites, between seasons, and among types of tractors used. However, recommendations were made as to an imported variety of rice which gave much greater yields than the best local variety when sown with fertilizer.

Karr's earlier study was an analysis of measures to encourage rice production.¹⁷ Specifically, he was concerned with use of various subsidies to promote the development of rice production of the inland-swamps.

Additionally, research reports on plant breeding, fertilizer trials, double cropping, and similar works were prepared by the Rice Research Institute at Rokupr and external agencies such as the United States Department of Agriculture.^{18,19}

Recent Studies

The above studies were concerned with one or two factors of production such as techniques and improved inputs. Although it had been recognized for years that land and labor were the two major inputs of traditional agriculture, intensive studies of labor utilization were not available for Sierra Leone until the 1970s. These recent studies were sharply focused on what Mellor calls ". . . the primary instrument for increasing production within the framework of traditional

¹⁷ Karr, G. L., "The Use of Subsidies for the Promotion of Inland Swamp Development," Economic Trends, Bank of Sierra Leone, November-December, 1969, pp. 1-7.

¹⁸ Rice Research Station, Annual Report of the West African Rice Research Station.

¹⁹ USDA/USAID, Rice in West Africa, Washington, D.C., December 1968.

agriculture . . . , " labor.²⁰ The studies relied on two standard techniques of data collection: the traditional procedure of collecting the materials through field assistants, using questionnaires and the anthropological method which relies upon questioning and observing individuals while they are at work.

Njoku's thesis studied labor utilization in two rice cultures, upland farming areas and partially mechanized farms, with the core of the data being collected from the Bonthe District over a nine-month period.²¹ The study examined the effects of the structure of population on labor availability, the farm labor resources utilized in the two rice cultures and the composition of that labor, farm wage rates and costs comparisons for the two cultures, and alternative opportunities for labor and influences on the farm operational decisions.

Costs and returns to each source of labor for various farm activities were described, estimated and analyzed. Certain features of the two cultures were compared and contrasted.

The methods of data collection and the problems encountered are of special interest because subsequent research discussed below used a similar method in a more sophisticated form. Njoku used two instruments, the stock record and the flow record for data collection.

The stock record contained information on household composition at home. Each member was classified as to sex, farming contribution, years of school, marital status and non-farm occupations. It is

²⁰ Mellor, J.W. The Economics of Agricultural Development. Ithaca: Cornell University Press, 1966, p. 156.

²¹ Njoku, A.O. "Labor Utilization in Traditional Agriculture: The Case of the Sierra Leone Rice Farms." Unpublished Ph.D. Dissertation, University of Illinois, Urbana, 1971.

generally difficult to obtain exact ages when collecting data in this setting (farms in low income countries) because of the lack of formal or informal record-keeping so that four broad age categories were used. Additionally, the stock record contained information on absentee household members, farm acreage tools, source of seeds, intercropping and the nature of farm organization. The stock record is a questionnaire used on a one-time basis.

The flow records are continuously kept over the period to be analyzed and contained data on the labor used. These records were classified as to sex, source, wages, and the costs of feeding for various farm activities. They gave indications of the sex division of labor in each household and were used to calculate labor for each farm activity.

Selected sampling, that is random sampling was not conducted at every stage of selection, was the method used for choosing the farmers. This method was justified for reasons discussed in the section of problems encountered.

One of the problems encountered was accessibility, i.e., the excessive cost of transport or psychological difficulties. Another problem was the suspicion often found in village communities. Njoku worked through the village hierarchy to minimize this problem. Another was the low level of literacy which implied a lack of record-keeping and made use of the flow record all the more important. Lacking were bench-mark data on physical and socioeconomic characteristics of the villages in the sample. The preliminary work had shown random sampling would have had political overtones. These problems and the solutions with which Njoku attempted to solve them provided valuable guidelines

for the researchers who continue to work in Sierra Leone and in other developing countries.

Njoku's work at the University of Illinois was followed in the same year by another thesis by Kallon.²² Kallon selected one culture, inland valley swamp production, for study. The basic hypothesis was that increased net returns could be obtained by the use of existing, improved technology. The major source of the data in this study was primarily records of the Peace Corps Rice Farming Scheme initiated in 1968. The record books contained detailed cost and returns data on both inland swamp and upland cultivation. Kallon used data for inland swamp rice farms in the Northern Province (7); Southern Province (12); and Eastern Province (2) for a total of 21 inland swamp farms. Technical practices (cultural), labor requirements, and determination of the components of total cost and returns were included in this research to delineate the economics of inland swamp rice production. Suggestions were made as to levels of mechanization that could be used in the future development of a commercial farm sector.

Spencer's Conference paper highlighted the most important elements in the development of the rice industry in Sierra Leone.²³ The types of rice culture, the important producing area identification and the organization and functioning of the marketing system were included. The increasing difference between domestic supply and demand

²²Kallon, M.F., "The Economics of Rice Production in the Inland-Valley Swamps of Sierra Leone." Unpublished Masters Thesis, University of Illinois, Urbana, 1971.

²³Spencer, D.S.C., "Rice Production and Marketing in Sierra Leone," paper presented at the Conference on "Factors of Agricultural Growth in West Africa," Legon, Ghana, March 1971.

is discussed as well as government efforts to increase the supply so as to meet the goal of self-sufficiency in rice production. Spencer concludes that if conditions are favorable, the government schemes will increase rice production and productivity, "not by any dramatic changes but by steady progress."²⁴

Spencer delved more deeply into the problems of resource utilization, using linear programming techniques, for the predominant rice production systems in Sierra Leone, i.e., upland, inland swamp, mangrove swamp, riverain grassland and boliland which used varying levels of technology, from the traditional shifting cultivation on upland, partially mechanized riverain and boliland cultivation to intensive cultivation of inland swamps. The purpose of this indepth study was to evaluate the policy of national self-sufficiency in rice production and to determine the most efficient way to deploy the resources to meet the goal.

In this context the studies by Njoku and Kallon were of limited usefulness as they were confined to two systems of production. Spencer undertook an extensive collection of primary input-output data on the six systems found in the country. The techniques used for primary data collection were summarized in the thesis but more fully elaborated upon in a later work.²⁵ He attempted to collect labor

²⁴ Spencer, D.S.C., "The Efficient Use of Resource in the Production of Rice in Sierra Leone: A Linear Programming Study." Unpublished Ph.D. Dissertation, University of Illinois, Urbana, 1971.

²⁵ Spencer, D.S.C., "Micro-Level Farm Management and Production Economics Research Among Traditional African Farmers: Lessons From Sierra Leone." African Rural Employment Paper No. 3, Department of Agricultural Economics, Michigan State University, September, 1972.

data in a systematic way. A stratified sampling technique was used to select farmers to be interviewed. The interviews were frequent, following the cost-route method, where farmers were visited repeatedly over a crop season to record activities and events as they occurred. A discussion of the measuring of the labor input in man-days versus man-hours, the rationale supporting the use of the weights of 1.0, 1.0 and 0.5 for men, women and children, respectively, the use of land measurement as opposed to aerial surveys, the capital input measurement and the estimation of output are to be found in this work. Spencer's works serve as important background to the methodology used for data collection of the materials used in this particular study.

The African Rural Employment Network publications have dealt extensively with rice production, marketing and labor utilization in Sierra Leone.²⁶ The survey undertaken and continuing data analyses provide additional bases for research efforts.

²⁶See the listing of publications specific to Sierra Leone rice industry in the bibliography.

CHAPTER III

PROBLEM SETTING

This section will acquaint the reader with the physical environment with which the Sierra Leonean farmer has to contend, the methods of rice production which he uses and the failure of rice production to keep pace with the demand for the staple.

Physical Environment

Sierra Leone is a tropical country lying entirely within the rain forest. The climate varies from warm to hot and, in common with other countries in this geographical zone, has well-defined wet and dry seasons. The wet season occurs from June to October and is characterized by frequent, heavy and prolonged rainfall, the amount of which varies by region. Annual rainfall ranges from 90 inches to 130 inches with the coastal areas receiving more rainfall than the interior. The dry season lasts from December to April and is of two types:

1. The harmattan, a period when dry, dust-laden winds blow from the Sahara during December through February, and
2. A period of high humidity with hot days and nights usually in March and April.

The vegetation of the country can be divided into six different types:

1. The forest type, made up of primary forests, secondary forests, and farm bush;

2. The savannah, consisting of savannah woodland, open savannah and lopina savannah;
3. The upland grassland, subdivided into hillside grass and sedge, grassland resulting from farming, and "pennisetum perbecum" grassland;
4. The riverine grassland made up of two types, Rokel grassland and Wanje grassland;
5. The swamps, consisting of inland fresh water sedge and mangrove swamps;
6. The coastal vegetation made up of coastal parkland, coastal farm bush and coastal scrub.²⁷

Soil types and the crops which could possibly be grown are extensive and have been analyzed and listed in tables by Odell and Dijkerman.²⁸ Because this study is concerned with upland farms which are found throughout Sierra Leone, the soil types differed from region to region and farm to farm. If one accepts the soil analysis carried out by Njoku, the soil type will vary extensively within each farm.²⁹

The climate, in conjunction with soil categories, alluvial and laterite, have greatly influenced the economic and agricultural organization of Sierra Leone.

²⁷Waldock, E.A., E.S. Capstick, and A.J. Browning, Soil Conservation and Land Use in Sierra Leone. Freetown: Government Printer, 1951.

²⁸Odell, R.T. and Dijkerman, J.C., Properties, Classification and Use of Tropical Soils, With Special Reference to Those in Sierra Leone. Njala, Sierra Leone: Njala University College, 1967, p. 84.

