THE ECONOMICS OF MECHANICAL CULTIVATION OF RICE LANDS IN SIERRA LEONE

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Rice production in Sierra Leone has not been sufficient to meet domestic demand despite intensive efforts by the National Government to increase production through the operation of a Mechanical Cultivation Scheme. The success of mechanization in many other countries at least suggests that some factors are operating in them which, up to this time, have not been exploited in Sierra Leone. The purpose of this investigation is to carefully study the Scheme and attempt to develop ways in which use of mechanical power can contribute more fully to increasing rice production and lowering the unit costs of production. An in-depth analysis of the Mechanization Scheme at Torma Bum in 1970 has been the focus of this study. Field work for collecting the data relevant to the study was conducted during September 1969 to July 1970, inclusive.

The study has had four objectives: (1) to identify and interpret the interrelationships of the farming systems in the Torma Bum area; (2) to identify important factors favoring or hindering the expansion of the Mechanization Scheme; (3) to determine feasible ways of reducing unit costs so as to make the operations more efficient and economical; (4) to develop generalizations which can serve as the basis for planning and organization of mechanical cultivation elsewhere in the country.

On the basis of the analysis of the data, there was conclusive evidence in support of the general hypothesis that

"cultivation costs per acre in the Torma Bum Scheme can be substantially reduced." A least-cost-approach to budgeting analysis was used in testing this hypothesis. The basis of the analysis rests upon the concepts of fixed, variable, and energy costs.

Costs associated with operating 33 tractors on 35 plowing sites were determined. The plowing cost per acre was calculated to be Le 14.13 based on 7,362 acres plowed during the 1970 season. Harrowing and seed harrowing were done to the extent of 5,416.5 and 4,140.0 acres, respectively; their costs per acre were determined to be Le 4.75 and Le 4.69, respectively. The analysis revealed that operating costs per acre were high because of the high incidence of mechanical breakdowns of tractors which may be traced partially to inadequate supervision. While this latter cause may not be due to lack of properly trained supervisory staff it may be traceable to certain local customs as well as attitudes. The number of tractors operating declines weekly. In the fourth week of the season, as many as seven tractors became inoperable. During the twelfth week, seventeen (or 52 percent of the original 33) were operating; from the eighteenth week to the end of the season in July, no more than four tractors (or 12 percent of the original fleet) were ever able to work during any given week.

Many plowing sites are too small to permit economic operations. On these sites, capital cost per acre is high, operating cost per acre is high. These factors coupled with the difficult accessibility conditions that prevail indicate definitively that these small sites should be eliminated. This would permit

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INTRODUCTION

The Problem

The existence of a Mechanical Cultivation Scheme for the past 20 years in Sierra Leone has not enabled that country to increase rice production enough to eliminate imports of rice, nor has it had the effect of materially reducing the costs of production.

The success of mechanization in many other countries at least suggests that some factors are operating in them which, up to this time, have not been achieved in Sierra Leone. The purpose of this investigation is to carefully study the Mechanical Cultivation Scheme and attempt to develop ways in which use of mechanical power can contribute more fully to increasing rice production and lowering the unit costs of production.

The Significance to Sierra Leone

Among many West African countries Sierra Leone is conspicuous for its dependence on rice as the most important staple cereal crop in the diet of the people. Rice consumption per capita in the country is one of the highest in the world; rice provides almost one-half of the calories in the diet of the people;[1] 86.3 percent of the farmers grow rice.[2] For the

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[1] Pauline Whitby, "Food Consumption, Nutrition and Demand Projection," unpublished working paper, UNDP/FAO Project IDAS, 1968, p. 21.

[2] Agricultural Statistical Survey of Sierra Leone 1965/66, Central Statistics Office, Freetown, March 1967, p. 13.

years 1950 to 1968 inclusive, paddy rice accounted for 90 percent of the total production of all cereals in the country.[3] Between 1954/55 and 1964/65, rice accounted for between 35 and 43 percent of the total value of agricultural production[4] and is the most important crop entering commercial trade, making up 30 percent of farm sales.[5]

In recent years the country has had difficulty meeting its domestic needs, and substantial imports have been necessary. However, there is potential for increased production of rice. Upland rice cultivation, although more widespread and long established, has failed to produce yields of sufficient magnitude to satisfy domestic demand. Indeed, the yields have been quite low even in the best areas, amounting to just 850 pounds per acre, while the swamp rice was yielding between 740 and 1,800 pounds per acre.[6]

During the late 1920's and early 1930's swamp rice cultivation was introducted into the Central and Southern Provinces. Under government auspices Temne mangrove fellers and instructor

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[3] Whitby, op. cit., p. 23.

[4] R. J. Mutti, Marketing Staple Food Crops in Sierra Leone, Department of Agricultural Economics, University of Illinois, Urbana-Champaign, 1968, p. 29.

[5] Agricultural Statistical Survey of Sierra Leona 1965/66, p. 13.

[6] J. I. Clarke, Sierra Leone in Maps, University of London Press Ltd., 1966, p. 76.

planters went to work in the areas around Sembehun, Moyamba, Bonthe, Pujehum, Gbangbama and Gbangbatok, all of which are now well defined swamp rice areas. The extension of the clearing scheme continued in the 1940's and between 1947 and 1957 the acreage of upland rice decreased by 20 percent.[7]

Since 1950 mechanical cultivation schemes have been sponsored by the government in order to improve production and to encourage farmers to produce rice in the southern deep-flooding grassland areas which are quite difficult to farm with traditional methods of cultivation. Since that time five plowing circles in which tractor units operate have been in existence in the country.

Several other measures have been taken to encourage rice production: establishment of the Rokupr Rice Research Station; swamp clearance schemes; seed distribution and credit extension programs; subsidized fertilizer schemes; location of rice mills near surplus producing areas and pegging of rice prices.[8]

Simultaneously with these developments, the Department of Agriculture began experimenting with the technical adaptability of tractors to Sierra Leonean conditions in the hope that mechanical cultivation schemes could be expanded on a large scale. However, these programs have not expanded production

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[7] Ibid., p. 76.

[8] R. G. Saylor, The Economic System of Sierra Leone, Duke University Press, Durham, North Carolina, 1967, pp. 75-85.

sufficiently to eliminate Sierra Leone's dependence on imported rice. During the 1954-1969 period, the average annual imports were over 21,000 tons (Table 1-1).[9] The Department of Agriculture believed that rice production could be expanded over 50 percent by mechanically cultivating 330,000 acres, but the largest area yet cultivated with the aid of mechanical devices amounts to just 24,276 acres.

The costs to the Sierra Leone government of developing and operating the mechanical cultivation schemes have been quite substantial in spite of some efforts to operate cooperative plowing schemes. Unless these operations are to be heavily subsidized by the government, their continuation is dependent upon improvements in the efficiency of organization.

Accordingly, there are several practical matters which an analysis of the feasibility and economy of mechanical cultivation must consider:

1. The physical conditions of the areas concerned: topography, soils, water control, and size of fields.
2. The labor situation: its availability during periods of peak requirement, particularly for the weeding and harvesting operations; present output per man, and probable increase with machinery.

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[9] Trade Reports, Government Printer, Freetown, 1961-1970.

Table 1.1. Annual Rice Imports--Sierra Leone

Year	Tons	Value (000 Leones)[a]
1954	4,586	580
1955	21,065	1,936
1956	38,800	3,300
1957	31,052	2,858
1958	21,784	2,054
1959	43,305	3,994
1960	28,591	2,474
1961	4,108	420
1962	26,827	2,718
1963	20,812	1,882
1964	543	94
1965	18,725	1,826
1966	34,549	3,449
1967	23,846	2,362
1968	10,581	2,541
1969	9,400	1,062

[a] One Leone = $1.20 U.S. ($1.40 prior to 1968).

SOURCE: Trade Reports, Government Printer, Freetown, 1961-1970.

3. The necessity for, and the possibility of, obtaining higher production through mechanization.
4. A careful consideration of all aspects relating to the financing of the Scheme.
5. The desirability of handling the Scheme through government, cooperative or private agencies.
6. An evaluation of the impact of mechanical plowing and seeding on the harvesting operation as well as overall production of rice; a determination of the degree to which mechanical plowing arrests and controls weed growth in the Scheme.
7. An estimation of the net returns from the resulting crop of rice after ascertaining the cost of producing it.

The Scope of This Study

Given the general problem and its significance, the particular problem on which this study focuses is a determination of the costs of the Mechanical Cultivation Scheme in the Torma Bum area. This study examines the operations of plowing, harrowing and seed harrowing for the 1970 season. Therefore it is of a more limited scope than the seven points enumerated in the proceeding paragraph.

Field work for collecting the data relevant to the study was done during September 1969 to July 1970. The first four months were devoted to collecting data and information by visits to many Government Departments and Ministries in Freetown. The chief ones visited were the Ministries of Finance and Agriculture and Natural Resources, the Rice Corporation, the Bank of Sierra Leone, and the Central Statistics Office. The method of analysis has been to determine the costs of the fixed and variable factors being used in the mechanization process. Because it is felt that an analysis of tractor costs according to fixed and variable costs is inadequate to permit conclusions regarding the different operations (plowing, harrowing and seed harrowing), the concept of energy cost was used to allocate costs to these operations. This concept is outlined more specifically in Chapter 3.

The Objectives

The objectives of this study are:

1. To identify the farming systems in the Torma Bum area and interpret their interrelationships.
2. To identify important factors favoring or hindering the expansion of the Mechanization Scheme.
3. To determine feasible ways of reducing unit costs so as to make the operations more efficient and economical.
4. To develop possible generalizations which can serve as the basis for planning and organization of mechanical cultivation elsewhere in the country.

Assumptions

Underlying this study are two assumptions:

1. In the Torma Bum area opportunities exist for increasing rice production by making greater use of soil resources by means of mechanical cultivation of the grasslands.

2. Mechanical plowing will permit more land to be brought under rice cultivation in a relatively short time.[10]

Hypothesis

The general hypothesis of the study is that cultivation costs per acre in the Torma Bum Scheme can be substantially reduced.

Theoretical Basis

This problem deals with cost determination in the production of rice by mechanized plowing of swamplands. Cost analysis is rooted in production theory; an understanding of its principles is thus basic to any cost studies.[11] According to the theory, inputs are utilized to produce outputs, implying a functional relationship. A derivation of cost functions therefore depends on two things: (1) the nature of the underlying production function and (2) relative prices of the inputs. A generalized production of the form:

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[10] This is consistent with a major argument in favor of mechanization in agriculture that it attracts more land into cultivation--either directly by performing tasks which are beyond the available labor force, or by improving the efficiency of labor. In either case the use of the tractors can only be justified if their costs are recoverable within a reasonable time. Both assumptions together imply that there is no immediate land scarcity in Torma Bum; if mechanization creates a situation where larger acreage of land is required, such land is available.

[11] Richard H. Leftwich, The Price System and Resource Allocation, Third Edition, Holt, Rhinehart and Winston, 1965, p. 126.

$q = f(X_1, X_2, / X_3, X_4, \ldots X_n)$ q = rate of output per unit of time
X_i = rates of inputs per unit of time

possesses three important properties: namely (1) it is single-valued, i.e. for any given combination of X's there is and only one value of q which is the maximum for that technique; (2) there is the possibility of continuous substitution between inputs thereby making q a continuous function; and (3), the presence of fixed inputs implies a short run time period. It is upon this last condition that division into fixed and variable inputs (and hence fixed and variable costs) depends. The distinction between fixed and variable inputs depends not only on the unit period of time under consideration but also upon the behavior of total cost.[12]

Under the assumptions listed above, choose now a specific production function of the type:

(1) $Q = K X_1^{a_1} X_2^{a_2}$; where Q = rate of output
X_1 = rate of machinery input
X_2 = rate of labor input
K, a_i = constants.

K represents the multiplicative influence of fixed rate of inputs, indicating the short run. The cost function:

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[12] At the beginning of the season a number of tractors purchased represents fixed cost; the number employed as well as the hours of operation per tractor may both be varied, so the rate of input services is variable.

(2) $C = Z + \sum_{i=1}^{2} P_i X_i$; where C = total cost

Z = fixed cost

P_i = price per unit of the ith input.

The problem is to minimize (2) subject to the constraint of the production function. For this constrained minimization problem, the artificial variable λ is introduced to write the expression in standard form

$$(3) \quad \phi = Z + \sum_{i=1}^{n} P_i X_i + \lambda \left(K X_1^{a_1} X_2^{a_2} - Q\right)$$ [13]

from which the cost function may thus be derived. Baumol has shown that the cost function obtained by this method is the minimum cost for the given level of output.[14]

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[13] The expression is minimized by setting each of its partial derivatives equal to zero; thus

$$\frac{\partial \phi}{\partial X_i} = P_i - \lambda \frac{\partial \phi}{\partial X_i} ; \; i + j = 3; \; i,j \geq 1$$

$$\frac{\partial \phi}{\partial \lambda} = K X_1^{a_1} X_2^{a_2} - Q$$

This system yields n+1 simultaneous equations which can be solved for the optimal values of n inputs as well as the artificial variable λ . The can be eliminated by dividing any one equation by the other, the expression $\frac{P_i}{P_j} = \frac{\partial \phi / \partial X_i}{\partial \phi / \partial X_j}$ is obtained, which states the rule for the iptimal combination of any two inputs, i.e., the ratio of marginal product must be equal to the ratio of their prices.

[14] William J. Baumol, Economic Theory and Operations Analysis, 2nd Edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1965, pp. 188-189.

According to the theory of the firm at minimum cost, with optimal combination of any two inputs, exists the condition:

$$MP_i/MP_j = P_i/P_j \;;\; i,j \text{ two inputs.}$$

The rationale is that the ratio MP_i/P_i is the measure of the yield of a leone (dollar) spent on input i (similarly MP_j/P_j yield for input j). Explicitly MP_i/P_i means marginal productivity of factor i divided by the price of factor i; MP_i is obtained by taking the first derivative of the total product function. As long as the two ratios continue to be unequal there is room for adjustment to bring about equality in the two ratios. In this situation MP_i & MP_j, are physical quantities (units of output). Empirical estimation of marginal productivities of the factors (labor and machinery) is therefore the crucial point in determining the extent to which reallocation of these factors can be made.[15]

Other productivity relationships that have a bearing on

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[15] The degree to which any possible reallocation can take place will depend on the solution to many practical problems, such as availability of machinery and equipment, trained personnel, alternative employment, the impact of family and nepotic attachments on the manager and his attitude toward costs of operation.
McPherson and Johnston conclude that "The problem is not simply one of minimizing cost by changing the quantity and mixture of resources currently being used. It is essential to enlarge production without excessive use of critically scarce resources of capital and foreign exchange. Hence a major need is for research that generates technical knowledge and new inputs capable of substantially raising the productivity of land and increasing the opportunity for productive employment of the abundant labor." See W. W. McPherson and Bruce F. Johnston, "Distinctive Features of Agricultural Development in the Tropics," in Agricultural Development and Economic Growth, ed. Herman M. Southworth and Bruce F. Johnston, Cornell University Press, Ithaca, New York, 1967, p. 222.

the study relate to the concept of returns. These include (1) constant productivity, (2) decreasing productivity, and (3) increasing productivity, depending on whether or not output is constant, decreasing or increasing for different changes in input. These relationships fall under a general law called the law of variable proportions. This law may be stated thus: if the quantity of one or more productive factors is increased by (equal) increments with the quantities of at least one factor held constant, the increments to total output may increase at first but will decrease after a certain point.

Estimates of unit costs (average and marginal) of output will be made. These are more appropriate than total costs in judging the cost-output relationship.[16]

Climatic and Soil Features

Geographically, Sierra Leone lies within the tropics, falling between 6°55' and 10° north latitude and 10°16' and 13°18' west longitude. In common with most West African countries, Sierra Leone falls within a zone traversed seasonally by the intertropical front associated with the equatorial low pressure belt. Correspondingly, the climate is continuously warm to hot with well defined wet and dry seasons controlling the annual agricultural cycle. Two main weather-

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[16] Joel Dean, Studies in Mathematical Economics and Econometrics, Oskar Lange, ed., Cambridge University Press, 1942, p. 222.

types are distinguishable in the dry season which extends from December to April:

> "(1) The Harmattan period of clear skies with dry winds;
> (2) The dry southwest regime is a time of high humidity, hot and oppressive days, and warm nights."[17]

In the wet season, the amount of rainfall per year varies considerably according to geographical locations. The ten-year mean rainfall at Hill Station on the Western side is 177 inches, at Yengema in the East, 119 inches, for Musaia in the far North, 79 inches, and at Pujehun in the South, 120 inches.[18]

With the exception of some alluvial deposits, the soils of Sierra Leone have all developed under similar climatic conditions from the same geological series. From this basic uniformity, local variations of topography are reflected in the soil pattern; accordingly it has been possible to group the individual soil series on the basis of land form sites into a number of categories having certain fundamental similarities. According to Stobbs:[19]

> "(1) The soils of the north and northeast consisting primarily of a reddish-brown laterite mixed with recent beach quartz sand.
> (2) The laterite zone, encompassing the major portion of the country, consisting of a reddish, primary laterite occasionally interspersed with sand and brown clay.

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[17] A. R. Stobbs, The Soils and Geography of the Boliland Region of Sierra Leone, Government Printer, Freetown, Sierra Leone, 1963, p. 9.

[18] Sierra Leone, Department of Agriculture, Report of the Department of Agriculture, 1960; Government Printer, 1962, p. 2.

[19] Stobbs, op. cit., p. 14.

> (3) The alluvial soils paralleling the coast. The parent material frequently consists of brown silt and pale gray clay interspersed with laterite sands."

This last category is descriptive of the area in which the present study has been made.