²⁹Njoku, A.O., op. cit., pp. 65-66.

Rice Production in Sierra Leone

There are five types of rice culture practiced in Sierra Leone: upland, inland swamp, boliland, riverain swamp, and mangrove swamp. As this study is concerned with upland production, only a brief description of the other systems will be given here.³⁰

Inland swamps are found throughout the country, wherever depressions occur in the rolling upland. Figure 2 shows the heavy incidence of these swamps and a comparison with Figure 1 will give an indication of how the swamps are located with respect to the enumeration areas. It has been estimated that there are approximately 12 percent of the 738,000 acres of inland valley swamp being cultivated. Rice is usually transplanted into these swamps and yields vary from 1,000 to 3,000 pounds per acre with an average yield of 1,800 pounds per acre. A single crop is usually grown and during the dry season, after the rice has been harvested, vegetable crops are sometimes grown.

Bolilands are low swamp grasslands located in the central and northern parts of the country as shown on the map. In a total area of 200,000 to 250,000 acres, approximately 50 percent are under swamp conditions, with an estimated 75,000 acres being suitable for farming. Yields in the bolilands are low, ranging from 600-800 pounds per acre.

Extensive riverain grasslands are primarily found in the south and southwest with an estimated area of 540,000 acres. The flood plains in this area are caused by the sand bar obstruction which prevents the rivers, Waanje and Sewa, from flowing into the sea. Because of the uncontrolled flooding and other physical features such

³⁰Spencer, D.S.C., op. cit., pp. 3-6.

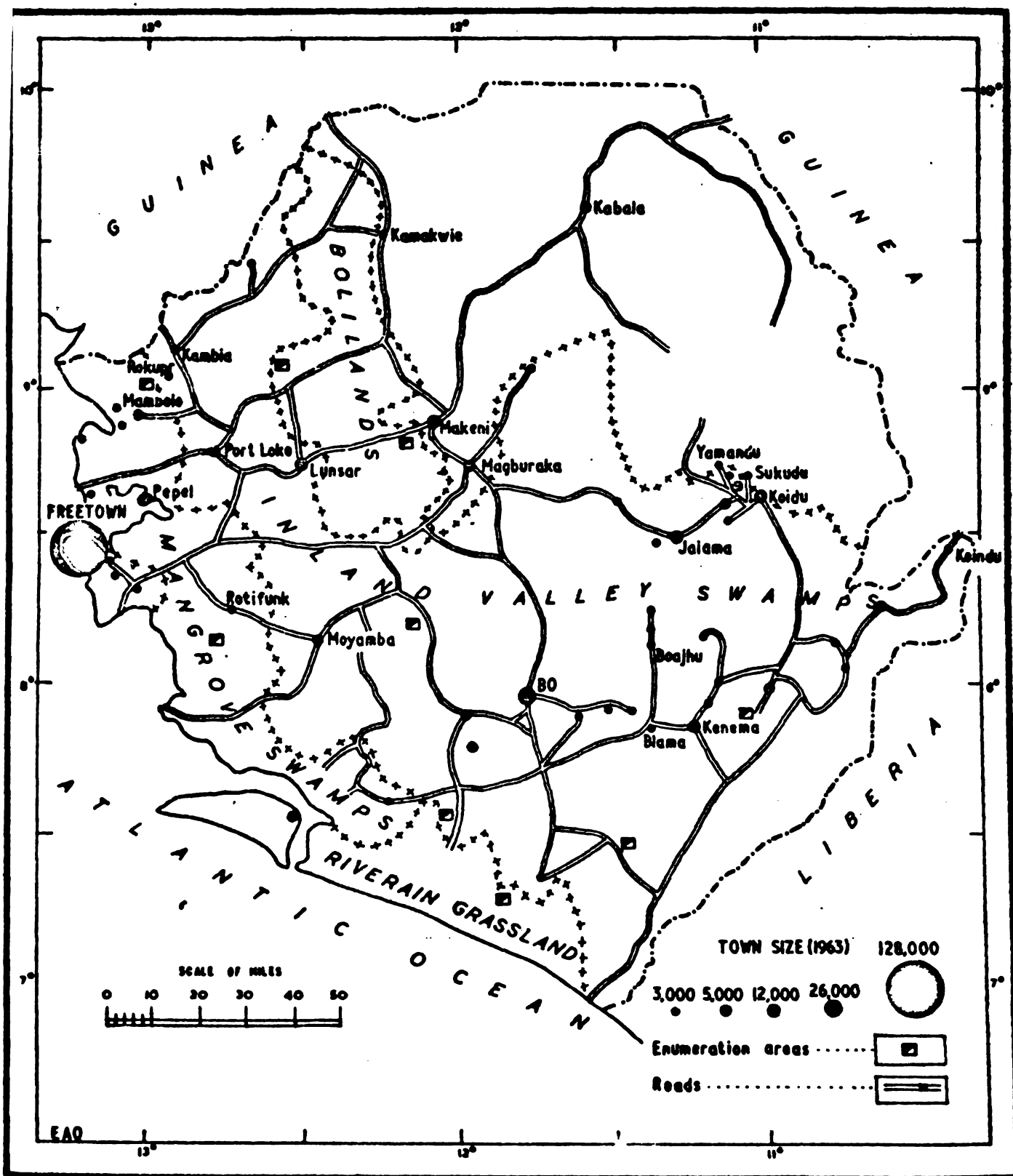


Fig 2 AREAS WHERE DIFFERENT TYPES OF SWAMPLAND ARE CONCENTRATED IN SIERRA LEONE, URBAN AREAS AND LOCATION OF ENUMERATION AREAS.

as aluminum toxicity, only 35,000 acres are being farmed. Yields nearing that of the inland swamp areas are expected, with an average yield of 1,600 pounds per acre.

Mangrove swamps are found in the west and southwest coastal region. These swamps arise from tidal action which causes an overflow of water at high tides and a draining at low tides. This area of approximately 81,000 acres, has been under swamp cultivation since around 1880 and it has been estimated that by 1900 all the better mangrove swamps were under cultivation. Yields vary between 1200 and 1400 pounds per acre.

Upland rice, which is the primary concern here, is a general classification which includes rice for which rainfall is sufficient for its growth. The natural inference then is that during the rainy season upland rice can be grown throughout Sierra Leone. Upland rice culture is the traditional mode of rice cultivation and is the most widely found type of production in Sierra Leone. Production is land extensive because traditionally, the "bush-fallow" system of cultivation has been used. This system involves clearing the land by felling trees with axes, clearing bush with cutlasses or knives, burning over, and hoeing and seeding the cleared land. The land is used for one to three years, with one rice crop per season, and then permitted to revert to farm bush for several years. This necessitates a shifting of cultivation from place to place and is only possible where land is in good supply.

The farmers using this system of production are quite diversified in the agricultural crops they produce with 70 different cultivated crops reported and one-third of all farmers growing 15 or

more crops.³¹ This same report indicated that in 1965-66, 86 percent of all farmers grew rice. Rice was 42 percent of the total value of all agricultural products. Upland rice comprised 75 percent of the production which gives an indication of its importance relative to the other four systems of production. The yields of upland rice are quite low with a national average of 950-1,000 pounds per acre. Upland is the predominant contributor to total production not because of high yields but because of the large acreage under cultivation (estimated at 591,000 acres for the reported period) of which only 8.3 percent were in pure stands.

However, of the farmers growing rice (86 percent), only 18 percent reported selling rice. This is especially applicable to upland farmers who produce only one crop per year with appreciably lower yields than wet rice cultivation. The small quantity of rice reported sold could indicate that much of the domestic supply is grown for home consumption. Of course the possibility exists that some rice may have been disposed of in non-market transactions such as gifts to relatives and others or else through exchanges. Whatever the case, non-rice farmers and the population of rural and urban dwellers have found rice in short supply. This supply-demand gap is exemplified by the fluctuation in the quantity of rice imported.³² This is a better indicator than the changes in foreign exchange expenditure for imports as the more recent years reflect an upward trend in fertilizer costs and freight charges which can be partially attributed to increases

³¹ USDA/USAID, op. cit.

³² Sierra Leone Monthly Economic Trends - Issues From 1969 to 1974. Bank of Sierra Leone.

in the price of oil. The varying prices of imports have created a foreign exchange drain which adversely affects the balance of payments.

<u>Year</u>	<u>Quantity (Metric Tons)</u>	<u>Cost (Le., Millions)</u>
1968	16,881	2.54
1969	12,409	1.46
1970	48,165	5.70
1971	27,004	2.47
1973	43,700	6.10

Spencer states the beginning of the failure to satisfy domestic needs coincides with the diamond boom of the early 1950s and postulates several reasons for this failure:³³

1. The migration of labor from agriculture into mining.
2. The failure of production increases to keep pace with increased demand resulting from growth in income and population and the accelerated pace of urbanization which has taken place during the past two decades.

In the evaluation of the goal of self-sufficiency in rice production by 1980, one of the conclusions reached by Spencer was that a substantial transfer of labor between regions was required.³⁴ Further he concludes that although the inland swamp rice had the higher potential for increased productivity, the capital expenditures required for development were high. Among his policy suggestions was the suggestion that increased emphasis should be placed on the upland system of production. If these conclusions are accepted, further basic research information on the upland production system is required.

³³Spencer, D.S.C., 1971, op. cit., p. 7.

³⁴Spencer, D.S.C., 1973, op. cit., pp. 116-121.

CHAPTER IV

DATA ANALYSIS

This section will describe the characteristics of the upland rice farms and the use of various labor classes.

Farm Characteristics and Labor Utilization

Farm size and yields on a regional basis are shown in Table 1. The average upland rice farm for the 86 selected farms was about 6 acres. This average farm size is in reference to land actually under cultivation in this crop year. The average age of bush felled was 8.38 years. This figure is lower than the previously reported age of bush for upland rice farms because of the exclusion of the Riverain Grasslands and the Northern Palteau whose average bush ages of 11.5 and 10.5, respectively, exceed the national average of 9.8 years. This indicates that farmers have access to about 50 acres of land.

Table 1 also provides information on the yields of rice in the regions. Rice yields averaged 780 pounds per acre, varying from 497 pounds per acre in the Scarcies to 1,174 pounds per acre in the Northern Plains. As noted earlier, the upland rice yields were 60 percent lower due to the pattern of rainfall during this crop year. Thus, most of the variation in year may be attributed to ecological conditions such as climate, soils, etc.

Table 1. Farm Characteristics of Resource Regions. 86 Upland Rice Farms: Sierra Leone, 1975/76,

Region	Sample Size	Total Acres	Average Farm Size	Bushels/ Year	Bushels/ Acre	Pounds/ Acre
1. Scarcies	10	79.14	7.914	654.83	8.27	496.46
2. Southern Coast	10	69.92	6.992	802.53	11.48	688.67
3. Northern Plains	13	66.81	5.139	1307.21	19.57	1173.97
5. Bolilands	11	60.39	5.49	556.69	9.62	553.09
6. Moa Basin	15	48.73	3.25	583.02	11.64	717.86
8. Southern Plains	27	128.51	4.76	2056.06	16.00	960.00

Source: Upland Rice data collected in crop year 1974/1975 for the farm management component of the African Rural Employment Project, Njala University College

Table 2 relates the man-hours per year to the yield in pounds per acre for the six regions. Here again, regional variations are apparent. In the Southern Coast, the Northern Plains and the Bolilands, a yield of one pound per acre required about the same labor input (i.e., 55.01, 55.90 and 59.95 man-hours per year respectively). In the Moa Basin the labor input required was much lower, 35.95, while in the Scarcies and the Southern Plains, 78.90 and 87.89 man-hours per year were required to produce one pound of rice per acre.

Table 3 shows the percentage of each labor class contribution. While this breakdown does not readily give further insights into the question of regional variation, it is interesting to note that Region 6, Moa Basin, which had the lowest labor input to produce a

Table 2. Labor Inputs and Yields in 86 Upland Rice Farms, Sierra Leone: 1974/75

Region	Total Farm Man-Hours Per Year ^a			Yield/Acre (Pounds/Acre)
	Family	Hired	Total	
1. Scarcies	31,666	7,504	39,169	496.46
2. Southern Coast	24,622	13,258	37,880	688.67
3. Northern Plains	53,471	12,162	65,633	1173.97
5. Bolilands	27,021	6,136	33,157	553.09
6. Moa Basin	20,608	5,199	25,807	717.86
8. Southern Plains	67,528	16,846	84,374	959.95

Source: Upland rice data collected in crop year 1974/1975 for the farm management component of the African Rural Employment Project, Njala University College.

^aMan-hour equivalents were computed by applying weights of 1.0, .75, .50 to male, female, and child labor respectively. The weights reflect the relative wage rates in those areas.

pound per acre, used substantially more female labor than the other five regions. The hired labor input was the same as for the two regions which required the most labor for similar yield and the male labor percentage was lower than for the other five regions. One could speculate that the higher yield is due to more intensive weeding (female work) which would result in increased productivity.

Hired labor comprised 18 to 35 percent of the total labor input with an average of 22 percent. Five of the regions had a percentage below the average. In the Southern Coast, the percentage was 35. This large percentage of hired labor may be made necessary by demographic characteristics of the region. It is reported that

Table 3. Regional Comparison of Labor Contribution By Class,
86 Upland Rice Farms, Sierra Leone: 1974/75

Region	Total Man-Hours/ Year ^a	Percent Male	Percent Female	Percent Child	Percent Hired
1. Scarcies	39,169	49	21	10	20
2. Southern Coast	37,880	41	21	3	35
3. Northern Plains	65,633	49	27	6	18
5. Bolilands	33,157	52	22	8	18
6. Moa Basin	25,807	36	40	4	20
8. Southern Plains	84,374	51	26	3	20

Source: Upland rice data collected in crop year 1974/1975 for the farm management component of the African Rural Employment Project, Njala University College.

^aMan-hour equivalents were computed by applying weights of 1.0, .75, and .50 to male, female, and child labor respectively. The weights reflect the relative wage rates in those areas.

household size is small, 5.4 compared to the national average of 7.4, while the net rate of out-migration, 12.2 per thousand compared to the national average of 4.8 per thousand, is by far the highest rural to urban migration rate.³⁵

Table 4 depicts very clearly the seasonal nature of farming activities. Labor inputs start to increase in June, reach a peak and taper off to a very small quantity by December. The peak and slack month for adult females and adult males are shown in Tables 5 and 6. For all regions, the peak months for female labor were July, August,

³⁵Spencer and Byerlee, *op. cit.*, p. 16.

Table 4. Monthly Use of Labor Inputs in 86 Upland Rice Farms: Sierra Leone, 1974/75

Region	Sample Size	Average Hours Worked Per Person Per Month												Total Hours Per Year
		M	J	J	A	S	O	N	D	J	F	M	A	
1. Scarcies	10													
Male		37	113	150	141	143	159	87	4	18	35	48	37	972
Female		25	77	121	127	64	81	52	2	5	5	5	3	558
Child		17	97	100	143	127	139	77	3	17	10	11	22	763
Hired		2	43	106	133	56	74	125	--	--	20	26	18	603
2. Southern Coast	10													
Male		52	125	101	48	38	73	109	25	21	59	89	70	810
Female		9	33	64	117	85	82	59	42	10	7	2	1	511
Child		4	18	19	34	20	28	30	16	1	3	1	1	175
Hired		21	46	70	31	9	39	126	92	49	58	101	26	668
3. Northern Plains	13													
Male		120	141	161	175	168	190	64	8	6	12	33	25	1103
Female		68	99	126	106	115	126	46	8	15	13	1	2	725
Child		67	145	154	130	141	143	73	14	15	11	1	4	898
Hired		105	113	65	85	20	184	57	11	7	36	60	13	756
5. Bolilands	11													
Male		40	40	93	77	80	119	28	4	1	18	48	67	615
Female		17	4	23	39	63	46	20	9	11	8	15	21	276
Child		37	21	59	46	57	65	24	1	--	8	25	42	385
Hired		50	19	127	22	25	2	80	9	1	21	74	1	431
6. Moa Basin	15													
Male		32	53	53	8	14	5	18	15	3	12	31	18	262
Female		5	50	111	82	66	29	65	23	3	2	1	1	438
Child		8	30	44	34	27	14	19	7	--	2	--	--	185
Hired		17	25	72	12	12	12	53	43	1	37	39	5	328
8. Southern Plains	27													
Male		89	90	81	115	106	72	81	15	41	79	63	46	888
Female		19	67	92	97	57	64	78	12	9	4	5	8	812
Child		19	37	47	47	42	33	33	3	5	8	6	6	286
Hired		37	57	42	21	43	53	82	11	44	113	43	9	555

Source: Upland rice data collected in crop year 1974/1975 for the farm management component of the African Rural Employment Project, Njala University College.

**Table 5. Hours Worked Per Adult Female Per Month Per Season,
86 Upland Rice Farms: Sierra Leone, 1974/75**

Region	Average Labor Input Hours/ Month	Peak Season			Slack Season		
		Labor Input Hours/ Month	Percent Change	Month	Labor Input Hours/ Month	Percent Change	Month
1. Scarcies	47	127	170	Aug.	.5	-99	March
2. Southern Coast	43	117	172	Aug.	1	-98	April
3. Northern Plains	60	126	110	July	1	-98	March
5. Bolilands	23	63	174	Sept.	8	-65	Feb.
6. Moa Basin	37	111	200	July	1	-97	March
8. Southern Plains	43	97	126	Aug.	4	-91	Feb.

Source: Upland rice data collected in crop year 1974/1975 for the farm management component of the African Rural Employment Project, Njala University College.

and September. These are the months of weeding for upland rice. During this season of intense labor, the labor input per month ranged from 110 to 200 percent higher than the average monthly input. By contrast, the slack seasons of February, March, and April, the labor input ranged from 65 to 99 percent lower than the average monthly input. This means that during the slack season, female labor inputs were negligible.

The peak months for male labor varied over a greater range among regions than for female labor. In the Scarcies, the Bolilands, and Moa Basin, the peak month was either July or August. For reasons not

Table 6. Hours Worked Per Adult Male Per Month Per Season,
86 Upland Rice Farms: Sierra Leone, 1974/75

Region	Average Labor Input Hours/ Month	Peak Season			Slack Season		
		Labor Input Hours/ Month	Percent Change	Month	Labor Input Hours/ Month	Percent Change	Month
1. Scarcies	131	274	109	Aug.	4	-97	Dec.
2. Southern Coast	123	190	55	May	47	-62	Sept.
3. Northern Plains	155	374	141	Oct.	13	-92	Jan.
5. Bolilands	87	220	153	July	2	-98	Jan.
6. Moa Basin	49	125	-155	July	4	-92	Jan.
8. Southern Plains	120	192	60	Feb.	26	-78	Dec.