In general the soils of Sierra Leone may be characterized as relatively infertile. They are not, however, incapable of production of certain crops. The potentially most productive and fertile soils of the Southern Province are the alluvial soils located in the riverain and mangrove swamps and in the alluvial flood plains. Problems of water conditions, the presence of sodium chloride and concentration of other harmful salts[20], as well as the deficiency of iron and manganese[21], will have to be surmounted in order to expand mechanical rice farming. The soils of the alluvial grassland floodplains in the Southern Province along the lower reaches of the Sewa and Waanje Rivers have been neatly summarized by Odell:[22]

> "The predominant grass is saccharum spontaneum. The annual rainfall is 130 to 150 inches, 90 to 95 per-cent of which falls between May and November. The soils are formed from Pliestocene and Recent river alluvium of the Bullom series. Unlike the coastal

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20 Ibid., p. 23.

21 R. Q. Craufurd and A. J. Carpenter, "Partial Mechanization of Rice in Sierra Leone," World Crops, March, 1968, p. 74.

22 R. T. Odell and J. C. Dijkerman, Properties, Classification, and Use of Tropical Soils with Special Reference to Those in Sierra Leone, Njala University College, University of Sierra Leone, 1967, p. 88.

> swamps, there is no influence of marine or brackish water, because (a) connection with the sea is blocked by the sandy beach ridges which force the Waanje and Sewa Rivers to run parallel to the coast for 30 to 60 miles before reaching the sea, and (b) because the alluvial grassland flood plains are flooded every year to depths of as much as 20 feet."

Odell[23] further pointed out that:

> "The suitability of the land for rice is determined by the length of time that the swamp is covered by fresh water."

The period during which the tidal water is harmfully saline decreases with the distance from the sea. Areas for which the fresh water period is too short can be relcaimed to exclude saline water so that rice can be grown as a rain-fed crop.

Review of Literature

Over the last seventy years mechanization of agricultural operations has proceeded at a rather rapid rate. There are economic and other justifications for its widespread application. Many argue that mechanization is a way to modernize agriculture by reducing the drudgery in agriculture and making it less tedious. It is quite common to talk of mechanization in farming mainly as a labor-saving device. Bakker and Wallace showed that mechanization reduced the labor requirement in U.S. agriculture by 91 percent between 1830 and 1951.[24] This matter of substituting machinery for labor (or draft animal) does not neces-

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[23] Ibid., p. 87.

[24] M. G. Bakker, and D. B. Wallace, Mechanization in Agriculture, Meij, J. L. ed., Quadrangle Book Press, Chicago, 1960, p. 179.

sarily result in lowering cost. Experience in the Central Nyanza District of Kenya has shown that:[25]

> "Data obtained on the cost of contract plowing did not indicate a great difference between tractor and ox-drawn plowing; particularly considering the superior and more timely land preparation achieved with tractor, the cost of plowing per acre was Ł 3-15 when done by oxen and Ł 4-15 when done by tractor."

The question of mechanization should be subject to empirical evaluation for each situation depending on the desired objectives.

In a broad general study of mechanization in some African countries, Kline and others[26] concluded that:

> "Mechanization is important for increasing agricultural productivity, but it is impracticable unless there is also means of profitably disposing of the resultant increase through commercial markets."

The study pointed out that notwithstanding the great shortage of farm power in Equatorial Africa (about 99 percent derived from human effort) mechanization programs are unlikely to be effective unless there is simultaneous development of the commercial economy. The study recommends research into particular projects if mechanization is to achieve the aim of increasing production

There is a dearth of literature specifically relating to the problem of mechanization in Sierra Leone. Articles that

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[25] John C. deWilde, Experiences with Agricultural Development in Tropical Africa, Vol. II, The Johns Hopkins Press, Baltimore, Maryland, 1967, p. 142.

[26] C. K. Kline, D.A.G. Green, Roy L. Donahue, B. A. Stout, Agricultural Mechanization in Equatorial Africa, Michigan State University, East Lansing, Michigan, 1969, p. 2-35.

have been written are mostly descriptive of rice cultivation in the country and give little or no insights into the problem of mechanization *per se*.[27] Some outline the principles of shifting cultivation and bush fallow as they affect rice growing whether it be the upland or swampland types.

One of the studies made in the bolilands of Sierra Leone showed that very little rice was grown there prior to the introduction of mechanical cultivation.[28] This same study indicated that of the several different types of tractors (wheeled and track-laying) tried, the Fowler Mark 5FA crawler was the most economical with respect to petrol consumption. Caterpillar D4 and International BTD6 crawlers also gave good performances in plowing and harrowing approximately 800 and 400 acres, respectively, in a season. Comparisons between the three makes of tractors with respect to costs of fuel and lubricants were made in the study (Table 1-2).[29]

Table 1.2. Fuel and Lubricants Cost Comparison for Three Tractor Makes

Operations	Cat. D4	BTD6	Fowler
Plowing (per acre)	8.5s	6.75s	6.25s
Harrowing (per acre)	6.75s	4.25s	4.0s
Total (shillings)[a]	15.25	11.00	10.25

[a] One shilling = 0.14¢ (U.S.).

[27] H. D. Jordan, International Rice Commission, UNDP/FAO, Project IDAS, Vol. XIII, No. 2, June, 1964.

[28] A. J. Carpenter, and R. Q. Craufurd, "Partial Mechanization of Rice in Sierra Leone," *World Crops*, Vol. 20, No. 1, March, 1968, p. 72.

[29] *Ibid.*, p. 74.

Gilbert[30] made a study of the mechanization schemes in Sierra Leone, looked at from the viewpoint of an engineer. In this study it was observed that the heterogeneous nature of the tractor population was a source of many difficulties such as the stocking of spare parts and finding enough skilled technicians to carry out the necessary repairs. This lack of trained mechanics, poor organization, an inefficient and difficult transportation system, and the almost constant shortage of fuel supplies were factors responsible for the high cost of mechanization. Gilbert estimated total cost per acre to be Le 14.76 ($17.71 U.S.). This amount does not include the cost of spare parts. Gilbert further estimated that a target of 30,000 acres can be plowed each season, given a tractor number of 104. Tractor use was found to be 3.6 hours per day per tractor or 2.1 acres per day per tractor.

According to this same study, a serious and continuing problem that plagues the tractors relates to the electrical starters. It is not always possible to provide enough batteries to facilitate starting the tractors; accordingly, the Sims Spring Starter was recommended to replace the electric starter. This, according to Gilbert, has given very good service in Ghana and Tanzania and is said to be quite cheap. The study emphasized the need for improved organization and supervision and the absolute necessity of having adequate

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[30] R. G. Gilbert, "The Mechanical Ploughing of the Rice Fields in Sierra Leone," unpublished working paper, UNDP/FAO Project IDAS, August, 1969.

supply of spare parts on hand during the plowing season.

Pollock[31] in another study traced the development of mechanical rice farming in the bolilands and estimated that about 200,000 acres of land are available for rice growing by expanding mechanization, using fertilizer and adapting water control methods. In this study, Pollock suggested that the Rice Corporation should handle the expansion of the mechanical plowing schemes as it would be better able to collect fees from the farmers. Collection of fees constituted a major problem facing the Agriculture Department.

Bhattacharjee[32] pointed out that despite the existence of an overall surplus of labor in India, mechanization provided great advantages where acute labor shortage prevailed due to seasonal factors and for carrying out certain agricultural operations. The conclusion was that the basic purpose of mechanization is to secure gains in production efficiency. Mechanization is amply justified then to the extent that it results in greater efficiency (lowering of cost) in production.[33]

In his study, Gadkary[34] compared two common types of

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[31] T. R. Pollock, "The Development of Mechanical Rice Farming in the Bolilands," The School of Development Studies Bulletin, Njala University College, 1966.

[32] J. Bhattacharjee, Mechanization of Agriculture in India, Its Economics. Visva-Bharati Sriniletan, 1949, p. 30.

[33] Ibid., p. 50.

[34] D. A. Gadkary, Mechanical Cultivation in India, Civil Lines, Delhi, 1957, p. 15.

tractors used in Indian agriculture. He noted that the crawler type tractors are quite useful for deep plowing of hariali-affected fields and sugar cane areas and also for bulldozing work. A further observation was made that "in spite of their advantages, such as very low soil consolidation effects, ability to ride easily on loose surfaces and high drawbar pull per horsepower, their high initial and subsequent maintenance costs often serve as impediments to most farmers unless enough work can be found for them."

As for the wheel-type tractors, Gadkary[35] noted that "in view of their propensity to slip and their unsuitability for heavy work, these did not find much favor in the beginning. However, the reduced vibration achieved through them and the resulting increase in life of the axle-bearings and other related parts, as well as greater comfort for the driver and the facility of putting the machine on the roads, make them increasingly popular." The wheel-type has the added advantage over the crawler type of easier maneuverability. Wheels often slip and this is a limiting factor in their performance. The wheel-slips reduce speed but not fuel consumption.

Purvis[36] in his study found that farmers increased their incomes by the use of tractors. Farmers realized that with the

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35 Ibid., p. 14.

36 Malcolm J. Purvis, "A Study of the Economics of Tractor Use in Western Nigeria," Nigerian Institute of Social and Economic Research, Ibadan, Nigeria, September, 1968 (mimeo).

tractors they were able to cultivate more acres, obtain larger yields per acre and increase the gross output of their farm more than their increase in costs. Purvis found that by spending about ₤ 3 on tractor services per acre, farmers could double their acreage cultivated;[37] 93 percent of the farmers estimated about 54 percent additional yields (p. 36).[38] He showed the following relationships in percent:

Farmers	Acres With tractors	Acres Without tractors
Group farmers	14.8	7.0
Private farmers	4.4	2.4

In this same study Purvis concluded that "tractor operations in West Nigeria suffer from low productivity arising from the seasonality of work loads, low intensity of use of equipment and high cost of operation. There is therefore need for a thorough evaluation of the existing tractor hire system. Technical suitability and costs of alternative means of land preparation and tillage should be considered."

He recommended that a way to correct this is to encourage the development of large agricultural enterprises which can utilize more tractor services. In the study under discussion, he noted that mechanization programs elsewhere in Africa have seldom been successful except where they have been tied to

[37] This tremendous increase in acreage cultivated is due to the fact that under traditional agriculture the major bottleneck on production is labor supply for land preparation.

[38] ₤ = three pounds British (₤ 1 = $2.40 U.S.).

rather specialized production conditions and have been under intensive management. The greatest need, he concluded, "is for greater sophistication in management and supervision of tractor work and maintenance; a significant reduction in the high level of breakdown and repair costs; a need for better trained drivers."

A study made by Newlyn[39] revealed that operating costs per hour in Nigeria varied widely according to the extent of the driver's training. Poorly trained drivers, apart from low output, often require a great deal more supervision and often cause up to two times as many breakdowns as a well-trained driver. Occasionally it was necessary to employ a driver's mate. Newlyn found wide variability in cost for different make tractors as to type of work. The Ferguson (28 h.p.) operating cost per hour was less than 50 percent of the Caterpillar D4 (48 h.p.) cost. They averaged 4.75 hours/acre and 0.75 hours/acre, respectively. This is the equivalent of 0.2 acre/hour and 1.3 acres/hour for the Ferguson and Caterpillar D4, respectively.

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[39] W. T. Newlyn, Costs of Mechanized Agriculture in Nigeria, A Symposium on the Operating Costs of Machinery in Tropical Agriculture, Colonial Advisory Council of Agriculture, Her Majesty's Stationery Office, London, 1957, pp. 1-8.

CHAPTER 2

A GENERAL DESCRIPTION OF PRESENT FARMING SYSTEMS AND DEVELOPMENT OF MECHANIZATION IN THE TORMA BUM AREA

Basically, the process of agricultural production combines land, labor and capital in a manner determined and supervised by the farmer acting in his role as manager. The nature of changes in the process of production depends on the quantities of the factors available to him. It is to be assumed that the introduction of new capital into the production process is aimed at increasing production.[1]

Comprehension of the influence of agricultural mechanization and the possibilities of shifting the production function upward requires an understanding of the farming systems into which mechanization should become intensified. This chapter describes the farming systems studied during the course of field observations. It is upon this description that the basis for a subsequent model building will depend.

Two main systems are identified, the mechanical cultivation system and the upland river levee system, although it is not always easy to maintain strict division between them.

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[1] Capital invested in labor-saving equipment is considered a labor-saving technological change. Capital invested in equipment which facilitates improved production without displacing labor is a land-saving technological change. A change involving capital as a substitute for neither land nor labor is a neutral technological change. This latter form can raise the productivity level of all factors. See John Mellor, "Toward a Theory of Agricultural Development," in Agricultural Development and Economic Growth, ed., Herman M. Southworth and Bruce F. Johnston, Cornell University Press, Ithaca, New York, 1967, p. 47.

Apart from fundamental difficulties endemic to the socio-economic agricultural system, there are also critical ecological factors of soil and climate as well as certain dynamic influences of population which must be examined. The farming system of the riverain grassland (bati = Mende name) is primarily the mechanical cultivation area, while the upland river levee (komboya) has a distinct existence. The interrelationships between them are very important in the overall farming pattern. The discussion here is limited to observations in the area of study: it describes the agricultural and economic environment and demonstrates the relevant considerations in developing proposals for the expansion of the mechanization scheme.

Mechanical Cultivation System

In looking at the farming system in the grasslands, a very interesting pattern unfolds. First of all, only a relatively small proportion of the grasslands is cultivated. Plowing occurs on the various sites according to their height above the river. Therefore, work begins on the lower sites immediately after the straw is burned after harvesting is completed, usually around the first part of February. Appreciation of the difference in elevation is a very important matter, since it is not possible to plow all the sites simultaneously and moving tractors and implements can cause long delays in plowing being started.[2] Occasionally a combination of several factors--early flood rains and mechanical failures--can result in the loss of many days when plowing will be held up.

Harrowing is the next operation after plowing. This is followed by plot allocation--a very important and time-consuming operation. This exercise is often marked by frequent disputes over the question of accuracy of measurement and the permanency of the plot. The farmer broadcasts his rice as soon as the plot is allocated to him, the site is then seed harrowed, thus completing the work done by machinery.

Weeding commences very soon after germination of the rice. Most plots are weeded once. In some cases the rising flood soon forces the workers off the land even before the entire plot is weeded. Weeding (ngulugbua) is the task of women, though men will often help. Where germination is particularly thick, the rice may be transplanted during the time of weeding the plot. From early July when the flood rains are coming down until the latter part of December when the rivers recede and the plots are quite dry to allow for harvesting, the rice is practically ignored.

Harvesting is by far the most arduous and labor-consuming task now that difficulties of clearing bush and plowing have

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[2] On Gondama site, four tractors lay idle for eight days because they could not cross a 50-yard stretch of land which was very soggy and the landing craft was not available for transporting them back across the river to another plowing site. In fact the tractors would have to travel back five miles to Mano, the only place where tractors may enter the landing craft this side of the Sewa.

been eliminated by mechanization.[3] A major difficulty in harvesting is the severe (complete) lodging of the rice. Being a deep-water variety it develops a stalk up to fifteen feet long which, as the flood water recedes, collapses into a tangled mass. Consequently, each panticle has to be harvested individually by using a small knive blade (blade knife). During the harvest, birds are a problem, especially in morning and late afternoon, and it is the task of the young children, armed with slings and projectiles made of dried mud, to keep them away from the rice. Indeed, harvesting is a lengthy process and it may last for up to three months on some sites. After harvesting, before plowing begins, the straw is burned. This can definitely affect the quality of the plowing. However, since individual plots are contiguous on any one site, the straw cannot be fired until the last farmer has brought in all his harvested rice.

Essentially then, the system is similar in timing and operations to that outside of mechanical plowing. There are, however, certain important differences: the limiting factor

[3] Based on observations and trials carried out by the researcher, this is a typical result for harvesting.

Rice variety: Indo-China Blanc

Total time	245 minutes
Harvesting	219 minutes
Resting time	26 minutes
Yield per man hour	0.152 bushel
Yield per man hour (without rest) . . .	0.170 bushel

Area harvested - 740 sq. ft. (.017 acre)
Yield - 0.62 bushel
Yield per acre - 36.5 bushels

as regards the size of the plot is the labor power a farmer can secure at harvesting, while on the other system, brushing and clearing are the limiting factors.[4] Secondly, prior to mechanical cultivation, a farmer could operate independently of others as regards the timing of operations. Farms would be scattered around rather than being contiguous, and therefore a farmer could burn the straw on his farm without the possibility of starting a fire on his neighbor's crop. This system of unitary sites of integral plots, requiring such high degree of synchronization of operations, raises several implications for the plowing scheme which will become clear as the discussion proceeds. In the meantime, a discussion of the upland levee (komboya) farming is now imminent.

Upland River Levee System

The upland levee is physiographically distinct, yet inseparable from the grassland in the overall farming pattern of the area under study. It is important in providing settlement sites above the level of the flood waters. Farmers often sleep in their riverside village and go out to the rice fields (not mechanically plowed) during the day where this is practicable in terms of distance. Here they will build only a small farmhouse (poi) next to his rice plot. Occasionally it becomes necessary to erect a more permanent dwelling where the entire household will live during the dry season. Because

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[4] The existing land tenure system does create some limitation on size of farms; it tends to encourage land fragmentation.

suitably high and wide levees are infrequent, it is usual to find an aggregation of such dwellings named as villages.[5] During the wet season most of these villages are abandoned when the farmers and their families return to their home villages. Whether a farmer's dry season house is near or at a distance from his rice plot, the characteristic farmhouse is constructed as before. The levee is thus distinguishable from the grasslands in that it is an area of temporary or semi-permanent settlement which the grassland is not. Concomitant with this feature is the number of shade trees which are planted on the levee of which the mango is notably the most numerous. But the levee is also of great importance as regards the crops grown on it.