Source: Upland rice data collected in crop year 1974/1975 for the farm management component of the African Rural Employment Project, Njala University College.

clear, male labor in the Southern Plains reached a peak in February, which for most regions would ordinarily be in the slack season. Overall, the same pattern of very high percentage increases of labor input occurred for male labor as for female labor during the peak season. The percent increase ranged from 55 to 155 percent higher than the average monthly input. The slack months for male labor was either December or January for almost 90 percent of the farms surveyed. During these months the labor input was substantially lower than the average monthly input ranging from 62 to 98 percent lower.

During the peak season, the average monthly labor input for males was about 230 hours, which based on a 28-day month, is over eight hours per day. Female labor inputs were an average of 106 hours per month or almost four hours per day.

CHAPTER V

PRODUCTIVITY ANALYSIS

This section will present the theory used as a framework for the analysis, i.e., production function theory and regression analysis theory. A Cobb - Douglas production function will be fitted, analyzed and the marginal value products and marginal factor costs will be equated.

Production Function Theory

For any type of physical output, inputs are required. For crops, dozens of factors are generally essential. Since it is not possible to list all input factors, indeed, many are impossible to satisfactorily quantify, one has to simplify. This simplification involves using the more important input factors upon which is based a theory of response. The most simple theory of crop response, under the present conditions of knowledge, makes the following assumptions:

1. There is a continuous smooth causal relation between the X_i 's (inputs) and the Y (output).
2. The principle of diminishing return prevails: when incremental units of a variable input is added to a set of fixed inputs, the increment to total output from equal increments of the variable input will increase, reach a maximum and then decline.

Assumption 1 implies that if our response equation is $Y = f(X_i)$, then the first derivatives $\alpha Y / \alpha X_i$ exists. Assumption 2 implies that $\alpha Y / \alpha X_i > 0$, which in turn implies that the second derivative $\alpha^2 Y / \alpha X_i^2$ exists and is negative.

If the algebraic form of $Y = f(X_i)$ is known, the following can be derived:

1. the average product of X_i ,
2. the marginal product of X_i ,
3. the maximum level of Y that can be attained,
4. elasticity of response with respect to X_i .

In the case of multiple inputs, the above measures are derived by holding all variables fixed except for the variable to be examined. In addition to the factor-product relations, we can examine factor-factor relations. These consist of:

1. the family of isoquant equations,
2. the marginal rate of substitution of X_i for X_j ,
3. the elasticity of substitution of X_i for X_j ,
4. the family of isocline equations,
5. the ridge line equations,
6. the optimum combination of inputs,
7. the optimum level of output.³⁶

Isoquant equations are loci of input combinations that yield a fixed level of output. These equations are obtained by rearranging the response function to give one input as a function of the other with output regarded as fixed. For various levels of output, this function

³⁶Dillon, J.L., The Analysis of Resonse in Crop and Livestock Production, Oxford: Pergamon Press, 1968.

will give a family of isoquant equations.

The marginal rate of substitution of X_i for X_j gives the rate at which X_i must be substituted for X_j if X_j is decreased by an infinitesimal amount and the level of Y is to remain unchanged.

The elasticity of substitution of X_i for X_j is defined as the relative change in X_i divided by the relative change in X_j if X_i is substituted for X_j while Y is unchanged. This elasticity is a pure number and can be interpreted as the percentage change in X_i needed to maintain Y at the unchanged level while changing X_j by one percent.

Isoclines are defined as the loci of all combinations of X_i and X_j which have the same marginal rate of substitution. They constitute paths up or down the response surface joining points of equal curvature on the isoquants. The family isocline equations is derived by solving for the change in X_i divided by the change in X_j and equating to the marginal rate of substitution of X_i for X_j which specifies a particular isocline.

Ridge lines are two special isoclines for which the marginal rate of substitution of X_i for X_j is equal to zero or infinity. The significance of ridge lines is that they mark the boundary between rational and irrational combinations of inputs.

The optimum combination of inputs are those quantities of inputs that will produce a given output at minimum cost. In order to determine these quantities, called the least-cost combination, one must know the relative prices of the inputs and their marginal rate of substitution. The least-cost combination is achieved when the marginal rate of substitution of X_i for X_j equals the price ratio of X_i to X_j .

The optimal level of output (Y) occurs when the marginal products of all inputs (MP_{X_i}) equals the inverse price ratio (P_{X_i}/P_y). For example, if the function is

$$(a) \quad Y = f(X_i, X_j)$$

maximum output is specified by:

$$(b) \quad \pi = P_y Y - (P_{X_i} X_i + P_{X_j} X_j)$$

where π = maximum output

P = price

Maximization of π with respect to X_i and X_j requires simultaneous solution of two equations.

$$(c) \quad \alpha\pi/\alpha X_i = 0$$

$$(d) \quad \alpha\pi/\alpha X_j = 0$$

to find the combination of X_i and X_j that gives the desired level of Y . The required second order conditions for a maximum is automatically satisfied through the assumption of diminishing returns. The first derivatives of equation (b), equations (c) and (d) can be rewritten as:

$$\alpha Y/\alpha X_i = P_{X_i}/P_y$$

$$\alpha Y/\alpha X_j = P_{X_j}/P_y$$

The above relationships would satisfy the aim of describing the response process. Another possible purpose of response analysis would be that of problem solving. This approach is geared to changing the response result, by controlling input levels, in order to achieve some specified result. Johnson expresses the relationship between positive and normative knowledge:

. . . objective knowledge of the normative can be processed with objective knowledge of the positive to reach objective prescriptive knowledge.³⁷

The normative knowledge in this case is reflected in prices, the positive in the marginal rate of substitution of the inputs and the prescriptive knowledge sought is the optimal level of output (sometimes called profit maximization). The following preconditions for maximization must be established prior to attempting maximization:

1. A common denominator among the goods and the bads involved;
2. Interpersonal validity of that common denominator;
3. Establishment of the second order conditions necessary to insure the existence of a maximum in the common denominator;
4. Agreement on the decision rule to use.³⁸

For use in production function analysis, these preconditions are met in the following way:

1. The use of money as the common denominator via the pricing of inputs and output;
2. It is assumed that money is an interpersonally valid common denominator, i.e., the value of money is the same for all persons;*
3. Second order conditions are established by an underlying assumption of production function theory, i.e., the

³⁷ Johnson, G.L., "Contributions of Economists to a Rational Decision Making Process in the Field of Agricultural Policy." Abbreviated version of a paper presented at the International Agricultural Economists Association Meeting. Nairobi, 1976, p. 4.

³⁸ Ibid., p. 5.

*Generally, economists confine themselves to only Pareto better changes in which case an interpersonally valid common denominator is not needed.

principle of diminishing returns is operative;

4. The decision generally used is that of profit maximization which states that profit is maximized if the marginal value product of the factor is equal to its marginal cost.

Regression Analysis Theory

Crop response functions are typically estimated from experimental data or from cross sectional data by multiple regression using the principle of least squares estimation. Multiple regression is a method of analyzing the collective and separate contributions of two or more independent variables (X_i 's) to the variations of a dependent variable (Y). The principle of least squares estimation involves minimizing the sum of the squared deviations of the observed from the predicted values. Regression techniques are a well developed theory and require no restatement.

When using regression techniques, the resulting estimates are often tested against null hypotheses. The standard error of the regression coefficients and their respective t values are examined for significant difference from zero at a percent level. One percent or 5 percent levels are those most commonly used.

The application of this test was designed to prevent two types of errors called Type I and Type II errors:

Type I error: to reject H_0 but H_0 is true.

Type II error: to accept H_0 but H_0 is false.

The levels of significance mentioned above refer to Type I error, i.e., the error of calling a true hypothesis false. In the majority of experimental work and hypothesis testing, consideration is given

only to the Type I error. The seriousness of committing either one of these errors is dependent on the problem being studied. Statistically it is possible to set any desired levels of protection for both types of error but the number of observations to give this protection is often very large. In the case of most practical work, the number of observations is given and it has been demonstrated in statistical research that if the level of protection for a Type I error is lowered this automatically increases the level of protection for a Type II error, and vice versa.

To use this test for the fitted production function the formulation would be:

$$H_0: \beta_j = 0$$

$$H_a: \beta_j \neq 0$$

This statement of the null hypothesis means that there is no relationship between X_j and Y .

Confidence intervals are often used in addition to testing a null hypothesis. The confidence interval can be estimated using the same information as used to test the null hypothesis and is estimated for the purpose of producing an interval which would contain the true value of the parameter with some given level of probability. If the test statistic falls within this interval the null hypothesis is accepted.

If, as often happens in fitted production functions, the regression coefficients are not significantly different from zero, the implication is that an increase in the input with which that regression coefficient is related will not contribute to an increase in output. Similarly, the test statistic for the regression coefficient

may fall within the confidence interval and one would be convinced that the null hypothesis should be accepted.

For the purpose of productivity analysis the testing of the regression coefficients in a null hypothesis is of limited usefulness. In the discussion of production function theory one of the relations which could be examined was the optimum levels of inputs to attain some level of output. A better method would therefore be to test the regression coefficients necessary to give a minimum set of returns. This type of test would better evaluate the allocative efficiency which would be a concern in productivity analysis.

Fitting the Production Function

From the 145 farmers interviewed for the upland rice sample, 86 usable records were obtained. The entire Northern Plateau (Region 7) and the Riverain Grasslands (Region 4) were not included in the analysis because:

1. Output data were incomplete for Region 7 and;
2. For Region 4, deletion of farms with missing data made the remaining number too small to represent the region.