As soon as the flood subsides the farmers return to the fields for clearing the komboya for cassava and sweet potato. Groundnuts and condiments, such as peppers and benniseed, are grown. Bananas, oil palm and sometimes a few coconut trees are planted around the dwellings both for their fruits and as shade. Like the adjacent rice farm in the grassland, no fallow or rotation is required or practiced. On the same plot of land will grow cassava and/or sweet potato year after year without any reduction in yield. Here it may be pointed out that despite the fact that cassava grown on the levee will out-

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[5] Torma Bum is an exceptionally large levee where frequent flooding of some homes and offices takes place. No very serious flooding has been reported in over 15 years.

yield cassava grown on the red earth lateritic soil by several tons per acre, there is one inherent drawback, the fact that for half the year it is either under water or severely water-logged. This means that the crop must be harvested completely before the onset of the floods or else a great part of the crop is lost. The sweet potato can be transplanted to perennially dry land, and, with the onset of the rains and the rising river level, farmers take their sweet potato to the village where it will be transplanted into gradens around the dwellings. Conversely, at the beginning of the dry season and the move to the rice fields it is planted out on the levee. Cassava does not, however, lend itself to transplanting and the tubers cannot be stored for more than a few days after harvesting before being in the ground, that is, with the tubers in the air. Parboiling will allow them to be kept for about two weeks. Grating and drying will produce garri which will keep indefinitely but this is a laborious task also requiring grating and drying equipments. In the face of these problems, a farmer is usually unable to produce enough cassava on the levee to meet his needs for the year. Moreover, the problem of finding fresh stalks of cassava for planting out on the levee at the beginning of the dry season, is a common one, as the stalks of the previous season are all rotten by this time. The strictly dry land cassava farmer does not have to face these problems.

In the riverain grasslands, each plowing site is set, as it were, within a complementary area of levee, the center of which is a group of farm houses which form the focus of all domestic and economic activities. Just close by is the river, forming a rich source of fish. There is indeed an interesting contrast here between life in the rice farms and levee during the dry season and the routine of village life during the wet season. On the farms there are plenty of activities and plenty of food and wine from the bamboo and raphia palms; there is much coming and going of people and there is generally a heightened vitality among them. During the dry season the riverside villages are virtually empty. During the wet season farm work is at a minimum; the store of food is dwindling fast and this may be causing some anxiety as the rains confine people to their houses. There is little or no dancing; people retire to bed early to escape the cold dampness of the night and the large army of ubiquitous mosquitoes.

As has been seen, the primary interests of the farmers of the riverain grasslands are wrapped up in the two systems of farming--the bati and the komboya. The traditional upland farmers, on the other hand, though they may have some interests in bati and komboya depend on the perennially dry land and on their shifting cultivation-bush fallow technique. The potentialities of this red earth lateritic relatively fertile land exceed those of the grassland and permit growing of a wide variety of crops. On this land a new farm must be cleared out of the thick bush each year. The brushing is a technically complicated process and involves several operations and a considerable amount of labor.[6] Only men can do the brushing satisfactorily, and there is a time limit within which all these operations must be finished for planting before the rains. Hence the timing of these operations is of utmost importance. Land preparation (bush cutting and clearing) alone occupies roughly four months; planting of cassava is done in early May. By September the first tubers are ready for harvesting. Ordinarily a cassava farm can furnish food for up to a year; thereafter there is degeneration in the quality of tubers as they become inedible and the whole farm reverts to forest. During this time, unlike the farms of the levee, there is movement of cassava stems to a new farm being established elsewhere. It is important to point out here that other crops are inserted between the cassava stems. Cereal crops are common. Rice, for example, is sown broadcast onto the newly burnt farm and hoed into the ground around May. By September to October this will be ready for harvesting.

Now everywhere, especially in the upland bush, are to be

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[6] Operations: 1. Ndogboi luwele (bush-brushing) This involves cutlassing the undergrowth while leaving the larger trees standing. This delimits the area of the future farm and produces Nduwe logboi (brushed bush). 2. Kpoi - Felling large trees for burning. The area is now called a farm (kpac). 4. Moi (fire) is set to the area. 5. Nglanglei (one-by-one) This involves going round the farm preparing any timber that has not burned satisfactorily for a second burn. 6. Nglanga ko molei (one-by-one log burning) that of 5.

found palm trees, the fruits of which are harvested quite regularly.[7] Immediately after harvesting the fruit is processed to obtain palm oil (ngulo gbo) from the pericarp.[8] The residue of fibres and nuts, after the oil has been removed, is used in mattress and pillow making and for the production of palm kernels from the nuts (which is an important export commodity). The oil is the most important by-product, however, being highly valued for culinary purposes as well as a source of cash through the sale of any surplus. It serves as a common form of gifts to relatives and friends. The number of processors in the area under observation is not very large due to the initial capital requirement for purchasing the necessary equipments. Consequently many farmers have to sell the fruits to processors. The fruits are sold at an average rate of 100 bunches for Le 2.00; this quantity of fruits will produce approximately eight gallons (imperial) of oil which may be sold for Le 6.00. Cassava, palm oil and rice are the main enterprises of the upland farmer; here palm oil is especially important as a source of cash. On the riverain, however, the picture is quite different. It is the rice surplus

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[7] These palm trees are not cultivated in essence. They are "naturally occurring" and the initial cost is the labor expended in harvesting the fruits.

[8] Certain items of capital equipments are required for the processing. A large boiler (steel drum), a concrete bath, several buckets and containers of varying sizes. After boiling, the contents are turned into the bath. The oil is separated and stored in the containers.

that constitutes the major source of cash.[9]

Fishing as a Supplementary Enterprise

Before considering the interrelationships between these different systems of farming, it is necessary to complete the picture by a brief discussion on fishing. Clearly this is a more significant activity of the reiverside than elsewhere. Three principal techniques are used--traps, nets, and lines. Traps and lines are used by the river banks and in the grasslands while nets are used in the river. They are left unattended, after setting in the evening, until the following morning when they are gathered. Quite often too, fish may be pulled from the river by young boys using a simple rod and line. As the flood subsides it leaves pools in the grasslands and these are raided systematically by bands of women using their own special nets (bimbei). Fishing activity is of particular importance in some areas--Minna Nyeni, Mano Kuranko, Mano Koriganya and Gbundapi are important ports from which

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[9] The upland farmer often supplements his crop of dry rice by cultivating rice in the "inland swamps." Palm trees are common to both types of swamp. The raphis vimfera (nduvui) is dominant in the riverain swamps (voi), while raphia gracilis (kili) predominates the more accessible inland swamps (yenge). Vinifera yields palm wine, raphia and piassava; gracilis, gives piassava and thatching material.

Piassava, apart from having many local uses, is quite important as an export commodity. It is, however, a complementary activity and is usually produced by individuals contingently upon an urgent need for cash. Over 90 percent of the piassava production takes place in the rainy season when farm work is at a minimum.

smoked fish is exported to the hinterland.

The farming systems, as they have been discussed up to now, demonstrate a type of specialization, though not quite, of two categories in terms of the economic well-being of the farmers. Farmers engaged in the riverain grasslands will have some interest in the adjacent levees and perhaps fishing. They will not be concerned with upland rice and palm oil production. So also will the upland farmers confine their interests to upland rice, cassava and palm oil operations; they will not in general concern themselves with mechanical cultivation. (There are a few exceptions to this generalization as when one engages in absentee farming, such as one may operate in both systems simultaneously.) However, the two systems do not operate independently and it is the interrelationships between them to which attention must now be focused.

Interrelationships of Farming Systems

Labor is of central importance in this respect. Its supply and mobility in response to the differential requirements between the two systems require some amplification. As a noticeable phenomenon in the area of study, labor differential is most marked on two occasions when significant movements occur. During late December to January through March there is a great dependence on the part of the riverain grassland farmers on imported labor. This labor is urgently required for harvesting the rice in the mechanically cultivated areas. The need for employment coupled with the demand for rice as an item of food are major factors attracting migrants to the riverside. Young men and women come not only from the contiguous farming region but from such densely populated areas as Freetown, Bo and Kenema.[10] The reward for harvesting consists in the form of cash as well as rice. Consequently there is a movement of cash but more importantly rice from the riverside into the upland area as well as into the towns. There are many ways of offering reward in kind. The most common principle is at the rate of one day's harvesting for every two days' harvesting for the owner of the farm; plus, of course, feeding during the period of the helpers' sojourn. Thus approximately 33 percent of the rice harvested on the grasslands goes as compensation for harvesting.[11] This is a considerable quantity of rice for the upland farmer and, as the riverside farmer comes to rely on securing labor from the upland, so, on the other hand, the upland farmer relies on participating in the harvest in order to supplement the upland, and hence increasing his total rice available. The rice, brought into the upland area, permits the

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[10] Of course, women greatly outnumber men for various reasons, among them is the fact that the men in the upland are engaged in brushing and clearing land for new farms.

[11] A significant portion of this amount leaves the grassland area. This does not include the amount that will further be transferred via sales to the Rice Corporation and Private Traders.

release, to a limited extent, of factors of production from the subsistence upland rice and cassava farms to the commercial production of palm oil for cash.[12] The complaint concerning the apparent labor shortage around harvest time is often more of an expression of heightened anxiety about crop losses at this time and of unwillingness to meet wage requirements, than of an actual condition of labor unavailability.

The second most noticeable movement of labor occurs in about April following the completion of harvesting. This consists mostly of female labor who return to the upland for participation in the production and marketing of palm oil.

Another important feature of the interrelationships between the systems relates to market demand for the commodities. There is little or no variation as to type of commodities produced; many of the commodities are common to the two systems; the difference is mainly in quantity produced. Although these commodities are consumed in relatively large volume (due to the complementary nature of production) in this predominantly subsistence agriculture, only rudimentary market demand appears. Only in the riverside grasslands can it be said that a monetized market economy really exists.[13] In the

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[12] At about this period farmers often complain of a conflict between upland farm preparation and palm oil production.

[13] These markets, however, have some very complex features about them as regards price-quantity relationship. Problems of bulk and perishability (e.g., fish and vegetables) are also present. Subsequently, in analyzing the economic impact of mechanization, account must be taken of marketing: farmers need attractive markets for their increased output; with the increased income, goods that will be demanded must be available in these village markets.

discussion on the komboya system, it was shown how cassava production became restricted because the flood-water forces its complete harvesting and immediate consumption so to speak; this cassava is entirely for home consumption. Cassava stems are obtained on a barter basis from within the upland system. However, for the riverside farmers, cassava stems are often exchanged for rice with very little cash sales taking place. But, as has been pointed out earlier, very few riverside farmers are engaged in cassava farming.

Generally there is a movement of labor, cassava stems, and palm oil from the upland levee (komboya) into the riverside (bati), and a movement of rice and fish from the riverside to the upland. There is usually a trade deficit in favor of the upland region which has to be made up in cash. The principal item here is palm oil which is paid for in cash from the proceeds of the sale of surplus rice produced under the mechanical cultivation scheme.[14]

These general interrelationships carry broad national implications. The total annual production of husk rice in the country averaged around 396,000 tons per annum (1965-68) from which approximately 265,000 tons of clean rice are obtained.[15]

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[14] Very often, during my field work, many farmers commented that in the face of the extensive and impressive plowing operations going on here in this fertile grassland, that they still regarded their upland farming activities as their primary source of wealth and well-being. The sense of this paradox is perhaps only understandable by personal observation.

[15] M. G. Fenn, "The Marketing of Farm Crops in Sierra Leone," unpublished working paper, UNDP/FAO, Project IDAS, Freetown, Sierra Leone, March 1970, p. 36.

Most of this rice goes directly into household consumption with less than 20 percent entering the marketing channel.[16] Earlier it was pointed out that the aim of the Government is to raise production to the level that will eliminate Sierra Leone's dependence on imported rice. As imports fall, there must be simultaneous adjustments in the marketing system in terms of buying, processing and distribution of the increased quantity of domestically produced rice. As commercial rice production develops at the expense of subsistence farming, together with simultaneous improvements in palm oil processing to meet an expanding national demand, emphasis must be given to the development of a good marketing system with significant improvements in infrastructural facilities such as transportation and communications. Furthermore, the tractors and other mechanical equipment have to be paid for; this involves foreign exchange considerations, a very complicated matter with which to deal. The ability of Sierra Leone to meet these external payments will depend immediately upon the returns derived from the sales of the products in a widening domestic market and also from the possibility of exporting these agricultural products.

Development of Mechanization

In 1947,[17] data were collected on periods and depths of

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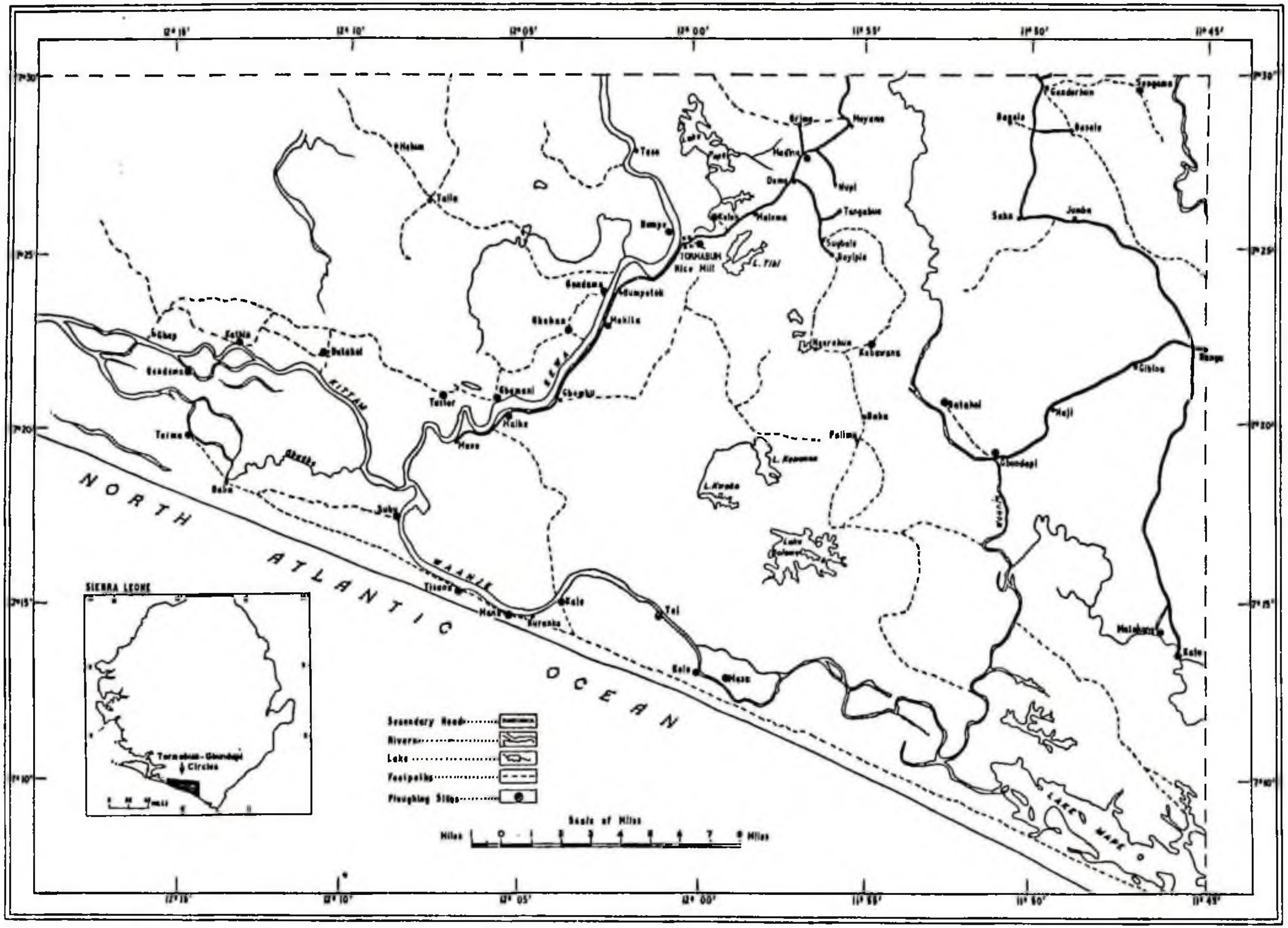
[16] Ibid., p. 36.

[17] G. M. Roddan, Report on the Existing and Potential Rice Lands East of the Bagru River and Including Sherbro Island, Government Printers, Freetown, Sierra Leone, 1949.

flooding and local farming techniques with a view to the possible use of tractors and plows on the grasslands by the Department of Agriculture. A West African Rice Mission concluded in 1948 that 50,000 tons of paddy rice could be produced annually from the Sewa-Waanje grasslands. The following year the first land was plowed by tractors at Subu (Fig. 2-1). The plot was sown with Indo-China Blanc seed and farmed by a local farmer. Approximately 2-1/2 tons of rice were produced from the four-acre plot. In 1951, 285 acres were farmed by mechanical plowing at Subu; by this time the advantages of plowed land were becoming apparent to farmers who now freely moved in to clear the elephant grass with cutlasses in order to facilitate plowing. The construction of a station at Solon for servicing and repairing of machinery got under way in 1953, and in that year 1,178 acres of land were plowed as other sites began to be opened. The elimination of wild rice, a very prevalent weed, by deep plowing was in progress and field trials were carried out with a view to establishing the optimum sowing date on these new sites. In 1957, 5,385 acres were plowed and the Mechanical Cultivation Scheme was well established not only in this area but it spread to other parts of the country as well (Table 2-1).

By this time a definite pattern was emerging. From the beginning, plowing was done by the Department of Agriculture; they owned the machinery, employed mechanics, fitters and field staff, plowing land by contract, then allocating to individual farmers. Thus, the farmers were from the very

FIG. 2-1. MAP SHOWING MECHANICAL CULTIVATION AREAS — TORMABUM-GBUNDAPI CIRCLES



beginning essentially nonparticipants in the administration and policy making of the plowing authority. The latter offered a service which the farmer may or may not use as he wishes. In this way the annual appearance and disappearance of the tractors and implements leaving behind plowed land took on the attributes, as far as the farmers are concerned, similar to the annual flooding of the rivers. Both are essential to their newly found economic state and both appear equally predictable but uncontrollable. Mechanical cultivation therefore has become and remained one of the "givens" in the ecological setting which the farmers can exploit.

Turning to the land itself, though the Department of Agriculture was officially plowing land for individual farmers, it was in fact plowing as units large sites averaging 240 acres (two sites exceeded 1,000 acres in 1969). The field staff of the Department was responsible for assessing the acreages required and after plowing, allocating plots according to the acreage paid for by the individual farmers. The collection of plowing fees proved a difficult task for the small number of field staff in relation to the large number of farmers paying for plots, hence the cooperation of the Chiefdom Native Authorities was requested and the collection of fees became the responsibility of the local administration. A lump sum would then be collected by the Department of Agriculture from the two District Councils involved (Bonthe and Pujehun). However, this arrangement soon became unworkable due to gross incompetence

Table 2.1. Mechanical Cultivation Scheme: Acreages Mechanically Plowed, 1951-1970

Circles	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[a]
Southern (Torma Bum)	282	465	1,178	2,278	4,073	5,530	5,302	4,346	3,788	5,508	6,945	7,720	8,630	10,461	11,171	7,214	9,297	8,079	9,087	7,362
South-Western (Gbundapi)	32	719	1,018	1,012	1,173	1,484	1,606	1,015	600	--	--	--	--	--	506	--	1,135	858	996	805
Northern (Makeni)	--	238	915	2,449	3,600	2,829	2,625	1,504	356	926	1,494	2,308	5,157	5,947	6,859	3,297	6,566	9,401	9,954	10,074
North-Eastern (Kabala)	--	30	163	127	141	250	--	206	319	594	721	529	684	1,368	2,144	1,910	2,000	2,046	2,859	1,987
North-Western (Port Loko)	80	645	683	758	1,014	2,008	2,334	320	243	592	690	676	359	474	939	1,013	1,461	1,220	1,380	--
Total	394	2,097	3,957	6,267	10,066	12,091	12,017	7,435	5,327	8,350	9,888	11,263	14,869	18,250	21,619	13,434	20,459	21,604	24,276	20,228

a Field and Office Records, Ministry of Agriculture and Natural Resources, Freetown

Dashes indicate data not available

SOURCE: Annual Reports (1952-1965, 1968-1969), Department of Agriculture, Freetown.
Annual Reports (1966-1967), Rice Corporation, Freetown.

of the local administration and the responsibility reverted to the Department of Agriculture and remained therewith until 1966. When the Rice Corporation took over from the Agriculture Department, the arrangement, with respect to plowing and fees collecting, was formally the same as before. However, a new factor had emerged, the Rice Farmers Marketing Cooperative Societies upon which devolved the task of collecting the plowing fees and generally performing the role of articulators between the farmers and the new plowing authority. There were five such societies in the country in 1970.[18]

Until 1958, plowing fees were paid in arrears, that is, the farmer paid when the plowing produced its harvest. In 1959, all fees were demanded in advance. This caused a drop in acreage plowed, though this was not as marked in Torma Bum as in Gbundapi. In effect, the situation remained unchanged after the farmers had paid for plowing twice out of the proceeds of 1959 harvest; they continue to pay after harvesting as they did previously.

The cost went up by an additional Leone, paid for seed harrowing in response to a popular demand for this service. Among other significant developments was the implementation of the policy decision to encourage producer cooperatives, that

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[18] The Southern Marketing Union Limited (Bonthe);
The Port Loko Rice Marketing Union;
The Mabole Rice Marketing Union;
The Marobi Rice Marketing Union (Bombali);
The Madinatu Rice Marketing Cooperative Union.

is, cooperatives of farmers owning their own machinery and implements.[19] In 1959, three, and in 1970, seven such cooperatives were in operation; they have always been inconsistent in their ability to plow a regular acreage and the Ministry of Agriculture is often faced with the problem of having to complete the plowing on their sites.[20]

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[19] In most cases, particularly in the Northern Province, these were the same as the Marketing Cooperatives. This in effect was a duplication of the services of the plowing authority.

[20] The collection of plowing fees remained a problem even though the Ministry prefers to collect fees through the Cooperative Department for plowing done for members of the cooperative societies. All the seven Producers Co-ops are in the Southern Province in the area of Mechanical Cultivation Scheme.

CHAPTER 3

ORGANIZATIONAL ASPECTS OF THE SCHEME AND THE FRAMEWORK FOR ANALYSIS

This chapter consists of two parts. Part one deals with the basic structure and organizational set-up of the Torma Bum Scheme.[1] Part two discusses the data, their nature and limitations as well as the basis for the analysis.

Structure and Organization

Mechanical plowing of rice fields falls under the responsibility of the Agriculture Division, headed by the Chief Agriculturist, of the Ministry of Agriculture and Natural Resources (Fig. 3-1). Torma Bum operations are most directly supervised by an Agricultural Officer (University Graduate) who is subordinate to a Principal Agricultural Officer in charge of Agricultural Services in the entire Southern Province of Sierra Leone. Practically, the Principal Agricultural Officer's relation to the day-to-day operation of the Scheme consists mainly in the disbursement of funds in the purchase of all local stores and in paying salaries and wages, controlling the release of data or any information pertaining to the Scheme, and those matters relating to logistics. At the Provincial level he is the Chief articulator between the farmers and the Ministry of Agriculture and Natural Resources.

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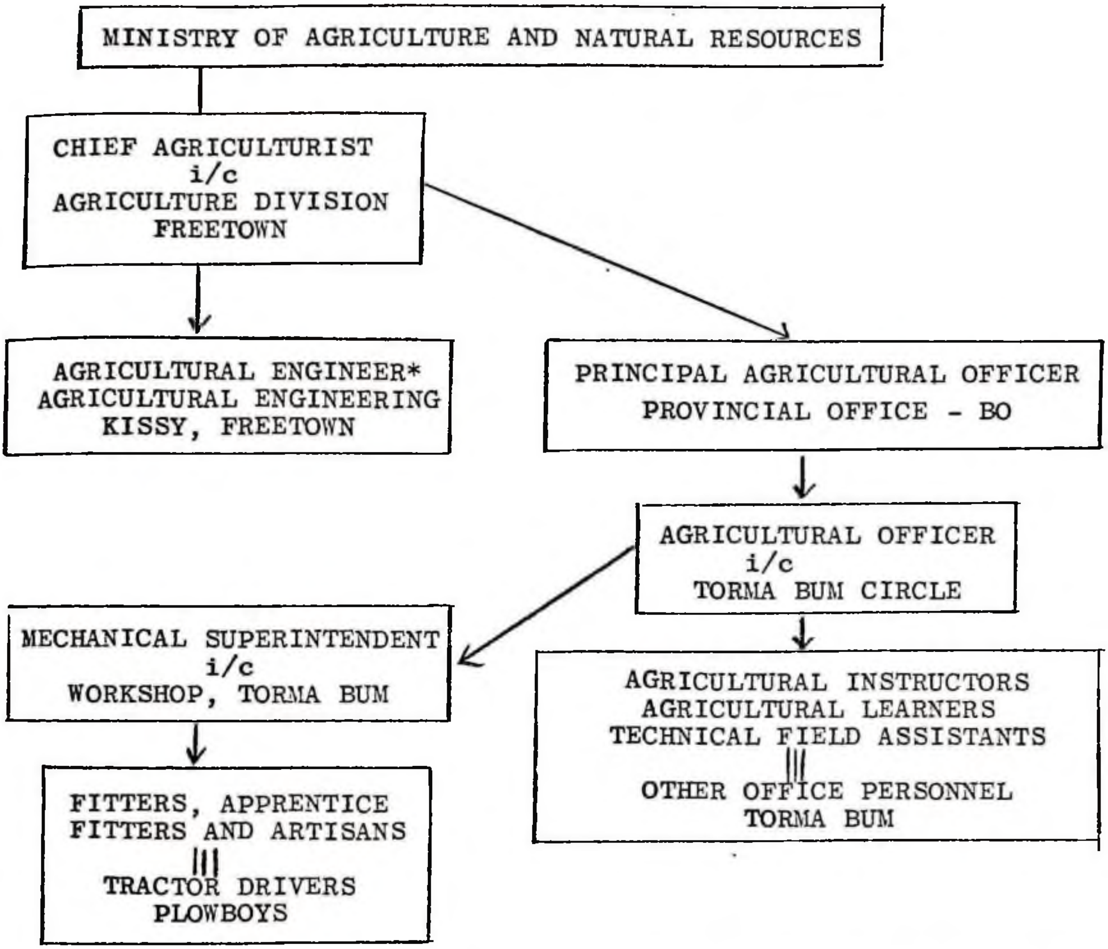
[1] The Torma Bum plowing operation is in fact part of a National Plowing Scheme, but on the basis of organization it operates as an independent unit. Henceforth in this study the Scheme is used synonymously with Torma Bum Scheme or Circle. Where reference is intended to the National Scheme it will be so stated.

Fig. 3-1. Mechanical Cultivation Set-up within the Ministry of Agriculture and Natural Resources.



Arrows indicate Line of Instruction

* The position of the Agricultural Engineer with respect to the workshop in Torma Bum is not clear. Indeed the Agricultural Engineer stated that his responsibility to the plowing scheme in general was that of an advisor, that he does not give instructions regarding repairs to tractors, etc.; if tractors came to Kissy workshop, that would be at the request of the Agricultural Officer or Principal Agricultural Officer. The observation is that neither the Agricultural Engineer nor the Kissy workshop plays any noticeable role in the operation of the Plowing Scheme.

The mechanical operations at Torma Bum fall under what is ordinarily referred to as Torma Bum Circle which includes houses, office and workshop at the base in Torma Bum and the plowing sites located over the grasslands of the Sewa-Waanje basin. A plowing site is a parcel of land upon which mechanical plowing takes place. Operationally and administratively it is a single unit. There are 35 sites under Torma Bum Circle, the sizes of which vary from 15 to 923 acres (Table 3-1). Sites are divided into plots (or farms) to meet the needs of farmers in the particular area where the site is located.

Table 3.1. Plowing Sites and Their Sizes--Torma Bum Circle, 1970

Sites	Acres		Acres
1. Taigba	15.0	20. Bumpe	210.0
2. Gendema II	18.0	21. Boyawoma	214.0
3. Kiban I	23.0	22. Tussor	216.0
4. Kiba II	20.0	23. Masa I	306.0
5. Gbehan	42.0	24. Masa II	219.0
6. Kathin II	60.5	25. Tei-Benduma	220.0
7. Njeilenda	70.0	26. Gendema I	226.0
8. Gondama	70.5	27. Gbemba	228.0
9. Keleh	73.0	28. Tisana (Waanje)	230.0
10. Keigah	78.0	29. Torma	253.0
11. Subu	80.5	30. Sengama	263.0
12. Mano-Bembeteh	100.5	31. Kele (Kpatobu)	304.0
13. Konigbenga	102.0	32. Hiima	306.0
14. Gbamani	105.0	33. Batahul	518.0
15. Kale I	215.0	34. Maike	837.0
16. Kale II	201.0	35. Makita	923.0
17. Kebawana	202.0		
18. Tissana Bum	206.0		
19. Kathin I	208.0		

A set of farm machinery, mechanical workshop equipment and marine vessels comprise the total machinery available to the Circle (Table 3-2).

The Staff

In charge of the Circle is the Agricultural Officer. He exercises local control with regard to supervisory and administrative matters affecting the Circle. Assisting him in the office is a staff of 10 who have mostly clerical responsibilities. The remainder of the staff can be placed in two categories, namely field and workshop.

Field Staff

Field staff is made up of Agricultural Instructors, Agricultural Learners, Field Technical Assistants, Tractor Drivers and Plowboys. A field supervisor assists the Agricultural Officer in the day-to-day supervision of work on the plowing sites. Normally an Agricultural Instructor takes charge of from one to four sites; he is then assisted by an Agricultural Learner and/or a Field Technical Assistant. In some cases, however, the Agricultural Learner is in charge, assisted by a Field Technical Assistant. In any case, the supervisor and his assistants keep all records concerning work done as well as overtime work of tractor drivers and plowboys, consumption of fuel and lubricants, allocation of farm plots to farmers, and the collection of plowing fees. Of course, the proper plowing, harrowing and seed harrowing of the sites are the

Table 3.2. Inventory of Machinery and Equipment, Torma Bum Circle, 1970

Tractors	Number Serviceable	Number* Unserviceable
Richard Continental	22	2
Caterpillar D4	4	1
Massey Ferguson 175	5	--
International BTD6	1	1
Fowler Mark VFA	1	1
Plows		
Massey Ferguson	8	--
Massey Harris	7	--
Ransome Dragoon	10	4
Ransome Hussar	14	2
Eberhardt	1	2
Harrows		
Massey Ferguson	6	--
Massey Harris	1	2
Ransome HR-34	20	--
Ransome Duchess	8	--
Eberhardt	1	--
Supporting Machines		
Mobile Workshop	1	--
Land Rover	1	--
Landing Craft	1	--
Cabin Boat	4	--
Outboard	2	--
Tractor-Trailer	2	--
Welding Plant	2	--
Pumping Plant	1	--
Charing Plant	1	--
Lister Generator	1	--

* Written off state: -- Zero value.

responsibilities of the supervisory staff. At the termination of the plowing season, the Agricultural Instructors, under the direction and supervision of the Agricultural Officer, compile the statistics concerning the performance of the Circle regarding acres plowed, harrowed, seed harrowed and allocated to farmers, direct operating cost of fuel and lubricants, yields of farmers, and the payment of fees. All the Agricultural Instructors have received some theoretical and practical training in agriculture for which they possess a certificate.[2] Agricultural Learners may or may not have had any formal agricultural training; they had been with the Rice Corporation when it handed back operation of the Scheme to the Ministry. The Field Technical Assistants are high school graduates.

The Tractor Drivers, apart from their normal driving duties, are required to assist in the routine servicing, cleaning and lubrication of the machinery placed in their use. Some of the more regular drivers are competent to carry out repairs and assist the fitters in many cases. Tractor Drivers have had no special training; they are mostly of limited experience and are unable to read.

The plowboys are general handymen who run errands, fetch water, clean machinery and are supposed to walk the area to be plowed ahead of the tractor, making sure no obstacles or ditches

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[2] Agricultural Instructors were formerly trained at what is now known as Njala University College. Among the present staff, two received some additional training in Taiwan.

exist which are likely to damage the tractors. Like most of the tractor drivers their employment is only seasonal and terminates at the end of the plowing operations.

Workshop Staff

The Mechanical Superintendent is in charge of the workshop and all mechanical equipment in the Circle. He is supported in his work by a crew of fitters and artisans. In consultation with the Agricultural Officer, the Mechanical Superintendent is responsible for the posting of workshop staff to plowing sites. Together, and in consultation with the Agricultural Instructors, they determine the allocation of tractors to sites. In the absence of the Agricultural Officer, the Mechanical Superintendent takes charge of the Circle. He is a university graduate.

The most senior fitters assist the Mechanical Superintendent in workshop supervision in addition to their share of mechanical work. They are quite frequently sent out to the field with the mobile workshop unit. Fitters and Apprentice Fitters have the responsibilities of carrying out mechanical repairs on the sites (and workshop during off-season) to which they have been assigned.

Plan of Work

Tractors are allocated to plowing sites in groups of two, three or four depending upon the size of the site. To each group is assigned a fitter or apprentice fitter; of course, there is a driver and a plowboy attached to each tractor. All of these, together with the Agricultural Instructor, Agricultural Learner and/or Field Technical Assistant, move to the field at the beginning of the season in February, moving from one site to the next as soon as the operations on one site are finished. Field personnel normally take part of their family with them when moving to the field in February.

The regular work day begins at 7:30 a.m. and ends at 3:00 p.m. with 30 minutes break at 12:00 noon. Overtime work which ordinarily begins at 3:00 p.m. was terminated (by the Agricultural Officer) after about the eighth week of the season.

Delivery of fuel and lubricants from Freetown is made to the base at Torma Bum by tankers and lorries owned by the Ministry of Agriculture and Natural Resources. Storage facilities consist of a 3,000-gallon tank and several oil drums of 45-gallon capacity located at the base. In addition, there are two 1,500-gallon and five 750-gallon tanks located at Mano Koriganya from where distribution is made directly to the sites along the rivers at the upper Waanje and lower Sewa areas by the landing craft and cabin boats. The farthest distance to which the landing craft delivers fuel is roughly about 28 miles, that is, from Mano Koriganya to Masa (upper Waanje).

The Agricultural Instructor often returns to the base to have consultations with the Agricultural Officer, to collect salaries for site personnel, or to arrange for the transporting of tractors and equipment from one site to the next. Moreover, it is primarily through these visits that the Agricultural Officer is able to learn of many problems relating to the running of the Scheme. In general, the field problems can be placed into two groups:

A. Problems of the field operations per se: referring primarily to the method and timing of plowing, conditions of dampness or grassiness, and to the (economic) use of machines, equipment and personnel.

B. Problems relating to the machines and equipment themselves, specifically to their proper functioning--repairing and servicing as well as maintaining adequate fuel and lubricants.

It is evident from this description so far that the Agricultural Instructor holds a key position in regard to the day-to-day plowing operations. As the field supervisor he exerts influence on the quality and quantity of work done by field personnel. From the farmers' points of view, the Agricultural Instructor is the man who determines if and when their plots will be plowed, harrowed and seed harrowed. The competency and attitude of the Instructor are therefore of great importance to the success of the Scheme. Their strategic position should not be overlooked.

At the end of the plowing season (the off-season) the fitters and a few of the more competent tractor drivers return to the workshop to carry out general overhaul and repairs of all tractors and equipment, getting them ready for the next plowing season; the majority of drivers and all plowboys are laid off work. During August to early January no field work is done.