The variables selected from the output data are:

Y = output: in bushels

X_1 = male labor: hours

X_2 = female labor: hours

X_3 = child labor: hours

X_4 = hired labor: hours

X_5 = cropped land: acres

X_6 = bush age: years

X_7 = seed: pounds

X_8 = capital: Leones

Output -- 22 x 22 feet yield plots were laid out at the time the fields were measured. The farmer cultivated the plots in the same way as the rest of the field and at the time of the major harvest. The yield plot was harvested by the farmer in the presence of the enumerator.

Labor -- measured in actual hours. This input was disaggregated into four classes:

Male: over 15 years of age

Female: over 15 years of age

Child: 10 to 15 years of age

Hired

For purposes of aggregation, as when computing total family labor inputs, man-hour equivalents were computed by applying weights of 1.0, 0.75 and 0.50 to male, female, and child labor, respectively. The weights reflect the relative wage rates on a national basis.

Land -- because of a shifting cultivation, each field was actually measured in each enumeration area.

Bush -- the age was measured by the number of years since the land was previously cropped.

Seed -- measured in pounds for the total acreage.

Capital -- measured in Leones (Le. 1.00 = \$1.10 U.S. in 1974/75) in terms of current depreciated value. The estimated annual capital cost, k , was calculated using the following formula:

$$k = \frac{rV}{1-(1+r)^{-n}}$$

where V is the original (acquisition) cost of the asset, r is the discount rate, and n is the expected life of the asset.

The application of the production function is based on production theory as previously discussed. When fitting the function, further assumptions to those of theory are added, that is, that the relevant variables have been identified and that they have been adequately measured. The problem then is to establish the form and nature of the relationship, i.e., establish the functional relationships among the variables.

The traditional approach is to identify types of functions that appear logical, i.e., consistent with the principle of diminishing returns. These functions are fitted and the function that fits the data "best" is chosen. A common criteria is "best" fit as measured by the highest R^2 (coefficient of multiple determination). There are limitations to this approach:

1. It is based on hindsight, consequently a number of functions will explain the relationships, e.g., the Cobb-Douglas, the modified Cobb-Douglas, the linear and many other types of functions.³⁹
2. When relying exclusively on empirical criterion the following are limitations:
 - a. It is always possible to increase R^2 by adding additional regressors; hence, functions of the same

³⁹MacGregor, M.A., "Statistical Problems in Measuring Production Relationships in Agriculture," Canadian Journal of Agricultural Economics, Vol. 7-8, 1959-60.

form with differing numbers of variables are not comparable.*

- b. A particular functional form may exhibit a high R^2 but may contain coefficients whose presence, signs and/or magnitudes have no theoretical support.
- c. Since R^2 measures the proportion of the variation of the regressand which is explained by the regressors, the R^2 's of functions which have different regressands are not directly comparable, therefore direct comparison of linear functions with logarithmic functions would not be a correct procedure.⁴⁰

With the above in mind, the data were subjected to standard regression analysis using a modified Cobb-Douglas function. The rationale underlying this decision was simply that this function was the one most commonly estimated empirically and is reasonably logical from a theoretical standpoint. The function takes the general form:

$$(1) \quad Y = AX_1^{b_1} \dots X_n^{b_n}$$

where A is a constant, Y is the output and the X_i 's are inputs.

The function is linear in the logarithms and may be specified:

*While R^2 , the coefficient of determination is not comparable for functions with different numbers of variables, R^2 , the adjusted coefficient is more comparable. R^2 takes into account the number of explanatory variables in relation to the number of observations.

⁴⁰Schmitz, A., "A Production Function Analysis as a Guide to Policy in Low-Income Farm Areas," Canadian Journal of Agricultural Economics, Vol. 15, 1967.

$$(2) \log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + \dots + b_n \log X_n$$

The variables, dependent and independent, were as specified earlier, with $n = 8$. The exponents (b_i 's) in the equation are the elasticities of the independent variables (X_i 's) with respect to the dependent variable (Y). The value of these exponents indicates the percentage change in output associated with a one percent change in the respective input category associated with the b_i , holding all other inputs constant. The constant $\log a$ is the intercept of the $\log Y$ axis.

When

$$\sum_{i=1}^n b_i = 1$$

constant returns to scale are exhibited; when

$$\sum_{i=1}^n b_i < 1$$

decreasing returns to scale are exhibited; when

$$\sum_{i=1}^n b_i > 1$$

increasing returns to scale are exhibited.

The marginal productivities of the input categories (X_i) may be calculated directly from the exponents by using the formula:

$$(3) \quad MPP_{X_i} = \frac{b_i \hat{Y}}{X_i}$$

where $\hat{Y}$, the estimated output, is the antilog of $\log Y$ in equation (1) and X_i is the quantity of the input under consideration ($i = 1, \dots, n$).

The strengths of the Cobb-Douglas function for this type of study are:

1. Its simple functional form is computationally economical;
2. It yields statistically significant estimates of the coefficients without imposing excessive demands for large samples.
3. It provides important information such as the extent to which a factor's marginal productivity declines as the level of input increases, given the quantities of all other factors of production; measures of returns to scale; and for the variables included, it is necessary to estimate relatively few parameters.^{41,42} This gives a considerable advantage over other types of functions in costs of computation as well as in minimizing the loss of degrees of freedom.

The limitations of this type of function are:

1. The elasticity of each factor is constant, and
2. All elasticities of substitution of X_i for X_j are constant regardless of the size or ratio of the factors.

These properties are derived from the fact that the function is linear in the logarithms which is the property which makes it possible to fit the function statistically by linear multiple regression. Many of the types of factor substitution found in agriculture are not of

⁴¹Yotopoulos, P.A., and Nugent, J.B., Economics of Development: Empirical Investigations, New York: Harper and Row Publishers, 1976.

⁴²The number of parameters for the equation is one more than the total number of variables.

constant elasticity. This makes special adjustment or rejection of observations necessary where the use of one or more observations is quite small. Shaw and Wright suggest that such adjustment or rejection must be on a subjective basis and they discuss briefly the consequences of adjustment or rejection of observations.⁴³ Griliches, in later articles also discusses the consequences of exclusion of observations.⁴⁴

The values of the parameters of the Cobb-Douglas function were obtained using ordinary least squares technique. The first fitted Cobb-Douglas function in logarithmic form for the selected sample is:

$$\begin{aligned}
 (4) \quad \log Y = & .444 + .094 \log X_1 + .058 \log X_2 \\
 & \quad \quad \quad (.098) \quad \quad \quad (.073) \\
 & - .015 \log X_3 + .096 \log X_4 + 1.058 \log X_5 \\
 & \quad \quad \quad (.020) \quad \quad \quad (.103) \quad \quad \quad (.109) \\
 & - .063 \log X_6 + .049 \log X_7 + .049 \log X_8 \\
 & \quad \quad \quad (.114) \quad \quad \quad (.133) \quad \quad \quad (.071)
 \end{aligned}$$

The b_i 's in the equation are the elasticities of the dependent variable (Y) output in bushels, with respect to the independent variables (X_i 's). The value of these b_i 's indicates the percentage change in output associated with a one percent change in the respective input category, holding all other inputs constant. The constant $\log a$ is the intercept on the $\log Y$ axis.

The regression coefficients (b_i 's), the associated standard errors (σ_{b_i}), and the level of significance are shown in Table 7. Land showed the only significant difference from zero at a low level,

⁴³Shaw, H.R., and Wright, P.A., "Alternative Methods of Farm Management Analysis," Canadian Journal of Agricultural Economics, Vol. 3, No.1, 1955, pp. 74-75.

⁴⁴Griliches, Z., "Specification Bias in Estimates of Production Functions," Journal of Farm Economics, 39:8-20, 1957.

Table 7. Regression Coefficients (b_i 's), Their Standard Errors (σb_i 's), and Level of Significance, 86 Upland Rice Farms: Sierra Leone, 1974/75

Input Category	b_i	σb_i	Significance Level
Male Labor	.09402	.09791	.359
Female Labor	.05764	.07268	.430
Child Labor	-.01492	.02027	.464
Hired Labor	.09588	.10278	.358
Land	1.05767	.10921	.000
Bush	-.06310	.11443	.583
Seed	.04855	.13349	.717
Capital	.04924	.07135	.492

the one percent level. The other inputs ranged in significant difference from zero from the 35 percent level to the 72 percent level.

More important than the percentage level at which there is significant difference from zero for the purpose of economic analysis is the sum of the regression coefficients (b_i 's) which was 1.325, indicating increasing returns to scale. This sum of the coefficients was tested to determine whether significantly different from one. There was significant different from one at the one percent level; therefore, the indication of increasing returns to scale was accepted. The implication is that an increase in all inputs of one percent would lead to a 1.325 increase in output.

It should be noted that although this indication of increasing returns is accepted, it is with qualifications. These estimates are based on averages and therefore it can not be assumed that increasing returns to scale apply to individual farms. The implication would be that farm size would be increasing. The average farm size in Sierra Leone is less than 6 acres with a range of 1 acre to 21 acres which

indicates relatively few large farms; therefore, while increasing returns to scale is statistically significant, this result is questionable on the basis of general evidence about Sierra Leonean agriculture.

The simple correlations among the logs of the input categories are shown in Table 8. Land (X_5) showed the highest correlation with output. The multiple correlation (R) was .82. The coefficient of determination was .69, while the adjusted coefficient (R^2) was .66. Using the adjusted coefficient gives an indication that 66 percent of the variation in the logarithm of the dependent variable (Y) output, was associated with the independent variables included in the equation. The unexplained variance of 34 percent may be attributed to variables such as the weather,⁴⁵ other inputs and institutional arrangements which are difficult to quantify. The effects of such non-included variables on the log of the output are assumed to be randomly distributed.