The Data

Method of Collection

The data for this study were collected during February to July 1970 in the Torma Bum Circle, where the plowing Scheme of the riverain grasslands in the Southern Province of Sierra Leone is being operated. First-hand knowledge was gained by personal observations of all workshop and field operations, by inter-views with many technical and nontechnical persons involved in these operations, and, more importantly, by keeping records of all daily operations. In addition, many visits were made to other parts of the country, which provided opportunities for making more general observations and for the collection of other relevant data. Particularly, visits to Rokupr Rice Research Station, Mechanical Plowing Schemes at Makeni and Gbundapi, and the Chinese Agricultural Mission at Mange-Bureh were quite important. An indispensable part of the field work was spent in visiting administrative and professional officials in head offices of the Ministries of Finance, Agriculture and Natural Resources, the Rice Corporation, the Bank of Sierra Leone and the Central Statistics Office. Through this means a significant part of the data and other information were obtained from office records and from persons intimately involved with the National Mechanization Scheme, including insights into some issues of policies.

Availability

During the course of field work, all 33 tractors which operated on all the 35 plowing sites in the Circle were studied. The data collected were:

a. The number and acquisition costs of tractors and equipments. (These were obtained according to make, type, and size, as well as the year and country of purchase.)
b. Value of buildings--houses, offices, stores and workshop.
c. Number of acres plowed--total, per tractor, per day.
d. Number of hours worked--total, per tractor, per day.
e. Consumption of fuel and lubricants--total, per tractor, per site.
f. Operating costs--repairs and maintenance, salaries and wages.
g. Staff-supervisory (field and administrative) personnel and non-supervisory, including daily paid personnel.
h. Allocation of plots (farms) to farmers.

Type and Limitations

The type of data used in this study can be classed as technical and economic. Technical data refer to the production method, time and output. Specifically under consideration are acres and hours collected in the field on Forms A and B, specifically designed for this purpose (Appendix A and B). These data represent actual work done as checked and reported to the office each week by the Agricultural Instructors. Most of the tractors had serviceable meters intact from which reliable readings were obtained. In some cases, hours of operation tend to correspond with the seven hour workday. Estimates were also made of the lifetime of tractors, equipment and other physical assets.

Economic data are concerned with prices and elements of costs. Consistent with convention, these data were classed as to those relating to fixed costs, namely, depreciation and interest rates, and those relating to variable costs, namely, repairs and maintenance, fuel and lubricants, salaries and wages.

Allocation of Costs

Fixed Costs

Depreciation cost, which is the annual decline in value of the machinery, depends upon the initial purchase price and the years of probable use of the machinery. In Sierra Leone, the life span of tractors and mechanical equipments is fairly short. Previous studies have allowed four and five years life span for wheeled and crawler tractors, respectively.[3] It was decided that for this study the depreciation rate would be on the basis of five and six years for wheeled and crawler type tractors, respectively. This is a fair judgment, since many tractors have already had four years of use and are still serviceable; two tractors have exceeded eight years of service. The straight-line method of depreciation was used in figuring depreciation cost. The method is: purchase price[4] less salvage value of machinery, divided by lifespan (in years). In this study salvage value was taken as zero; therefore, depreciation cost is simply purchase price divided by lifespan. Depreciation charges have been calculated considering each

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[3] Gilbert, op. cit., pp. 2-18.

[4] The present sales value was not used as the alternative opportunity cost there is no market for used tractors in Sierra Leone.

tractor and its ancillary equipment as a unit. The charges are computed on an annual and a per acre basis. Depreciation charges on supporting machines have been calculated by considering variable lifespan depending on the machine. Judgment regarding the lifespan of the machines was based on the accounting practice of the Rice Corporation. Buildings were allowed a life expenctancy of 20 years.

Interest cost: Implicit in the cost of using the machinery and equipment is an interest payment on the capital involved. The capital used here, it is assumed, possesses an alternative-use-value or opportunity cost. However, this capital, having been committed to the present use, cannot be used elsewhere. The rate of interest charged should therefore be equivalent to what this capital would earn if placed in an alternative investment, or the rate of interest actually paid if the capital were borrowed. In this particular case, 5-1/2 percent was chosen representing the rate at which Class B stocks were sold by the Rice Corporation in the process of obtaining capital. It is assumed that part of the capital used in the purchase of these machinery and equipments was derived from stock sales. The interest cost was computed as the interest rate times the purchase price less salvage value, divided by two.

Variable Costs

Spare parts: The Ministry of Agriculture and Natural Resources does not keep any records on the consumption of spare parts. In the absence of such data, satisfactory estimates can be made based on a percentage of annual depreciation or of the purchase price of the machinery.[5] Estimates based on figures furnished by the Rice Corporation for spare parts consumed during a year revealed that 30 percent of the annual depreciation cost is an acceptable assessment for parts. The charges for parts were then spread over the acreage on an equal basis. Therefore, in a total variable cost sense, the cost of parts relates directly with output, but on a per acre basis this cost is constant. Form C was designed for the collection of data relevant to this component (Appendix C).

Maintenance: The cost of maintenance on the machines is normally assumed to be proportional to their use. The cost here refers to that for labor (parts being taken care of above). The approach used was to allocate the wages of the workshop staff for the season on a basis proportional to acreage plowed. Logically, as a larger acreage is plowed, the maintenance cost increases.

Fuel and Lubricants: The figures used represent the actual consumption per tractor as collected in the field on Form C-1 which was specifically designed for this purpose (Appendix C-1). The total consumption of fuel and lubricants

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[5] W. Bowers, Modern Concepts in Farm Machinery Management, Oklahoma State University, Stipes Publishing Company, Champaign, Illinois, 1968, pp. 38-45.

corresponds with the figures supplied by the Storekeeper to all the plowing sites. The prices are the official ones furnished by the Ministry for delivery at the base:[6]

Diesel fuel (per gallon)	Le 0.455
Gasoline (per gallon)	Le 0.61
Lubricating oil (per gallon)	Le 1.10
Grease (per pound)	Le 0.19

Salaries and Wages: Salaries and wage costs are given according to the categories (a) supervision--administrative, (b) supervision--field, (c) workshop staff, (d) tractor operation. These are given according to the period of the plowing season chargeable to the particular operation, for example, field supervision is charged six months of annual salary. Most of the labor involved (supervision or tractor operation) are transferable to other activities relating to the plowing operation during the season. Therefore, labor cost is not strictly dependent on output as such. For this reason, it is more accurately an overhead cost. However, total labor cost varies with output. In the context of the study, whether or not labor cost is fixed or variable, is not critical to the analysis.[7]

The Model

An economic model is an organized set of relationships

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[6] One Leone (Le) = $1.20 U.S.

[7] See Gerard K. Boon, Economic Choice of Human and Physical Factors in Production, Stanford University, Stanford, California, 1964, p. 87.

that describes the functioning of an economic entity, such as a household, a firm, an industry or a national economy, given a set of simplifying assumptions. The model used to test the hypothesis of this study is based on budgeting analysis.[8]

Basically, a budgeting analysis converges on two figures. One of these is total revenue, the other is total cost. The difference between them is profit (π). Algebraically this may be stated:

$$Q\,P_i \;-\; X_i p_i \;-\; Z = \pi$$

Total Revenue — /Variable cost + Fixed Cost/ = Profit

where Q_i = rates of output; X_i = rates of input; p_i = prices.

Specifically, the Least-Cost-Approach method of budgeting is used. In this approach, it is assumed that changes in total cost affect only profit, there is no effect on total revenue. This approach is considered appropriate, in that the specifications required are consistent with the way the data were collected (Appendix E).

Scheme of Analysis

The general scheme of the analysis consists of determining total costs. Total costs are divided into two broad categories: fixed and variable costs.

Total fixed costs are a result of the use of indivisible factors; these do not vary with output but remain constant

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[8] Lawrence A. Bradford, and Glenn L. Johnson, Farm Management Analysis, John Wiley & Sons, Inc., New York, 1967, pp. 328-361.

over the whole range of output. The fixed costs taken into account in this study are depreciation and interest costs for the different assets used.

In order to calculate depreciation cost, the lifespan of the assets must be known. The lifespan of a machine is not unique; it can be prolonged by careful use, repairs and maintenance; or, it can be shortened by lack of these. In calculating depreciation cost for tractors and their ancillary equipment, it was decided to allow five and six years lifespan, respectively, for wheeled and crawler tractors. Later, different lengths of life were chosen to see how total fixed costs would be affected. In the case of interest rate, which, as an exogeneous variable, is not determined by the use or abuse of the tractors and equipment, it was decided that 5-1/2 percent per annum would be valid. Subsequently, different magnitudes of interest rates were used in order to develop a total cost comparison.

Total variable costs result from the use of divisible factors. These costs vary continuously with output. It is not always easy to distinguish between fixed and variable costs; the distinction depends on the circumstances or the length of run under consideration. Some type of labor is an example of this type of problem. As far as this study is concerned, costs resulting from the following sources were included under variable costs: spares, maintenance, fuel, lubricants, labor for field operations and for supervision.

Throughout the analysis attention was given to total cost per acre. Also for tractor costs according to the type of field operations, it was decided to use the concept of energy costs as the basis for determining costs of plowing and harrowing and seed harrowing. The cost of plowing a piece of land is different in every respect from the cost of harrowing that same piece of land. Energy costs are those costs which are in direct proportion to the amount of work done by a tractor, regardless of its size.[9] Included are fuel, lubricants, all maintenance and repairs, as well as the proportion of depreciation and interest associated with the use of the tractors and equipment. Consequently in this study an allocation was made of 70 percent and 30 percent for the respective operations of plowing and harrowing. The basic calculations determining this allocation are as follows:

The Energy requirement for plowing per acre is $43,560 \text{ ft.}^2 \times 175$ lbs/ft.; where 43,560 = number of square feet per acre; 175 pounds of draft per foot of width for a plowing depth of 7 inches (or 25 lbs/ft. per inch depth of plowing).

The Energy requirement for harrowing per acre is $43,560 \text{ ft.}^2 \times 75$ lbs/ft. (depth of 3 inches).

Total tractor energy requirement is therefore 43,560 (175 + 75) or 10,890,000 lbs/ft.

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[9] Agricultural Engineers Yearbook, 1969, pp. 279-281.

Fraction of energy requirement (and therefore cost) for each operation is as follows:

Plowing: $\frac{43,560 \times 175}{10,890,000} = \frac{7}{10} = 0.70$

Harrowing: $\frac{43,560 \times 75}{10,890,000} = \frac{3}{10} = 0.30$

CHAPTER 4

ECONOMIC ANALYSIS OF THE DATA

Increased rice production is a main objective of the Mechanization Scheme in Torma Bum. This objective can be accomplished in two ways: (1) increase the yield per acre; (2) increase the number of acres cultivated. The concern of this study is with the second way through the process of mechanization. However, the fact that yield increases can be experienced, because of the better quality of seedbed preparation, when land is mechanically plowed, is not without notice. A total cost approach is used in the analysis of the data. Separate estimates are presented for plowing and harrowing/seed harrowing. This separation is deemed to be conceptually useful, as it permits greater understanding in regard to the structure of costs relative to the two operations.

Hypothesis

The general hypothesis of the study is that cultivation costs per acre in the Torma Bum Scheme can be substantially reduced.

Allocation of Costs

Total costs are divided into two broad categories: fixed and variable costs. The fixed costs, depreciation and interest, are treated first. These are followed by a treatment of the variable costs: fuel-lubricants, repairs-maintenance, tractor operating labor, field and administrative supervision.

The Fixed Costs

Depreciation:

Depreciation cost is an allowance made for that part of the capital assets consumed by the plowing operation during the year. It consists of depreciation costs on tractors, supporting machines and equipment, as well as on building. The total depreciation allocable to plowing amounted to Le 42,616.29. Tractors alone accounted for Le 30,548.12 of this amount; supporting machines take up Le 7,708.17, plows take up Le 4,185.00 and buildings accounted for Le 175.00. The landing craft is the biggest single item in the cost of depreciation; Le 4,550.0 were due to depreciation of this item (Table 4-1).

Depreciation cost per acre was obtained by dividing total depreciation by the acreage plowed during the season. For the 1970 plowing season, per acre depreciation plowing cost was Le 5.79. Generally once the lifespan of the machines is established the annual depreciation cost is also established (under the straightline method). On a per acre basis, however, depreciation cost can vary from year to year depending on the yearly variation in acreages plowed. In this sense the figure Le 5.79 is considered to be quite high. Regarding depreciation cost per acre therefore, in addition to the two factors (initial price and lifespan) mentioned in Chapter 3, as affecting depreciation, must be added a third--the level of tractor utilization (or level of output). As will be shown

Table 4.1. Depreciation and Interest Charges for Plowing Operation (Leones), Torma Bum Circle, 1970

No.	Machinery	Total Outlay	Life-Span	Annual Depreciation	Annual Interest[a]	Cost[b] Depreciation	Cost[b] Interest
	Tractors						
22	Richard Continental	211,200.00	6	32,200.00	5,808.00	24,640.00	4,065.60
4	Caterpillar D4	29,776.00	6	4,962.67	818.84	3,473.87	573.19
5	Massey Ferguson-175	14,750.00	5	2,950.00	405.62	2,065.00	283.93
1	International BTD6	3,400.00	10	340.00	93.50	238.00	65.45
1	Fowler Mark VFA	1,875.00	10	187.50	51.56	131.25	36.09
	Plows[c]						
14	Ransome Hussar	9,100.00	6	1,516.67	250.25	1,516.67	250.25
10	Ransome Dragoon	5,750.00	6	958.33	158.12	958.33	158.12
8	Massey Ferguson	5,600.00	5	1,120.00	154.00	1,120.00	154.00
7	Massey Harris	5,250.00	10	525.00	144.38	525.00	144.38
1	Eberhardt	650.00	10	65.00	17.88	65.00	17.88
	Supporting Machines						
1	Mobile Workshop	8,800.00	15	586.67	244.00	410.67	170.80
1	Land Rover	3,200.00	5	640.00	88.00	448.00	61.60
1	Landing Craft	78,000.00	12	6,500.00	2,145.00	4,550.00	1,501.50
4	Cabin Boat	12,000.00	5	2,400.00	330.00	1,680.00	231.00
2	Outboard Boat	1,100.00	4	275.00	30.25	192.50	21.18
2	Tractor-Trailer	1,500.00	5	300.00	41.25	210.00	28.88
2	Welding Plant	500.00	5	100.00	13.75	70.00	9.62
1	Pumping Plant	200.00	5	40.00	5.50	28.00	3.85
1	Charging Plant	250.00	5	50.00	6.88	35.00	4.82
1	Lister Generator	1,200.00	10	120.00	33.00	84.00	23.10
	Buildings	5,000.00	20	250.00	137.50	175.00	96.25
	Total			59,086.84	10,977.28	42,616.29	7,901.49

a Interest rate is 5-1/2 percent.
b Fraction charged to plowing operation
c For this type of equipment 100 percent of annual depreciation and interest is charged to plowing operation.

later, attempts to reduce depreciation cost should be directed at these three factors.

Interest:

This component has been included to reflect the opportunity cost of using the capital involved in operating the Scheme. This capital could be used in other ways and consequently possesses an alternative use value. At 5-1/2 percent interest rate per annum, a total amount of Le 7,901.49 has been added from this source to the total cost of plowing for the 1970 season (Table 4-1). The interest cost per acre turned out to be Le 1.07. The Ministry of Agriculture and Natural Resources does not recognize any explicit interest payment. However, it is felt that interest at a reasonable rate should be included in the analysis. What is reasonable is usually a matter of one's judgment. Generally a rate consistent with Government Corporation returns and Stock, or the Treasury Bill discount rate is considered acceptable. In Sierra Leone, during 1969 and 1970, the Treasury Bill discount rates varied between 5 and 6 percent. The 5-1/2 percent chosen just reflects the situation existing at the time of the data collecting.

Depreciation and interest costs amounted to a total fixed cost of Le 50,517.78 for the 1970 plowing operation in the Circle.

The Variable Costs

Fuel and Lubricants: The total direct cost for fuel and lubricants (grease and oil) on the plowing operation amounted to Le 14,158.23 (Table 4-2). To this was added Le 4,781.06 due to the cost of fuel consumption in the transportation system. The delivery of tractors, equipments and supplies to plowing sites, as well as the general transporting of supervisory personnel, therefore accounted for 25 percent of the cost of fuel and lubricants.

The range of fuel cost per acre between tractors of the same make was remarkably close. However, there was a wide variation between tractor-makes in regard to fuel cost per acre. For example, costs varied from a high of Le 3.42 per acre in the Richard Continental make to a low of Le 0.79 among the Massey Ferguson-175.

The variations in costs of fuel and lubricants among plowing sites are noticeable. For those under 200 acres the fuel cost was Le 2.34 per acre (on Gendema II it was as high as Le 5.67); for those sites between 200 and 500 acres the per acre fuel cost was Le 2.00 and for those over 500 acres fuel cost was Le 1.62 per acre computed from data in Table 4-3. A high fuel cost often indicates the presence of high-thick grass on the plowing site. Poorly fired trash as well as conditions of dampness also affect fuel cost.

The relative tractor efficiency is an important factor accounting for noticeable cost-differences among tractor-makes. This factor with respect to fuel cost may be compared by examining an index of mechanical input. This index is obtained

Table 4.2. Acres Plowed and Cost of Fuel and Lubricants, by Tractors--Plowing Operation, Torma Bum Circle, 1970

Reg. No.	Tractors	Type	Acres	Fuel and Lubricants (Leones)	Cost/Acre
RCT-1	Richard Continental	Crawler	346.0	614.85	1.78
RCT-2	Richard Continental	Crawler	197.0	434.63	2.21
RCT-3	Richard Continental	Crawler	239.0	630.55	2.64
RCT-4	Richard Continental	Crawler	31.0	75.03	2.42
RCT-6	Richard Continental	Crawler	179.0	386.72	2.16
RCT-7	Richard Continental	Crawler	11.0	37.67	3.42
RCT-9	Richard Continental	Crawler	158.5	367.78	2.32
RCT-12	Richard Continental	Crawler	269.5	642.86	2.39
RCT-13	Richard Continental	Crawler	256.0	601.60	2.35
RCT-14	Richard Continental	Crawler	74.0	213.16	2.88
RCT-15	Richard Continental	Crawler	307.5	673.27	2.19
RCT-16	Richard Continental	Crawler	44.0	98.40	2.24
RCT-17	Richard Continental	Crawler	101.0	209.35	2.07
RCT-18	Richard Continental	Crawler	217.0	377.07	1.74
RCT-19	Richard Continental	Crawler	211.0	391.67	1.86
RCT-20	Richard Continental	Crawler	430.0	786.28	1.83
RCT-21	Richard Continental	Crawler	212.5	510.13	2.40
RCT-22	Richard Continental	Crawler	175.0	349.77	2.00
RCT-23	Richard Continental	Crawler	407.0	852.52	2.09
RCT-24	Richard Continental	Crawler	157.5	325.51	2.07
RCT-25	Richard Continental	Crawler	219.0	479.05	2.19
RCT-26	Richard Continental	Crawler	48.0	143.90	3.00
			4,290.5	9,201.77	2.14
RCT-91	Caterpillar D4	Crawler	524.0	859.44	1.64
DA-90	Caterpillar D4	Crawler	605.5	1,314.48	2.17
DA-75	Caterpillar D4	Crawler	27.0	74.55	2.76
DA-76	Caterpillar D4	Crawler	35.0	109.90	3.14
			1,191.5	2,358.37	1.98
RCT-50	Massey Ferguson	Wheeled	236.5	187.62	0.79
RCT-52	Massey Ferguson	Wheeled	437.0	468.52	1.07
RCT-56	Massey Ferguson	Wheeled	34.0	48.21	1.42
RCT-60	Massey Ferguson	Wheeled	453.0	556.63	1.23
RCT-61	Massey Ferguson	Wheeled	9.5	17.33	1.82
			1,170.0	1,278.31	1.09
DA-87	International	Crawler	503.0	861.98	1.71
DA-44	Fowler Mark	Crawler	207.0	457.80	2.21
TOTAL			7,362.0	14,158.23	1.92

Table 4.3. Torma Bum Plowing Sites with Hours of Work and Fuel Costs[a] of Tractor Operation--1970 Plowing Operation

Plowing Sites	Acres	Hours worked	Fuel[b] cost/acre	Plowing Sites	Acres	Hours worked	Fuel[b] cost/acre
1. Keleh	73.0	147.0	2.09	19. Masa I	306.0	462.0	1.80
2. Keigah	78.0	128.0	2.09	20. Masa II	219.0	335.5	1.92
3. Gbehan	42.0	110.0	2.82	21. Kele (Kpatobu)	304.0	471.0	2.26
4. Konigbenga	102.0	179.5	2.20	22. Kale (Karleh) I	215.0	344.0	2.07
5. Njeilenda	70.0	157.0	2.03	23. Kale (Karleh) II	201.0	323.0	1.99
6. Gbamani	105.0	211.0	2.48	24. Hiima	305.0	548.5	2.33
7. Taigba	15.0	63.0	4.54	25. Tussor	216.0	337.0	1.97
8. Gendema II	18.0	67.5	5.67	26. Tisana (Waanje)	230.0	342.0	1.88
9. Gondama	70.5	126.0	2.00	27. Baba (Sewa)	228.0	344.0	1.86
10. Subu	80.5	115.5	1.89	28. Bumpe	210.0	319.0	1.92
11. Kathin II	60.5	130.5	1.96	29. Kathin I	208.0	294.5	1.99
12. Mano-Kuranko	100.5	161.0	1.41	30. Gendema I	226.0	343.5	2.16
13. Kiban I	23.0	90.0	5.14	31. Boyawoma	214.0	332.0	2.14
14. Kiban II	20.0	71.0	5.12	32. Tei (Benduma)	220.0	361.0	2.11
15. Sengama	263.0	396.0	1.89	33. Batahoz (Waanje)	518.0	748.5	2.05
16. Tissana-Bum	206.0	326.0	1.73	34. Makita	923.0	1,253.0	1.49
17. Kebawana	202.0	343.0	2.17	35. Maike	837.0	1,140.0	1.50
18. Torma	253.0	357.0	1.74				

a Includes fuel, oil and grease.

b Given in Leones.

by multiplying tractor-hours per acre by the horsepower rating of the tractor. It is not a measure of actual power delivered as such; it is simply a device commonly used by Agricultural Engineers for weighting tractor utilization so as to allow for differences in capacities of the tractors. Thus a 70 horsepower Richard Continental had an input level of 119.00 corresponding to a fuel cost per acre of Le 2.14; the 57 horsepower Caterpillar D4 had an input level of 75.24 and a per acre fuel cost of Le 1.98 (Table 4-4). Moreover, this index compares the energy developed relative to fuel consumption by tractor-make. Due to the differences in relative efficiency, by the time the Caterpillar D4 could develop an input of 119, other things being equal, fuel cost would have exceeded Le 3.13 per acre compared with Le 2.14 for the Richard Continental.

Repairs and Maintenance: Cost obligations due to this component were divided into those for spare parts and those for labor. The total amounts, respectively, were Le 12,874.89 and Le 8,095.48 (Table 4-5). In the case of spare parts, cost was distributed according to machines, equipment and buildings; the overall cost per acre was Le 1.74. Labor cost has been split up according to tractor-make on a proportional basis. For example, the Richard Continental accounted for 67 percent of the labor cost which is equal to 22 out of 33 tractors. The labor cost per acre for repairs and maintenance was Le 1.10. The cost per acre according to tractor-make represented the fraction of cost divided by the acreage plowed by that par-

Table 4.4. Mechanical Input Per Acre--1970 Plowing Operation, Torma Bum Circle

Tractor-makes	(1) Horsepower	(2) Hours worked	(3) Acreage done	(4) Tractor-hour per acre	(5) Index[a] of input	(6) Fuel cost per acre (Le)
Richard Continental	70	7,315.5	4,290.5	1.70	119.00	2.14
Caterpillar D4	57	1,571.5	1,191.5	1.32	75.24	1.98
Massey Ferguson-175	65	1,637.5	1,170.0	1.40	91.00	1.09
International-BTD6	50	619.0	503.0	1.24	62.00	1.71
Fowler Mark-VFA	45	334.0	207.0	1.61	72.45	2.21

a Column 1 times column 4.

Table 4.5. Costs of Repairs and Maintenance--Plowing Operation, Torma Bum Circle, 1970

		Spares			Labor		
No.	Machinery	Value of spares[a]	Cost of spares used[b]	Cost per acre	Cost	Cost used[b]	Cost per acre
	Tractors						
22	Richard Continental	10,560.00	7,392.00	1.72	7,748.55	5,423.98	1.26
4	Caterpillar D4	1,488.80	1,042.16	0.87	1,387.80	971.46	0.82
5	Massey Ferguson-175	885.00	619.50	0.53	1,734.75	1,214.32	1.04
1	International-BTD6	102.00	71.40	0.14	346.95	242.86	0.48
1	Fowler Mark-VFA	56.25	39.38	0.19	346.95	242.86	1.17
	Plows						
14	Ransome Hussar	455.00	455.00[c]	0.11			
10	Ransome Dragoon	287.50	287.50	0.24			d
8	Massey Ferguson	336.00	336.00	0.29			
7	Massey Harris	157.50	157.50	0.31			
1	Eberhardt	19.50	19.50	0.09			
	Supporting Machines						
1	Mobile Workshop	176.00	123.00	0.02			
1	Land Rover	192.00	134.40	0.02			
1	Landing Craft	1,950.00	1,365.00	0.19			
4	Cabin Boat	720.00	504.00	0.07			
2	Outboard Boat	82.50	57.75	0.01			
2	Tractor-Trailer	90.00	63.00	0.01			
2	Welding Plant	30.00	21.00	--			
1	Pumping Plant	12.00	8.40	--			
1	Charging Plant	15.00	10.50	--			
1	Lister Generator	36.00	25.20	--			
	Buildings	75.00	52.50	0.01			
	Total		12,784.89	1.74		8,095.48[e]	1.10

a 30 percent of annual use-cost (column--Annual Depreciation of Table 4.1).
b Fraction allocated to plowing operation (70 percent of value).
c 100 percent (for the plows) taken for the plowing.
d Included above.
e From Table 4.6.

ticular make of tractor. Thus the Richard Continental had Le 1.26 which is equal to Le 5,423.98 divided by 4,290.5 acres. Labor chargeable to plows and supporting machines was included under tractors; this avoids the possibility of double counting. Labor costs attendant with repairs and maintenance represented the expenditures on salaries and wages of the mechanical staff. During the plowing operation repairs and maintenance carried out in the workshop as well as in the field were not separable (Table 4.6). Only a minimum staff remained at the workshop during this period and there was a considerable amount of movement of staff between workshop and field.

Table 4.6. Workshop Staff, Torma Bum Circle, 1970

	Staff	Status	Salary[a] (Leones)
1	Mechanical Superintendent	Permanent	1,692.00
2	Senior Fitter	Permanent	1,056.00
7	Fitters	Daily	3,318.00
6	Apprentice Fitters	Daily	1,836.00
1	Coxswain[b]	Permanent	511.00
4	Sailors[b]	Daily	1,896.00
2	Artisans	Daily	708.00
2	Workshop laborers	Daily	548.00
			11,565.00

a Annual includes servicing and repairs during off-season.
b Assigned to workshop when not manning the marine vessels.

The plowing season was marked by numerous and frequent breakdowns of tractors and equipment. In a single week, as many as seven tractors became inoperable. During the third week of operation two tractors fell in ditches and were damaged beyond immediate repair. After this point (in time) the number of tractors working each week started to decline. In the twelfth week of the season, 17 tractors (or 52 percent of the original number of 33) were actively engaged in the plowing operation; from the eighteenth week to the end of the season in July, no more than four tractors (or 12 percent of the original fleet) were able to work during any given week. A multiplicity of factors has been blamed for these setbacks of tractors. Some of the more common causes of mechanical breakdowns were:

1. Richard Continental - breaking of the timing cog, faulty gear system, breaking of generator bolts and breaking of tracks.
2. Massey Ferguson - failure in the hydraulic system, breaking of drawbar, and frequent leaking of radiators.
3. Damaged oil seal rings--common to all makes of tractors.
4. Serious shortage of batteries and fan belts--a regular problem of spare-parts unavailability.
5. Frequent breakages of plow bolts and air locks.

Many tractors when once broken down were not able to return to work for the remainder of the plowing season. The contingence of repairs upon the availability of parts was clearly reflected in the rapid decline in the number of tractors working per week. Lack of even a simple part resulted in an immobilization of the machine for several days, or even for the season. For example, there was a Unimog 406 which never worked a single day out of the entire season because it needed a set of oil seals and two tires which were not available.

Tractor Operating Labor: The cost of this component was comprised of the wages of tractor drivers and plowboys. There were 33 of each, a driver and a plowboy for each tractor. The total expenditure on this component was Le 9,011.18 (Table 4.7). The per acre cost was Le 1.22. Per acre cost according to tractor-make varied from Le 0.54 for the International to Le 1.41 for the Richard Continental. The amount due to overtime was Le 1,422.83, which was a clear 16 percent of the total cost for this component.

Table 4.7. Tractor Operating Labor Cost*--Plowing Operation 1970, Torma Bum Circle

Tractors	Driver[a]	Plowboy[b]	Overtime[c]	Total[d]	Per acre
Richard Continental	2,965.77	2,118.42	953.30	6,037.49	1.41
Caterpillar D4	531.18	379.42	170.74	1,081.34	0.91
Massey Ferguson-175	663.98	474.26	213.43	1,351.67	1.16
International-BTD6	132.80	94.86	42.68	270.34	0.54
Fowler Mark-VFA	132.80	94.86	42.68	270.34	1.31
Total	4,426.53	3,161.82	1,422.83	9,011.18	1.22

* Direct cost for plowing.
a Driver's wages varied between Le 1.05 and Le 1.07 per day.
b Plowboy's wages varied between 75¢ and 80¢ per day.
c Overtime was during February and March.
d Amounts taken from pay bills.

Field Supervision: Field supervision cost amounted to Le 2,740.15 (Table 4.8). This amount represented 50 percent of the annual salaries of the field supervisory staff, which was consistent with the proportion of .ime spent on the Scheme during the year. There is no general agreement as to whether or not the period spent on extension work, to which the super-

Table 4.8. Salaries for Field Supervisory Staff--1970 Plowing Operation, Torma Bum Circle

	Field Staff	Salary[a] (Leones)	Allocation by Tractor-Make	Amount[b] (Leones)	Cost[c] (Leones)	Per Acre (Leones)
2	Agricultural Instructor Grade II	1,740.00	Richard Continental	2,622.72	1,835.90	0.43
3	Agricultural Instructor Grade III	1,953.00	Caterpillar D4	469.74	328.82	0.28
6	Agricultural Learner	2,496.00	Massey Ferguson	537.18	411.03	0.35
5	Technical Field Assistant	1,640.00	International	117.43	82.20	0.16
			Fowler Mark	117.43	82.20	0.40
		7,829.00		3,914.50	2,740.15	0.37

a Annual.
b Pro-rated according to proportion of total salary allocable to tractors in each make.
c Fraction charged to plowing operation (70 percent).

visors go after the plowing season, is chargeable to the mechanical operations. The Ministry of Agriculture and Natural Resources does not impute this portion of their work to the Scheme. This study concurs.

Administrative Supervision: In Government schemes of this nature it is usually difficult to determine just where administrative supervision begins or ends. Even when the ranks of personnel to be considered in administration are determined, the question as to the proportion of salary must then be answered. Because of these difficulties, invariably, important elements of indirect costs cannot be identified in the overall administrative structure. These indirect costs include provision of production requisites for tractors, spare parts, fuel and lubricants, as well as in the determination of policies affecting the organization and operation of the National Scheme.

For the purpose of this study, however, administrative superivison began at the Agricultural Officer's level. The cost obligations of staffing his office were imputable to the Scheme in the proportion which was relevant. Officials in the Ministry of Agriculture and Natural Resources have determined in concurrence with this study that 50 percent of their time was generally devoted to mechanical cultivation work, hence that portion of the staff's salaries was relevant to the plowing operations. Accordingly, an amount of Le 1,981.20 from this source was added to total cost, which gave a per acre cost of (administrative supervision) Le 0.27 (Table 4.9).

Table 4.9. Salaries for Administrative Personnel--1970 Plowing Operation, Torma Bum Circle

Staff	Salary[a] (Leones)	Allocation to Tractor-Make	Amount[b] (Leones)	Cost[c] (Leones)	Per acre (Leones)
1 Agricultural Officer	1,320.00	Richard Continental	1,896.29	1,327.40	0.31
1 SNR Agricultural Instructor	1,224.00	Caterpillar D4	339.63	237.74	0.20
1 Storekeeper	582.00	Massey Ferguson	424.54	297.18	0.25
1 Assistant Storekeeper	330.00	International	84.91	59.44	0.12
1 Clerk-Typist	458.00	Fowler Mark	84.91	59.44	0.29
1 Driver (Landrover)	420.00				
1 Messenger	352.00				
1 Rest House Keeper	317.55				
2 Watchmen	657.00				
	5,660.55		2,830.28	1,981.20	0.27

a Annual.
b Total salary pro-rated according to number of tractors in each make.
c Fraction charged to plowing operation (70 percent).

Per Acre Costs

Per acre costs show essentially the same general information as do total costs, but from a different point of view which is more usable for interpretation purposes. Four types of per acre costs are discussed below: fixed, variable, marginal, and total costs per acre. In order to lend lucidity to the discussion, it was necessary to determine several (intermediate) output levels. These are shown in Table 4.10.

Fixed Cost Per Acre: This amount was obtained by dividing total fixed cost by acres plowed at various levels of operation. Since total fixed cost remains unchanged regardless of the acreage, it is spread over many more acres as operation expands, consequently fixed cost per acre declined continuously throughout the whole range of acreages plowed. According to Table 4.10, fixed cost per acre dropped from Le 38.14 to Le 6.86 between 1,324.5 and 7,362.0 acres. The fixed cost per acre curve (AFC) slopes downwards to the right throughout its entire length, indicating that at larger acreage, fixed cost per acre becomes lower (Fig. 4-1).