Because of the difficulties involved in measuring adequately some of the input (and in defining what is a input⁴⁶), a second function which omitted the input category of bush was run in an attempt to obtain a better fit with greater confidence in the meaning of the regression coefficients. The logarithmic form becomes:

⁴⁵The upland rice yields are about 60 percent of those reported in earlier surveys due mainly to the pattern of rainfall that prevailed in Sierra Leone in the 1974/75 crop season. See Spencer and Byerlee, *op. cit.*, p. 54.

⁴⁶Bush age may not be a suitable variable as is, i.e., as a measure of soil fertility. If bush were multiplied by acreage it would have given total land availability but this would not be an appropriate measure as the aim was to estimate a coefficient for land actually under cultivation for the crop year.

Table 8. Regression 1: Regression Equation and Correlation Coefficients for 86 Upland Rice Farms: Sierra Leone, 1974/75

$$\log Y = .444 + .094 \log X_1 + .058 \log X_2 - .015 \log X_3 + .096 \log X_4 + 1.058 \log X_5$$

$$- .063 \log X_6 + .049 \log X_7 + .049 \log X_8$$

	R = 0.82		R ² = 0.69		R ² = 0.66			
Supplemental Statistics	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈
Correlation Coefficients:								
Male Labor....X ₁	1.							
Female Labor...X ₂	.195							
Child Labor....X ₃	.029	.137						
Hired Labor....X ₄	.393	.261	.065					
Land.....X ₅	.296	.232	.207	.376				
Bush.....X ₆	.380	-.039	.072	.240	.265			
Seed.....X ₇	.218	.345	.243	.237	.440	.116		
Capital.....X ₈	-.010	.134	.164	.316	.244	.065	.126	
Output.....Y	.321	.273	.132	.406	.815	.204	.399	.253
Regression Coefficients ^a	.094	.058	-.015	.096	1.058	-.063	.049	.049
Standard Error	.098	.073	.020	.103	.109	.114	.133	.071
t Values	.923	.793	-.736	.933	9.685 ^b	-.551	.364	.690

^aThe regression coefficients are the elasticities of the dependent variable (Y) output, with respect to the independent variables (X_i's).

^bSignificantly different from zero at the 1 percent level.

$$\begin{aligned}
 (5) \quad \log Y = & .433 + .074 \log X_1 + .065 \log X_2 - .015 \log X_3 \\
 & \quad \quad \quad (.093) \quad \quad \quad (.071) \quad \quad \quad (.021) \\
 & + .091 \log X_4 + 1.049 \log X_5 + .049 \log X_7 \\
 & \quad \quad \quad (.101) \quad \quad \quad (.107) \quad \quad \quad (.132) \\
 & + .048 \log X_8 \\
 & \quad \quad \quad (.071)
 \end{aligned}$$

The modified equation had an adjusted coefficient of determination (R^2) of .66 which is identical to the initial equation. The sum of the coefficients (b_i 's) increased by .036 or a 2.7 percent increase to 1.361.

A comparison of Table 9 and Table 10 shows insignificant changes for most of the regression coefficients (b_i 's). A noticeable change occurred in the regression coefficients for male labor and female labor. The male labor coefficient decreased by 21 percent while the female labor coefficient increased by 12 percent. This phenomena is discussed by Griliches in the article previously cited.⁴⁷ In summary, if one accepts as a plausible assumption that there is correlation to some extent between the excluded variable and the included variables, the exclusion will bias the estimate of at least one of the coefficients upward and in this particular function because the sum of the coefficients was larger than one, there will be an overestimation.

A third function aggregated labor into a single input category. This was accomplished using the weighing system previously specified which gives homogeneous man-hours. The rationale for the estimation of this farm follows from the general rule of classifying input categories, i.e., combine good substitutes and measure according to

⁴⁷Griliches, op. cit., pp. 10-13.

Table 9. Regression 1: Input Categories and Output (in Logarithms and Antilogarithmic Form), Regression Coefficients (b_i 's) and Marginal Products of the Inputs, 86 Upland Rice Farms: Sierra Leone, 1974/75

Input Category	$\log \bar{X}_i$	Antilog $\bar{X}_i$	b_i	$\log Y$	Antilog Y	MPP X_i	MVP X_i
X_1	7.1351	1255.26	.094	3.823	45.741	.0034	.02
X_2	6.7967	894.89	.058	3.823	45.741	.0030	.02
X_3	2.6574	14.26	-.015	3.823	45.741	-.0481	-.24
X_4	6.3203	555.74	.096	3.823	45.741	.0079	.04
X_5	1.4423	4.23	1.058	3.823	45.741	11.4407	57.20
X_6	2.0119	7.48	-.063	3.823	45.741	-2.8816	-14.41
X_7	5.2741	195.22	.049	3.823	45.741	.0115	.06
X_8	1.8268	6.21	.049	3.823	45.741	.3609	1.81

Table 10. Regression 2: Input Categories and Output (in Logarithms and Antilogarithmic Form), Regression Coefficients (b_i 's) and Marginal Products of the Inputs, 86 Upland Rice Farms: Sierra Leone, 1974/75

Input Category	$\log \bar{X}_i$	Antilog $\bar{X}_i$	b_i	$\log Y$	Antilog Y	MPP X_i	MVP X_i
X_1	7.1351	1255.26	.075	3.797	44.574	.0026	.013
X_2	6.7967	894.89	.065	3.797	44.574	.0032	.016
X_3	2.6574	14.26	-.015	3.797	44.574	-.0469	-.234
X_4	6.3203	555.74	.091	3.797	44.574	.0073	.037
X_5	1.4423	4.23	1.049	3.797	44.574	11.054	55.270
X_7	5.2741	195.22	.049	3.797	44.574	.011	.056
X_8	1.8268	6.21	.048	3.797	44.574	.345	1.715

the common denominator which makes them good substitutes and/or good complements. The form with labor inputs aggregated becomes:

$$(6) \log Y = -.352 + \frac{.322 \log X_1}{(.138)} + \frac{1.024 \log X_5}{(.104)} + \frac{.001 \log X_7}{(.128)} + \frac{.050 \log X_8}{(.064)}$$

Table 11 shows the results. In terms of R (.83), R^2 (.69), R^2 (.67), and the Σb_i 's (1.397), regression 3 does not differ significantly from regression 2 in which the labor inputs are disaggregated.

The decision as to the final form of the function and the specification of the variables should be based on more than arbitrary choice. The justification for choosing to use the disaggregated form, equation (5) is as follows: male labor, hired labor, female labor and child labor are complementary. Complementary as used here does not imply complementarity in the economic sense which involves proportionality between the inputs. Rather, the term is used in the sense that there are certain tasks for certain labor classes which are more or less institutionalized. These socio-cultural constraints also prevent the labor classes from being good substitutes for all farm tasks. For example, although women are capable of many of the less arduous bush clearing activities, in fact, they do not engage in such activities even when it leads to the employment of hired labor to accomplish these activities. Therefore, when evaluating allocative efficiency by comparing the marginal value product of labor to the market wage rate, it seems appropriate to do so with disaggregated marginal value products of labor.

As with equation (4), equation (5) contains only one independent variable, land (X_5), which is significantly different from zero at the

Table 11. Regression 3. Input Categories and Output (in Logarithms and Antilogarithmic Form), Regression Coefficients (b_i 's) and Marginal Products of the Inputs, 86 Upland Rice Farms: Sierra Leone, 1974/75

Input Category	$\log \bar{X}_i$	Antilog $\bar{X}_i$	b_i	$\log Y$	Antilog Y	MPP X_i	MVP X_i
X_1	7.9891	2942.75	.322	3.792	44.351	.0049	.024
X_5	1.4428	4.23	1.024	3.792	44.351	10.7464	55.68
X_7	5.2741	195.22	.001	3.792	44.351	.0002	.001
X_8	1.8268	6.21	.050	3.792	44.351	.3571	1.786

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one percent level. This significance of only one variable could be interpreted in various ways. One could hypothesize that:

1. there is high correlation between land and the other variables. If a high correlation existed, the extent could be ascertained by examining the correlation coefficients shown in the simple correlation table. A correlation coefficient greater than $|0.8|$ between a pair of independent variables is usually taken as evidence of high multi-collinearity. This does not appear to be the case.
2. land is the most important factor in the productive process. This statement is, of course, true but is not a sufficient reason for the lack of significance of the other inputs.
3. the level of aggregation, e.g., the labor inputs are aggregated for the entire year, may have an effect of the resulting coefficients. This indication of seasonality will be discussed more fully at a later point.
4. in addition to possible seasonality, there will be unexplained variance.

The marginal physical products (MPP_{X_i}) of the input categories (X_i 's) were calculated directly from the exponents using the formula given in equation (3). The marginal value products represent the value of the marginal physical products at the per unit cost of Le. 5.00 which was the minimum government price per bushel during the 1974/75 crop season.

The marginal value product for male labor (X_1) of Le. .013 is below the value of Le. .02 specified by Spencer and Byerlee as the

hourly return to labor.⁴⁸ Of special interest is the marginal value product for female labor (X_2) which at Le. .016 is higher than for males although not significantly so. The going wage rate for women is .75 percent of the male wage rate but in so far as can be determined from this data, the value of female labor is the same as the value of male labor. This has implications for the weighing system which was used here. The utilization of a conversion scale, whereby women have been weighed by 0.75 may be inappropriate. In recent studies Spencer and Tollens have used a weight of 1.0 for women based on the belief that women are as efficient as men in the types of farm work performed by women and that any conversion of female and child labor to man labor units is arbitrary.^{49,50}

The negative value for child labor (X_3) is not startling. While child labor may be used for such tasks as bird-scaring, the quantity of labor used is small and the negative sign would indicate that there is a substitute for child labor. Since it is known that females also perform this task, female labor may substitute for child labor.