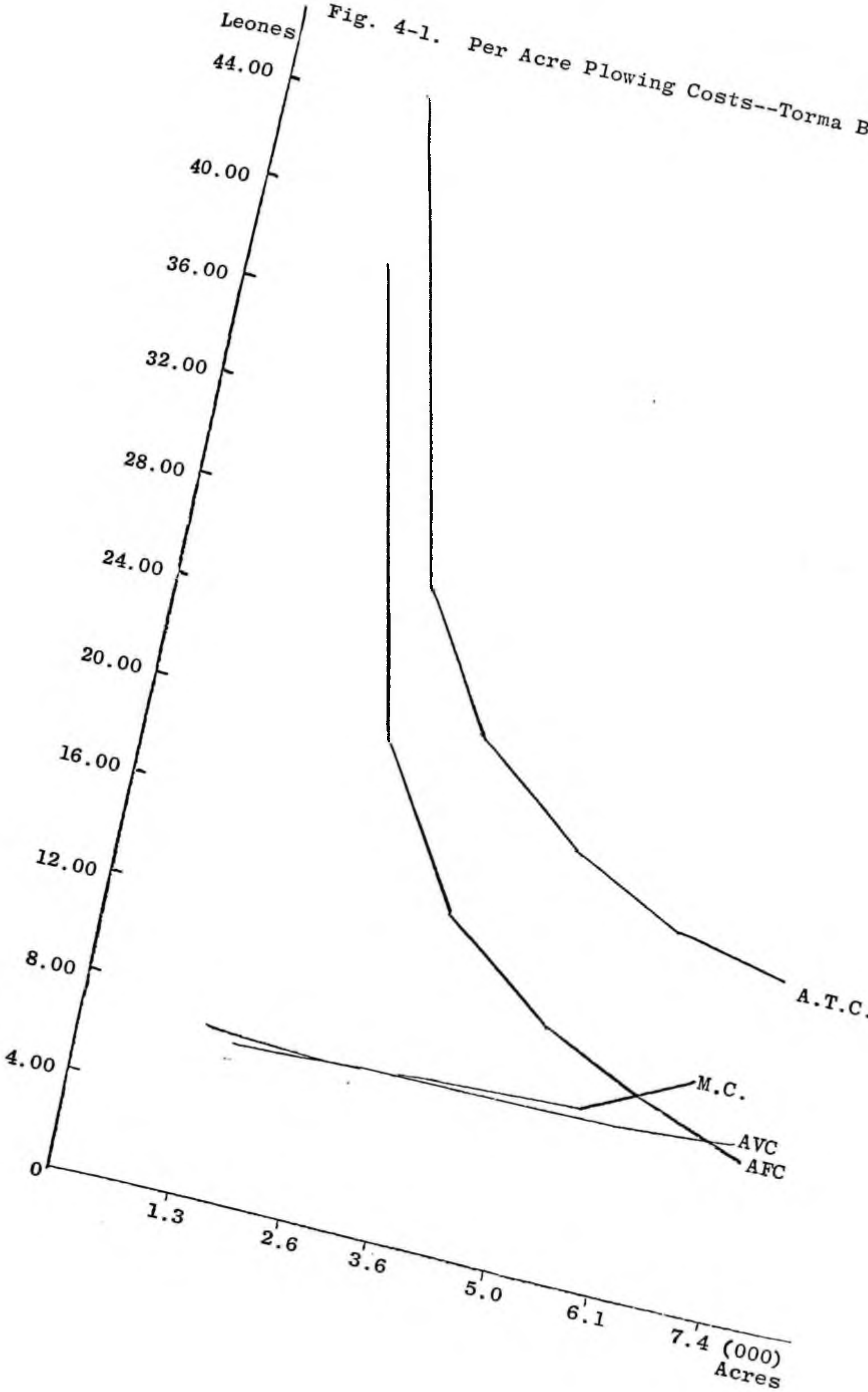
Variable Cost Per Acre. This amount was obtained by dividing total variable cost by acres plowed at various levels of operation. Observation of Table 4.10 indicates that this cost appeared to vary only very slightly over the whole output range. The variable cost per acre curve (AVC) shows only a very slight curvature, having its minimum point at 3,595 acres (Fig. 4-1).

Table 4.10. Cost Schedule for Different Output Levels--1970 Plowing Operation, Torma Bum Circle

Acres[a]	Depreciation	Interest	Total Fixed cost	Average fixed cost	Spares	Labor for repairs	Fuel and lubricant	Tractor operating labor	Administrative supervision	Field supervision	Total variable cost	Average variable cost	Total cost	Average total cost	Marginal cost
1,324.5	42,616.29	7,901.49	50,517.78	38.14	2,304.63	1,456.95	3,445.60	1,126.41	357.62	490.06	9,181.27	6.93	59,699.05	45.07	--
2,569.5				19.66	4,470.93	2,826.45	6,457.14	1,877.35	693.76	950.72	17,276.35	6.72	67,794.13	26.38	6.50
3,595.0				14.05	6,255.30	3,954.50	8,995.99	2,628.29	970.65	1,330.15	24,134.88	6.71	74,652.66	20.76	6.68
4,961.0				10.18	8,632.14	5,457.10	12,586.45	3,754.70	1,339.47	1,835.57	33,605.43	6.77	84,123.21	16.95	6.93
6,079.5				8.31	10,578.33	6,687.45	15,462.34	4,881.11	1,641.46	2,249.42	41,500.11	6.82	92,017.89	15.13	7.05
7,362.0				6.86	12,784.89	8,095.48	18,939.29	9,011.18	1,981.20	2,740.15	53,552.19	7.27	104,069.97	14.13	9.39

a These output levels were chosen purely as a matter of convenience. See Appendix E for further explanation.

Fig. 4-1. Per Acre Plowing Costs--Torma Bum Circle 1970



Theoretically, with given factor prices, the shape of the average variable cost-curve depends upon the efficiency (production function) with which the variable factors are being utilized. Normally this curve has a U-shape. The particular curve under discussion has demonstrated this general curvature, declining at first to a minimum of 3,595 acres, after which it inclined upwards. This inclination was only slight, however, until 7,362 acres were reached when it becomes more apparent.

Marginal Cost: Marginal cost is a ratio of two changes, the change in total cost divided by the change in acreage plowed. This is essentially the rate of change of total cost as the variable factors are being changed. Fixed factors do not affect marginal cost. Theoretically, at the minimum point of the average variable cost curve (representing the optimum rate of output for that level of operation), the marginal cost curve will be equal to it. The results of the analysis were, at least in this respect, consistent with economic theory. Marginal and average variable costs were (approximately) equal at output 3,595 (Fig. 4-1). In terms of variable costs acreages on either side of this point were slightly more costly to produce. The basic problem then is to devise ways and means of shifting the average variable cost curve downwards, so that at each level of operation, plowing will be done at a lower cost per acre.

Total Cost Per Acre: It is now convenient to examine the total costs (total fixed + variable costs) divided by acres. The results are presented in Table 4.11, given according to the various components analyzed. The extent to which total costs were dominated by depreciation is evident. Fixed costs per acre constituted 49 percent of total costs, while variable

Table 4.11. Total Cost per Acre--1970 Plowing Operation, Torma Bum Circle

Components	Cost in Leones	Percent of Total
Depreciation	5.79	41
Interest	1.07	8
Total Fixed	6.86	49
Fuel and Lubricants[a]	2.57	18
Spares	1.74	12
Labor for repairs	1.10	8
Tractor operating labor	1.22	9
Field supervision	0.37	2
Administrative supervision	0.27	2
Total Variable	7.27	51
Total	14.13	100

a Includes fuel and lubricants for transportation system.

costs per acre made up 51 percent. The costs of fuel and lubricants occupied 18 percent of total cost per acre, while spare parts took up 12 percent. The average total cost of plowing one acre of land in the Torma Bum Circle in 1970 was determined to be Le 14.13.

Harrowing and Seed Harrowing

Harrowing and seed harrowing are secondary operations in both a chronological and a cost sense. The general practice was to have the tractors plow one site then move on to another site, returning sometime later to the first, for harrowing and seed harrowing. Seldom do the tractors get back to harrow all the acreage previously plowed. In the 1970 season, the failure to harrow/seed harrow all plowed acres was enormous. The acreage harrowed for the season totalled 5,416.5 of which 4,140 acres were seed harrowed (Table 4.12). There were two important factors upon which this failure may be blamed. The first of these was the high incidence of tractor breakdowns which became quite serious during the months of June and July. The second factor was the early rains which caused a lot of bogging of tractors in the field and generally slowed down the movement of machines during actual harrowing on the sites as well as their movement between sites.

The costs of harrowing/seed harrowing were determined using the same analytical technique and including the same set of components as used for the plowing operation. Tractor performance and fuel consumption are shown in Table 4.12. Capital costs for harrowing/seed harrowing are shown in Table 4.13. Total outlay on all the components as well as the per acre costs is presented in Table 4.14. Fixed cost makes up 55 percent of the total cost, and variable costs make up 45 percent.

The costs per acre for these operations are quite comparable with other estimates made with respect to mechanical

Table 4.12. Fuel, Consumption and Cost for Harrowing/Seed Harrowing

Tractors	Acres harrowed	Acres seed harrowed	Consumption of Fuel (gal.)	Consumption of Oil (gal.)	Consumption of Grease (lb.)	Cost (Leones) Fuel	Cost (Leones) Oil	Cost (Leones) Grease	Total cost of fuel and lubricants
Richard Continental	3,196.0	2,440.5	2,708.0	146.53	93.70	1,232.14	161.18	17.80	1,411.12
Caterpillar D4	1,034.5	939.5	1,001.5	70.41	35.00	455.68	77.45	6.65	539.78
Massey Ferguson	549.5	405.0	267.0	15.71	10.90	121.48	17.28	2.07	140.83
International	322.5	155.0	196.5	16.60	7.28	89.41	18.26	1.38	109.05
Fowler Mark	314.0	200.0	265.5	24.47	12.00	120.80	26.92	2.28	150.00
Total	5,416.5	4,140.0	4,438.5	273.72	158.88	2,019.51	301.09	30.18	2,350.78

Table 4.13. Capital Costs of Harrowing/Seed Harrowing--Torma Bum Circle 1970

	Machinery	Total Outlay	Lifespan in Years	Annual Depreciation	Depreciation Cost[a]	Annual Interest	Interest Cost[a]
	Tractors						
22	Richard Continental	211,200.00	6	35,200.00	10,560.00	5,808.00	1,742.40
4	Caterpillar D4	29,776.00	6	4,962.67	1,488.80	818.84	245.65
5	Massey Ferguson-175	14,750.00	5	2,950.00	885.00	405.62	121.69
1	International BTD6	3,400.00	10	340.00	102.00	93.50	28.05
1	Fowler Mark	1,875.00	10	187.50	56.25	51.56	15.47
	Harrows[b]						
24	Ransome Hussar	16,200.00	6	2,700.00	2,700.00	445.50	445.50
8	Ransome Duchess	4,600.00	6	766.67	766.67	126.50	126.50
6	Massey Ferguson	3,900.00	5	780.00	780.00	107.25	107.25
3	Massey Harris	2,025.00	10	202.50	202.50	55.69	55.69
1	Eberhardt	525.00	10	52.50	52.50	14.44	14.44
	Supporting Machines						
1	Mobile Workshop	8,800.00	15	586.67	176.00	244.00	73.20
1	Land Rover	3,200.00	5	640.00	192.00	88.00	26.40
1	Landing Craft	78,000.00	12	6,500.00	1,950.00	2,145.00	643.50
4	Cabin Boat	12,000.00	5	2,400.00	720.00	330.00	99.00
2	Outboard Boat	1,100.00	4	275.00	82.50	30.25	9.08
2	Tractor-Trailer	1,500.00	5	300.00	90.00	41.25	12.38
2	Welding Plant	500.00	5	100.00	30.00	13.75	4.12
1	Pumping Plant	200.00	5	40.00	12.00	5.50	1.65
1	Charging Plant	250.00	5	50.00	15.00	6.88	2.06
1	Lister Generator	1,200.00	10	120.00	36.00	33.00	9.90
	Buildings	5,000.00	20	250.00	75.00	137.50	41.25
	Total				20,972.22		3,825.18

a Fraction of annual amount allocated to harrowing/seed harrowing is 30 percent.
b Harrows: charge is 100 percent.

Table 4.14. Components and Costs (Leones) for Harrowing and Seed Harrowing Operations--Torma Bum Circle 1970

Components	Harrowing		Seed Harrowing	
	Outlay	Per acre	Outlay	Per acre
Depreciation	11,954.17	2.21	9,018.05	2.17
Interest	2,180.35	0.40	1,644.83	0.41
Total Fixed	14,134.52	2.61	10,662.88	2.58
Fuel and Lubricants[a]	2,699.87	0.50	2,036.74	0.49
Spare parts	3,586.25	0.66	2,705.42	0.65
Maintenance	1,977.60	0.36	1,491.88	0.36
Tractor operating labor	2,201.30	0.41	1,660.63	0.40
Field supervision	669.38	0.12	504.97	0.12
Administrative supervision	483.98	0.09	365.10	0.09
Total Variable	11,618.38	2.14	8,764.74	2.11
Total	25,752.90	4.75	19,427.62	4.69

a Includes cost for the transportation system.

cultivation in Sierra Leone. The earliest costings for mechanical cultivation in the country appeared in the Rokupr Summary of Work 1953,[1] for the International-BTD6 tractors. These figures have little relevance to current operations. The very low cost of fuel, spare parts, and wages permitted plowing, harrowing and seed harrowing to be done at a direct cost of Le 2.80 per acre. The next costings were those of Professor Jack for the 1957 season.[2] In this report the direct operating

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[1] Annual Report, West African Rice Research Station, Rokupr, Sierra Leone, 1954.

[2] D. T. Jack, Economic Survey of Sierra Leone, Government Printers, Freetown, Sierra Leone, 1958.

cost per acre for the Bonthe[3] Circle was Le 3.45. In fact, the total cost for the circle was estimated to be Le 12.38 (Table 4.15).

Table 4.15. Mechanical Cultivation Cost for the 1957 Season (Leones)

Circles	Acreage	Operating cost	Depreciation[a]	Supervision	Total
Bonthe	5,385	3.44	6.90	1.94	12.28
Makeni	2,625	4.82	7.50	2.10	14.42
Port Loko	2,344	4.42	7.00	2.40	13.82
Gbundapi	1,605	4.82	7.50	3.82	16.14
Average cost/acre		4.38	7.22	2.56	14.16

a Depreciation was calculated at 20 percent per annum on machinery and 5 percent on buildings.

SOURCE: Economic Survey of Sierra Leone, p. 15.

The costs for the 1967 operations country-wide were analyzed by the CODEA Team.[4] Total cost per acre came out at Le 21.46, of which a depreciation cost of Le 8.55 was the highest component. Depreciation was calculated based on four and five years lifespan for wheeled and crawler tractors, respectively. Gilbert[5] determined the costs for the 1968 season for Torma Bum Circle and obtained a total cost per acre of Le 14.76, of which Le 8.29 went to depreciation per acre. The costs of spare parts and some repairs were not included in the calculations.

3 Bonthe was the administrative headquarters for the circle at that time.

4 CODEA, op. cit.

5 Gilbert, op. cit.

The costs determined in this study appear to be different from those of other studies for at least four reasons; none of these studies has ever: (1) separated the costs of plowing and harrowing; (2) separated the categories of labor, field supervision, administrative supervision, labor for repairs and field operating labor; (3) allowed a life expectancy of tractors beyond five years; (4) included interest cost in their analysis. Reasons 1 and 2 do not directly affect the level of costs; to the extent that the approach enables a more detailed examination of the particular component to be made, it offers opportunities for making desirable adjustments which could lead to cost reduction or increased efficiency. The effects of reasons 3 and 4 are quite evident.[6]

Tractor operation in the Torma Bum area suffers from low productivity. At the present level of acreage the Scheme is therefore a high cost operation. Technical suitability and costs of alternative means of operation should be considered with a view to lowering costs. A more complete (greater productive) use of tractors and equipment offers considerable room for achieving this objective. In the next chapter some specific considerations which can serve as the basis for the reorganization and operation of the Scheme on an economically feasible footing are presented.

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[6] In passing, it is observed that only Le 7.00 of the cultivation cost is recoverable from fees, which does not even cover direct operating cost per acre; this reveals the extent of Government's subsidy to the scheme.

CHAPTER 5

DETERMINATION OF MEANS FOR EXPANSION OF ACREAGES AT LOWER COSTS PER ACRE

In the previous chapter, the analysis has demonstrated that there is much need for acreage expansion in larger sites at the Torma Bum Circle. It was shown that if such expansion can be accomplished, there are possibilities for significant gains in cost economies. The aim of this chapter is to present more clearly, without being all inclusive, some feasible ways for increasing the annual acreage cultivated. The discussion, which precedes the testing of the hypothesis, is focused on two types of feasibility: (a) technical and (b) economic.

Technical Feasibility

Considerations regarding the technical feasibility for the expansion of acreages are primarily rooted in the (agricultural) engineering aspects of the plowing operations. The type of tractors available demands immediate attention. The choice of machinery in general falls outside the scope of the analysis--the machinery used in the Torma Bum Circle is treated as a given; the Agricultural Officer makes no decision regarding the type of machinery. It is worthwhile to observe that the type of tractors represents a very important factor for lowering the cost per acre; therefore, those in authority, when proposing to purchase tractors, should consult with the Agricultural Engineer in order to determine the technically most suitable type of tractors. The general impression is that the lack of such consultation has resulted in the collection of a very heterogeneous set of tractors in Torma Bum. Such an agglomeration of different makes of tractors constitutes an undesirable feature of the Scheme and tends to be cost increasing in at least three respects. Firstly, spare parts also have to be purchased according to the country of make of tractors. This can cause a cumbersome credit or financing arrangement. It may require earning larger quantities of foreign exchange capital with which to pay for these tractors and parts. Secondly, it contributes to greater storage and inventory cost in ordering, bin space and record keeping since parts have to be accounted for and kept according to tractor-make; this takes up much space and labor time. Thirdly, to take care of repairs and servicing requires very highly trained mechanics (preferably ones with facility in reading French[1] and Russian, for example). The landing craft and cabin boats are Russian-made; the former has been operating on only one of its two engines for the last two years. The Mechanical Superintendent complained often of this difficulty: the mobile workshop is of Russian make; even to carry out some minor repairs a great deal of trial and error type of approach.

Technical factors reveal themselves in regard to agronomic practices of site location and method of plowing as well as the

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[1] Of the present tractor strength 67 percent is French-made. There is no French tractor dealer in the country.

timing of operations. Soils and topographical considerations fall within the realm of technical feasibility. The nature and conditions of the plowing sites, their slope, dampness, grassiness and their sizes are matters of technical concern. The presence of obstacles, such as water and broken bridges, which can impede the movement of machines also fall under this category. The way these matters are handled by the Agricultural Officer will in a large measure determine the direction of plowing costs per acre. Organization of field work and staff in a manner consistent with the best plowing method and with the most efficient tractor-labor combination is the logical approach for the Agricultural Officer. Practically, this is a difficult matter to determine; help can be secured from experience and by studying results of past experiences and data. This management issue involves economic questions; usually there is not a clear-cut distinction between technical and economic considerations. To a great extent technical efficiency implies at least a minimum economic efficiency.