The calculated marginal value product of land (X_5) appears to be very high but whether in fact it is high will be determined by the equating of marginal value product and marginal factor cost. The capital (X_8) marginal value product may be realistic or it may not. It is entirely dependent on the source of the capital. If the farmer

⁴⁸Spencer and Byerlee, op. cit., p. 59.

⁴⁹Spencer, op. cit., 1972, p. 15.

⁵⁰Tollens, E.F., "Problems of Micro-Economic Data Collection on Farms in Northern Zaire." African Rural Employment Working Paper No. 7, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, 1975, p. 18.

borrowers at an established credit institution (bank) the interest rate will be approximately 11 percent. If borrowing from a local lender, the range of interest may be very wide. The same is the case when borrowing from relatives and friends.

Equating Marginal Value Product and Marginal Factor Cost

Theoretically the farms should make use of the inputs at the level where the marginal value product of each input is equated with the marginal factor cost of the input ($MVP = MFC$). Rather than test the regression coefficients against the null hypothesis, the estimated regression coefficients (b_i) shown in Table 5 were compared with the coefficient which would be required to yield marginal value products equal to a set of minimum expected returns. This calculation was done for the labor and land inputs although in Sierra Leone, as in many African countries, it is difficult to value land because there is no land market. Similarly, the true opportunity cost of capital is difficult to establish since there is usually a fragmented capital market. The minimum expected returns are:

Male labor per hour	.10 Le.
Female labor per hour	.075 Le.
Child labor per hour	.050 Le.
Hired labor per hour	.10 Le.
Land per farm	5.00 Le.

1. The minimum expected return on male labor was based on the national average hourly wage rate for Sierra Leone during the 1974/75 crop year.

2. The minimum expected return on female labor was based on the national average hourly wage rate. This rate was generally 0.75 percent of the male wage rate.
3. The minimum expected return of 0.50 for child labor is based on child labor being calculated at 50 percent of an adult male.
4. The hired labor rate is normally the same as the first three categories, dependent upon sex and age. However, for reasons of simplification, all hired labor was converted to man-hour equivalents using weights of 0.75 and 0.50 for female and child labor, respectively. The rationale for this is that the quantity of female and child hired labor was not sufficient to justify a separate category within the regression on one hand but on the other, was sufficiently significant such that it could not be ignored.
5. Land return is the amount given as rent for the entire farm. Most land is communally owned in Sierra Leone and this type of ownership has not been a serious constraint to rice production. The family communal system of land ownership has precluded the development of an effective market for agricultural land. Additionally, there is a land surplus. Token fees are sometimes paid by a small proportion of farmers and it is this token fee which is being used here.

The regression coefficient which will yield a minimum return will be termed the standard regression coefficient and designated b_i^* . This b_i^* was obtained by solving for equation (7):

$$(7) \quad b_i^* = \frac{MVP_{X_i} \cdot X_i}{Y}$$

where MVP_{X_i} is the expected return; X_i and Y are from equation (5). Table 12 shows the results of the calculations.

Table 12 also shows the t-test which was used to test whether the estimated regression coefficient ($\hat{b}_i$) was significantly different from the standard regression coefficient (b_i^*) required to yield a minimum return. The t-value was derived using the following equation (8):

$$(8) \quad t = \frac{\hat{b}_i - b_i^*}{\sigma b_i}$$

The results indicate that the estimated regression coefficients ($\hat{b}_i$'s) for the labor classes of male, female and hired labor were significantly different from the standard regression coefficients (b_i^* 's) at the 5 percent level. Taken at face value this would indicate misallocation of these resources.

There are several hypotheses one could suggest to explain these results.

1. The result may reflect that the wage rate is inappropriate for use in this context. It has been suggested that since the demand for wage labor is seasonal, it may be artificially high, that is, not reflect the year round cost of labor.
2. Measurement problems--when a farmer is asked the amount of time spent on his upland rice farm and he gives a number of hours, these hours may be recorded without qualification.

Table 12. Comparison of the Estimated Regression Coefficients ($\hat{b}_i$'s) and the Standard Regression Coefficients (b_i^* 's) Required to Yield Minimum Marginal Value Products

b_i	$\hat{b}_i$	b_i^*	Difference $\hat{b}_i - b_i^*$	Standard Error	t Value	Level of Significance at 5 Percent
b_1	.074	2.816	-2.742	.092	5.961	Significant
b_2	.065	1.506	-1.441	.071	4.059	Significant
b_3	-.015	.016	-.031	.020	.310	Not Significant
b_4	.091	1.247	-1.156	.101	2.289	Significant
b_5	1.049	.475	.574	.108	1.063	Not Significant
b_7	.049					
b_8	.048					

No consideration as is given to the "arduousness and urgency" of the task being performed. These, taken together with his health and environmental factors will result in substantially different rates of work for the same task. What this means in a practical sense is that the farmer may take an entire day at a task on one occasion but complete the same task in a matter of hours on another occasion. The implication for productivity analysis is that the labor input will be overestimated in terms of hours productively engaged and the results would make it appear that productivity is quite low.

3. Seasonality--one of the weaknesses of fitting an annual function is that it does not allow for the introduction of time, i.e., in this case the year is condensed into a point in time. But most agricultural work is highly seasonal, reflecting the effect of climate on the biological processes in agricultural production. This means that the demand for labor for a particular enterprise will also be seasonal, displaying wide fluctuations, while the supply of family labor is relatively evenly distributed throughout the year.

During these slack periods, the productivity of the family labor is very low and one could say, does not effectively contribute to output. However, since hired labor is used only in those particular seasons when required, their productivity would be expected to be high. Further, if productivity analysis were done only for the seasons when there was hired labor present, we could expect to find that family

labor productivity was also high. As hired labor is used mainly in periods of high productivity, the higher marginal value productivity estimates for hired than family labor is reasonable.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This paper attempts to add to the body of knowledge about traditional agriculture among upland rice farmers in Sierra Leone, the farm characteristics, labor utilization, and possible constraints to increased productivity.

Characteristically, an upland farmer cultivates about 6 acres per year but when taking the bush fallow system into consideration, he has access to about 50 acres. The upland farmer uses traditional methods and tools, i.e., does not make use of fertilizers or machinery, consequently his capital input is quite small.

Labor, then, is the primary input with family labor the primary source. Hired labor is used in all regions and comprises 22 percent of the total labor input. This is 2 percent higher than reported by Spencer and Byerlee⁵¹ and may be attributed to the high use of hired labor (35 percent) in the Southern Coast which is characterized by the unusual demographic features of small household size (5.4) and high net out-migration rates (over 12 percent).

The remaining 78 percent of the labor input which is the family contribution may be broken down as follows: males - 46 percent; females - 26 percent; and child - 6 percent. It is worth noting that Moa Basin had a much higher incidence of the use of female labor at

⁵¹Spencer and Byerlee, op. cit., p. 28.

40 percent more than the other regions.

The average male labor input, combining both family males and hired males, was 1,330 hours per year or 110 hours per month. This is a deceptively low figure. When looking at the peak month, it is seen that male labor inputs are 229 hours. A similar analysis holds for female labor. The yearly average is 506 hours or 42 hours per month but in the peak month female labor contributes 107 hours.

The output of rice from the farms averaged 780 pounds per acre, varying from 497 pounds in the Scarcies to 1,174 pounds per acre in the Northern Plains. It was noted that the rainfall pattern had contributed to a 60 percent lower yield than normally expected.

Relating man-hours to yield, an average labor input of about 62 hours was required to produce one pound of rice. The range was from a low of 36 hours in Moa Basin to 88 hours in the Southern Plains.

Cobb-Douglas functions were fitted for three equations. The initial Cobb-Douglas, using eight independent variables was not analyzed because it was felt that bush as measured in years between cultivation periods was an inappropriate measure of soil fertility, i.e., not really an input.

In the second regression equation with seven independent variables, four labor classes, land, seed, and capital, the marginal value products were calculated. The male labor value of 0.013 Le. was less than previous studies have found. This may be due to rounding differences. Female labor value was higher than male at 0.016 Le., a somewhat unexpected result. However the value was not significantly higher which implies equality. This suggests that within the sex-related tasks, the female is as productive as the male. Hired labor

had a value three times that of male labor which may suggest that there are variations in the quality and intensity of labor, i.e., paid labor is more effective than family labor. Child labor was not significant and could very easily be substituted for by female labor. Nothing conclusive was said earlier in the text about the marginal value products of land, seed, and capital because no land market exists, seed is retained from the previous year's crop, and the capital market is highly fragmented. However, after determining the b_i^* required to equate the MVP and MFC of land, it was discovered that b_i and b_i^* were not significantly different. This implies allocative efficiency in the use of land.

A third function with labor aggregated into an homogeneous input yielded regression coefficients which were not statistically significant from zero and the equation had the same explanatory power as the disaggregated labor equation, therefore the second equation was used for further analysis.

The standard regression coefficients required to yield a minimum expected return were derived by which to test the estimated regression coefficients. The results indicated that, if no error had been made in the estimation, the utilization of labor resources was not at the efficient level of organization. However, the hiring of labor during the planting and harvesting seasons even on the smallest farms makes it difficult to accept these results.

When taking into consideration that the measurement of labor use was for the entire year and therefore does not say anything explicitly about the existence of excess labor or labor shortages at particular seasons during the year, one feels that the calculated marginal value

products may be misleading, i.e., too low for the labor inputs. Another consideration is the validity of equating the family year round productivity with a seasonal wage rate. A more detailed analysis of regional and seasonal productivities would be required less one make such sweeping generalizations as to cast doubt on the whole analysis.

However, based on the information available, it may be concluded that the use of non-family labor is an important factor during the peak season and helps to relieve labor constraints at that time. But in Sierra Leone, a class of landless laborers has not yet arisen, consequently the time non-family labor would be most in demand coincides with the period when this labor must also devote more time to their own farms. Therefore, not only the extent to which a family can afford to employ non-family labor but the availability of this labor at the appropriate time is of importance.

Njoku and Karr⁵² have suggested that one possible way to increase upland rice production in Sierra Leone is to increase the labor availability by adjusting agricultural prices, thereby providing increased employment opportunities in the agricultural sector for the rural to urban migrants. This possibility should not be casually dismissed; however, evidence both in Sierra Leone and other countries suggests income may not be the most important variable in the decision to migrate to an urban area; further, the net rate of out-migration is not very high in Sierra Leone.

Another suggestion is that perhaps the output of the current labor force can be increased by shifts, i.e., redistribution of labor

⁵²Njoku and Karr, op. cit., p. 297.

within the agricultural sector. The feasibility of this suggestion is dependent on many factors. For example, if the peak season for upland rice farmers coincides with the slack season for farmers using other modes of production (such as mangrove swamp or inland swamp rice) or for farmers with other crops and this does not conflict with their other off-farm activities, with economic incentives, this seasonal migratory employment pattern may be helpful.

In addition to increased output due to labor availability, labor productivity must be considered. Productivity increases can be obtained by using non-traditional inputs. Among the conventionally suggested inputs are tractorization, combine harvestors, improved seed varieties, fertilizers, pesticides, water control, small mechanical aids and more efficient hand tools.

With respect to tractorization, Spencer and Byerlee⁵³ point out that the use of tractors in Sierra Leone was only possible with heavy government subsidization. That is to say, without the subsidy, it is not economically feasible to use tractors. Additionally, while tractor cultivation may relieve constraints at one point, the labor constraints are often transferred to other periods such as the time of harvesting.

The use of the combine harvester is possible only on farms of a much greater acreage than the average farm size for the Sierra Leone upland rice farms. Further, Winch has reported that in Ghana the increased output was only 17 percent for the large farms using combine

⁵³Spencer and Byerlee, op. cit., p.

harvestors while the labor displacement in man-hours was very high.⁵⁴

A more fruitful avenue to increased productivity would be the use of small mechanical aids, more efficient hand tools, improved seed varieties, fertilizers, and pesticides. A discussion of the requirements for the introduction and adoption of these non-traditional inputs in Sierra Leone is not within the scope of this study but will be further pursued in a later study.

⁵⁴Winch, F.E., "Costs and Returns of Alternative Rice Production Systems in Northern Ghana: Implications for Output, Employment and Income Distribution." Unpublished Ph.D. Dissertation, Michigan State University, East Lansing, 1976, p. 136.

BIBLIOGRAPHY

BIBLIOGRAPHY

- Byerlee, D. and Eicher, C.K. Rural Employment, Migration, and Economic Development: Theoretical Issues and Empirical Evidence From Africa. African Rural Employment Paper No. 1, East Lansing: Department of Agricultural Economics, Michigan State University, September 1972.
- Clayton, E.S. Agrarian Development in Peasant Economies. Oxford: Pergamon Press, 1964.
- Clayton, E.S. Economic Planning in Peasant Agriculture. Department of Agricultural Economics, Wye College, University of London, 1970.
- Crauford, R.Q. and Carpenter, A.J. "Partial Mechanization of Rice in Sierra Leone," World Crops, Vol. 20:1, March 1968.
- Dillon, J.L. The Analysis of Response in Crop and Livestock Production. Oxford: Pergamon Press, 1968.
- Griliches, Z. "Specification Bias in Estimates of Production Functions." Journal of Farm Economics, 39:8-20, 1957.
- Government of Sierra Leone. National Development Plan, 1974/75 - 1978/79. Central Planning Unit, Ministry of Development and Economic Planning, Freetown, 1974.
- Heady, E.O. and Dillon, J.L. Agricultural Production Functions. Ames: Iowa State University Press, 1972.
- Jarrett, H.R. A Geography of Sierra Leone and the Gambia. London: Longmans and Green, 1954.
- Jedrej, M.C. "Sociological Aspects of Mechanical Cultivation in the Southern Province of Sierra Leone." Mimeo. School of Development Studies, Njala University College, Njala, Sierra Leone, April 1967.
- Johnson, G.L. "Contributions of Economists to a Rational-Decision-Making Process in the Field of Agricultural Policy." Abbreviated Version of a Paper Presented at the International Agricultural Economists Association Meeting, Nairobi, 1976.
- Jordan, H.D. "Rice in the Economy of Sierra Leone." World Crops, Vol. 17:4, December 1965.

- Kallon, M.F. The Economics of Rice Production in the Inland-Valley Swamps of Sierra Leone. Unpublished Masters Thesis, University of Illinois, Urbana, 1971.
- Karr, G.L. "The Use of Subsidies for the Promotion of Inland Swamp Development." Economic Trends, Bank of Sierra Leone, November-December, 1969.
- Karr, G.L.; Njoku, A.O.; and Kallon, M.F. "Economics of Upland and Inland Rice Production." Illinois Agricultural Economics, Vol. 12:1, Department of Agricultural Economics, University of Illinois, January 1972.
- Lipton, M.A. "The Theory of the Optimizing Peasant." Journal of Development Studies, 4:327-351, 1968.
- Little, K. "The Mende Rice Farm and Its Cost." Zaire, Vol. 5:3, March, 1971.
- Little, K. The Mende of Sierra Leone. London: Rowledge and Paul, 1967.
- MacGregor, M.A. "Statistical Problems in Measuring Production Relationships in Agriculture." Canadian Journal of Agricultural Economics, Vol. 7-8, 1959-60.
- Mellor, J.W. The Economics of Agricultural Development. Ithaca: Cornell University Press, 1966.
- Morgan, T. Economic Development: Concept and Strategy. New York: Harper, 1975.
- Myint, H. "Agriculture and Economic Development in the Open Economy" in Agriculture in Development Theory, Reynolds, ed., New Haven: Yale University Press, 1975.
- Njoku, A.O. Labor Utilization in Traditional Agriculture: The Case of the Sierra Leone Rice Farms. Unpublished Ph.D. Dissertation, University of Illinois, Urbana, 1971.
- Njoku, A.O. and Karr, G.L. "Labor and Upland Rice Production." Journal of Agricultural Economics (Reading), Vol. 24, No. 2, May 1973.
- Odell, R.T. and Dijkerman, J.C. Properties, Classification and Use of Tropical Soils, With Special Reference to Those in Sierra Leone. Njala, Sierra Leone: Njala University College, 1967.
- Osifo, D.E. and Anthonio, Q.B.O. "Costs and Returns: A Study of Upland Paddy Production Under Traditional Farming Conditions in the Wasimi and Ilaro Areas of the Western State of Nigeria." Nigerian Journal of Economics and Social Studies, 12(3):303-314, 1970.

Rice Research Station. Annual Report of the West African Rice Research Station.

Roddan, G.M. "The Cultivation of Swamp Rice in Sierra Leone." Tropical Agriculture, Vol. XIX:5, May 1942.

Saylor, R.G. The Economic System of Sierra Leone. Durham: Duke University Press, 1967.

Schmitz, A. "Production Function Analysis as a Guide to Policy in Low-Income Farm Areas." Canadian Journal of Agricultural Economics, Vol. 15, 1967.

Shaw, H.R. and Wright, P.A. "Alternative Methods of Farm Management Analysis." Canadian Journal of Agricultural Economics, Vol. 3, No. 1, 1955.

Sierra Leone Monthly Economic Trends. Issues From 1969 to 1974. Bank of Sierra Leone.

Spencer, D.S.C. "Rice Production and Marketing in Sierra Leone." Paper presented at the Conference on "Factors of Agricultural Growth in West Africa," Legon, Ghana, March 1971.

Spencer, D.S.C. The Efficient Use of Resources in the Production of Rice in Sierra Leone: A Linear Programming Study. Unpublished Ph.D. Dissertation, University of Illinois, Urbana, 1971.

Spencer, D.S.C. Micro-Level Farm Management and Production Economics Research Among Traditional African Farmers: Lessons From Sierra Leone. African Rural Employment Paper No. 3, Department of Agricultural Economics, Michigan State University, September 1972.

Spencer, D.S.C. and Byerlee, D. Small Farms in West Africa: A Descriptive Analysis of Employment, Incomes and Productivity in Sierra Leone. African Rural Economy Program Working Paper No. 19, Department of Agricultural Economics, Michigan State University, February 1977.

USDA/USAID. Rice in West Africa. Washington, D.C., December 1968.

Winch, F.E. "Costs and Returns of Alternative Rice Production Systems in Northern Ghana: Implications for Output, Employment and Income Distribution." Unpublished Ph.D. Dissertation, Michigan State University, East Lansing, 1976.

Yotopoulos, P.A. and Nugent, J.B. Economics of Development: Empirical Investigations. New York: Harper and Row Publishers, 1976.



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