Economic Feasibility

Sierra Leone, like many developing countries, is plagued with a serious capital shortage. Moreover, the purchasing of the machinery involves meeting the difficult requirement of earhing the necessary foreign capital. This problem gets into broad general issues: issues as to (1) whether or not through this Scheme the country can save or earn foreign exchange by replacing some imports or by generating new exports; or (2) it may give rise to new claims on foreign exchange capital by the creation of continuing needs to import machinery, spare parts, fuel and lubricants. Many of these issues fall outside the scope of this study; it seems sufficient to recognize their existence. The Scheme is a subsidized one; plowing fees per acre have just barely covered average fixed cost, and they have not even covered the variable cost per acre. This is a broad question to be determined at Governmental level.

The capital outlay on machinery is high, but this is not the only cost. Fuel, lubricants and parts, the matter of servicing and repairs, method of plowing, the actual hours of work and idle time, all of these are involved in the economics of mechanization. Given the machinery, the responsibility of those supervising the Scheme is to keep them operating for as long as possible--in other words, to encourage a long productive life. Effective management of these capital resources provides a great possibility for lowering fixed cost per acre. For example, if the life of the tractors could be extended by one year, the total depreciation cost would fall from Le 42,616.29 to L3 37,315.61, which is a saving to the Scheme of 12.4 percent. If the tractor life could be extended by two years, this cost could fall to Le 33,659.07, representing an overall decline of Le 8,967.22 or 21.4 percent on depreciation (Table 5.1). If acreage plowed remained the same, this potential saving represents a per acre depreciation cost of Le 4.57, or a saving of Le 1.22 per acre from this source.

Table 5.1. Comparison of Effects of Different Lifespan for Tractors on Depreciation Cost--Torma Bum, 1970

No.	Machinery	Primary Lifespan[a] Total Outlay (Leones)	Years of Lifespan	Annual Depreciation (Leones)	Depreciation Cost (Leones)	Extended Lifespan If Lifespan were	Annual Depreciation (Leones)	Depreciation Cost (Leones)	If Lifespan were	Annual Depreciation (Leones)	Depreciation Cost (Leones)
	Tractors										
22	Richard Continental	211,200.00	6	35,200.00	24,640.00	7	30,171.43	21,120.00	8	26,400.00	18,480.00
4	Caterpillar D4	29,776.00	6	4,962.67	3,473.87	7	4,253.71	2,977.60	8	3,722.00	2,605.40
5	Massey Ferguson-175	14,750.00	5	2,950.00	2,065.00	6	2,458.33	1,720.83	7	2,107.14	1,475.00
1	International BTD6	3,400.00	10	340.00	238.00	10*	340.00	238.00	10*	340.00	238.00
1	Fowler Mark VFA	1,875.00	10	187.50	131.25	10*	187.50	131.25	10*	187.50	131.25
	Plows[b]										
14	Ransome Hussar	9,100.00	6	1,516.67	1,516.67	7	1,300.00	1,300.00	8	1,137.50	1,137.50
10	Ransome Dragoon	5,750.00	6	958.33	958.33	7	821.43	821.43	8	718.75	718.75
8	Massey Ferguson	5,600.00	5	1,120.00	1,120.00	6	933.33	933.33	7	800.00	800.00
7	Massey Harris	5,250.00	10	525.00	525.00	10*	525.00	525.00	10*	525.00	525.00
1	Eberhardt	650.00	10	65.00	65.00	10*	65.00	65.00	10*	65.00	65.00
	Supporting Machines										
1	Mobile Workshop	8,800.00	15	586.67	410.67	15	586.67	410.67	15	586.67	410.67
1	Land Rover	3,200.00	5	640.00	448.00	5	640.00	448.00	5	640.00	448.00
1	Landing Craft	78,000.00	12	6,500.00	4,550.00	12	6,500.00	4,550.00	12	6,500.00	4,550.00
4	Cabin Boat	12,000.00	5	2,400.00	1,680.00	5	2,400.00	1,680.00	5	2,400.00	1,680.00
2	Outboard Boat	1,100.00	4	275.00	192.50	4	275.00	192.50	4	275.00	192.50
2	Tractor-Trailer	1,500.00	5	300.00	210.00	5	300.00	210.00	5	300.00	210.00
2	Welding Plant	500.00	5	100.00	70.00	5	100.00	70.00	5	100.00	70.00
1	Charging Plant	250.00	5	50.00	35.00	5	50.00	35.00	5	50.00	35.00
1	Pumping Plant	200.00	5	40.00	28.00	5	40.00	28.00	5	40.00	28.00
1	Lister Generator	1,200.00	10	120.00	84.00	10	120.00	84.00	10	120.00	84.00
	Buildings	5,000.00	20	250.00	175.00	20	250.00	175.00	20	250.00	175.00
	Total				42,616.29			37,315.61			33,659.07
	Decreases				---			5,300.68			8,957.22

Depreciation Cost = The fraction of annual depreciation charged to plowing operation is 0.70

a As used in the main calculations of depreciation.

b Depreciation cost for plows is the same as annual depreciation for plowing operation.

* These tractors have no salvage value after 10 years.

Interest cost is an exogenous factor outside the direct control of the Mechanization Scheme. However, in the ownership of machinery there is an implicit interest cost (on the capital involved) which must be borne by the Scheme. At the outset, efforts can be made to obtain the required capital at the lowest possible rate of interest.[2] Interest rates of 4-1/2 and 3-1/2 percent per annum were used in order to demonstrate the effects on plowing costs per acre. Assuming the same level of acreage, these interest rates resulted in a saving on interest cost per acre of 20¢ and 40¢ (S.L.), respectively (Table 5.2).

With respect to variable costs, attention should be directed to the managerial functions of organization, supervision and control. The allocation of tractors to plowing sites, the number and utilization of field staff, the availability of spare parts and fuel, the method of actual plowing, and the hours of work require specific attention each day. In sending tractors to plowing sites, consideration should be given to the relative sizes; it is uneconomic to send the larger tractors on sites of just a few acres in size. The Massey Ferguson tractors are used to greatest advantage when used on the smaller sites. They were the lowest priced and had the lowest fuel consumption cost per acre; they can be more easily manipulated on these small sites, therefore, capital and operating costs per acre can be lowered if they are first used

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[2] The securing of capital is a Ministerial responsibility, not that of the Torma Bum Circle.

Table 5.2. *The Effects of Varying Interest Rates on the Cost of Fixed Assets--1970* Plowing Operation, Torma Bum Circle

No.	Machinery	5-1/2 Percent Interest Rate: Total Outlay (Leones)	5-1/2 Percent Interest Rate: Annual Interest (Leones)	5-1/2 Percent Interest Rate: Interest Cost (Leones)	Percent Interest Rates of 4-1/2: Annual Interest (Leones)	Percent Interest Rates of 4-1/2: Interest Cost (Leones)	Percent Interest Rates of 3-1/2: Annual Interest (Leones)	Percent Interest Rates of 3-1/2: Interest Cost (Leones)
22	Richard Continental	211,200.00	5,808.00	4,065.60	4,752.00	3,326.40	3,696.00	2,587.20
4	Caterpillar D4	29,776.00	818.84	573.19	669.96	468.97	521.08	364.76
5	Massey Ferguson-175	14,750.00	405.62	283.93	331.88	232.32	238.12	180.68
1	International BTD6	3,400.00	93.50	65.45	76.50	53.55	59.50	41.65
1	Fowler Mark-VFA	1,875.00	51.56	36.09	42.19	29.53	32.81	22.97
	Plows[a]							
14	Ransome Hussar	9,100.00	250.25	250.25	204.75	204.75	159.25	159.25
10	Ransome Dragoon	5,750.00	158.12	158.12	129.38	129.38	100.62	100.62
8	Massey Ferguson	5,600.00	154.00	154.00	126.00	126.00	98.00	98.00
7	Massey Harris	5,250.00	144.38	144.38	118.12	118.12	91.88	91.88
1	Eberhardt	650.00	17.88	17.88	14.62	14.62	11.38	11.38
	Supporting Machines							
1	Mobile Workshop	8,800.00	244.00	170.80	198.00	138.60	154.00	107.80
1	Land Rover	3,200.00	88.00	61.60	72.00	50.40	56.00	39.20
1	Landing Craft	78,000.00	2,145.00	1,501.50	1,755.00	1,228.50	1,365.00	955.50
4	Cabin Boat	12,000.00	330.00	231.00	270.00	189.00	210.00	147.00
2	Outboard Boat	1,100.00	30.25	21.18	24.75	17.32	19.25	13.48
2	Tractor-Trailer	1,500.00	41.25	28.88	33.75	23.62	26.25	18.38
2	Welding Plant	500.00	13.75	9.62	11.25	7.88	8.75	6.12
1	Pumping Plant	200.00	5.50	3.85	4.50	3.15	3.50	2.45
1	Charging Plant	250.00	6.88	4.82	5.62	3.93	4.38	3.07
1	Lister Generator	1,200.00	33.00	23.10	27.00	18.90	21.00	14.70
	Buildings	5,000.00	137.50	96.25	112.50	78.75	87.50	61.25
	Total			7,901.49		6,463.69		5,027.34
	Decreases			--		1,437.80		2,874.15

Interest Cost = The fraction of annual interest charged to plowing is 0.70.

a Interest cost for plowing operation is 100 percent of annual cost.

on small sites and later on large sites. Output per tractor (and per worker) has been far too low; the largest and most expensive tractors (Richard Continental) have the lower output per tractor--195 acres. Placing these larger tractors on large plowing sites would enable the Scheme to take advantage of scale economies in plowing and harrowing. For instance, Maike and Makita sites can each permit operations well in excess of 5,000 acres.[3] It is on these larger sites that much scope exists for bringing more land into use and in a relatively short time. Here too, exist opportunities for establishing a more desirable tractor/labor combination. For instance, a plowboy could serve two to three tractors on such sites. This immediately cuts cost per acre from this source (plowboy) by 50 to 67 percent. Furthermore, when tractors become inoperable, and there is clear and immediate indication that they will not return to plowing for the season, these now redundant plowboys should be retrenched. This applies as well to the drivers, except where they can be placed into some productive assignment. This points out a need for training tractor drivers in mechanical work as well so that they can become effectively absorbed in the workshop and offered a more secure job. Under the present arrangement it is very costly to the Scheme to retain drivers whc have no productive assignment after their tractors are broken down (Table 5.3).

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[3] In 1969, 1200 and 1500 acres were plowed on Maike and Makita, respectively.

These latter points may appear small at first, but the large number of tractor breakdowns which occurred had a heavy impact on costs per acre. A very simple illustration is in order: acres per tractor were (the same as per driver) 223. Twenty of the thirty-three tractors fell below the average--aggregating only 2,022 acres (Table 5.4). Now suppose that each of these tractor was actually able to plow 223 acres, the total acres plowed would be 9,384 (7,362 + 2,022). This would have driven down average fixed cost per acre to just Le 5.38 and, other things being the same, average total cost per acre (plowing) would automatically be Le 12.65 (instead of Le 14.13). Moreover, and this is a second effect, much time would have been saved and this would permit larger acreage to be harrowed (even so before the rains started). This type of reasoning is perfectly valid and can be extended further. Seven tractors have plowed over 400 acres (three exceeded 500, only one reached 600) for the season; is it not possible that many more could have achieved this level? During the season, the 33 tractors logged 11,477.5 hours which is equivalent to just 3.02 tractor-hours per day. Plowing lasted 115 days. With a seven-hour work day, this 3.02 tractor-hours per day is just 43 percent of the former. Under sophisticated supervision (field and administrative) tractor-hour per day can be brought closer to equality with a work-day-hour. During the field work it was observed that many tractors were plowing well over an acre per hour; as the season progressed the rate started falling off and finally

Table 5.3. Number of Tractors Operating per Week--Torma Bum Circle 1970

Week ending	Number of Tractors Operating	Number of Redundant Drivers[a]
February 7	27	6
February 14	27	6
February 21	27	6
February 28	20	13
March 7	24	9
March 14	22	11
March 21	22	11
March 28	23	10
April 4	18	15
April 11	17	16
April 18	14	19
April 25	17	16
May 2	15	18
May 9	11	22
May 16	14	19
May 23	11	22
May 30	17	16
June 6	4	29
June 13	3	30
June 20	3	30
June 27	4	29
July 4	3	30
July 11	3	30
July 18	3	30

a Same number for plowboys.

Table 5.4. Tractors Plowing Less Than 223 Acres--1970 Plowing Season--Torma Bum Circle

Reg. No.	Tractor-make	No. of weeks worked	Acres plowed	No. of acres below 223
RCT-56*	Massey Ferguson-175	2	34.0	189.0
61	Massey Ferguson-175	2	9.5	213.5
2	Richard Continental	13	197.0	26.0
4	Richard Continental	3	131.0	92.0
6	Richard Continental	8	197.0	44.0
7*	Richard Continental	1	11.0	212.0
9	Richard Continental	10	158.5	64.5
14	Richard Continental	6	74.0	149.0
16	Richard Continental	4	44.0	179.0
17	Richard Continental	5	101.0	122.0
18	Richard Continental	8	217.0	6.0
19	Richard Continental	12	211.0	12.0
21	Richard Continental	13	212.5	10.5
22	Richard Continental	8	175.0	48.0
24	Richard Continental	9	157.5	65.5
25	Richard Continental	14	219.0	4.0
26*	Richard Continental	3	48.0	175.0
DA 44	Fowler Mark-VFA	11	207.0	16.0
DA 75+	Caterpillar-D4	1	27.0	196.0
76⊕	Caterpillar-D4	3	35.0	188.0
20		--	--	2,022.0

* Accident--damaged beyond repairs.

\+ Gearbox damaged.

⊕ Engine block broken.

the rate was just 0.64 acres per hour. Had the tractors turned in a final rate of an acre per hour, a total of 17,120 acres would have been plowed. This is an ambitious estimate for 33 tractors; the important point here is, under good management tractor-hours can be brought closer to work-day-hours. This will cause a great impact on the output potential of the Scheme.[4] Elsewhere in Africa, tractors have averaged from 0.84 acres[5] to 0.91 acres[6] per hour. It should be observed that the above estimate does not imply any overtime work. In the process of collecting the data for this study it was observed that drivers deliberately sought overtime work by much idling during the regular work hours. It is the responsibility of the field supervisors to get effective work out of the drivers during the normal work hours each day. In substance therefore, given 33 tractors, the acres plowed during the 1970 season should have ranged between 9,384, with efficient repairs and maintenance, and 17,120--under good supervision as well as with the necessary repairs.

A final, but important factor which, although external to the plowing scheme, can exert great influence upon the economic feasibility of acreage expansion relates to the marketing sys-

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[4] Gilbert predicted that Torma Bum Circle would have plowed 14,000 acres in the 1970 season; he anticipated 40 tractors to have been available; there were 33 tractors but they only plowed 7,362 acres. Gilbert, op. cit., p. 223.

[5] Purvis, op. cit., p. 37.

[6] Newlyn, op. cit., p. 11.

tem. Since the demand for plowed acres is derived from the demand for rice, acres demanded are therefore limited by the size of the effective (market) demand for rice. Consequently, efforts to expand rice production through mechanization require complementary efforts to develop a marketing system which will effectively absorb and distribute the increased production of rice. Increased rice production has to be viewed in the context of the production-distribution-consumption process. At the production end exist a host of problems: technical, administrative, financial, social and several cultural factors. Even if these problems are solved, significant increases in rice production will not occur unless market opportunities are there and are seen. In this way, production of rice will tend toward more commercialization, and the opportunities for more significant marketable surpluses will increase. This situation leads to increased per capita income of the farmers, increased purchasing power and savings capacity, increased effective demand for plowed acres. In the Torma Bum area the marketing of rice suffers from two main weaknesses. First, the farmers are forced to market through the Rice Corporation which behaves as a monopsonist (though not a pure monopsonist because of the existence of black market operations), exerting a price control on rice which is too low; causing the farmers to suffer losses in the quantity of rice to be marketed by failing to pick up the rice on time and by the long delay in paying the farmers, they experience other financial difficulties. Consequently, the farmers upon this arrangement remain shackled to the same number of acres year after year and are unable to break out from under the great financial strains which bind them continuously. If this obstacle (The Rice Corporation) were immediately removed, permitting price to be determined in the free market, the farmers as a group would demand larger numbers of plowed acres. Transportation is the second weakness. The feeder roads in this part of the country are quite inadequate; even those that exist now are of poor quality. Improvements are deemed essential in this area of infrastructure. At the moment, the number of vehicles is not quite adequate, but this does not appear to be such a serious problem. Judging from the number of new vehicles placed on the road by private individuals during 1970, it seems fairly reasonable to expect that this tendency will continue as rice production increases. When increased production and marketing efficiencies take hold, the problem of keeping consumer prices low and farmers' prices high can be greatly minimized or may even disappear.

Testing the Hypothesis

In testing the hypothesis, fixed and variable costs are tested separately.

Fixed Costs

An important result of the analysis of fixed costs is that average fixed cost (AFC) continues to decline as larger acreages are plowed. With the level of total fixed cost being Le 50,517.78, a direct result of increases in acreage was a substantial reduction in fixed cost per acre and axiomatically a reduction in average total cost per acre ceteris paribus. Increases in acreage demonstrated this result (Table 5.5).

Table 5.5. The Variable Cost Assumptions*--Regarding the Test of Hypothesis

	1. Constant Average Variable Cost			2. Increasing Aver. Variable Cost	
Acres	Average Fixed Cost	Average Variable Cost	Average Total Cost	Average Variable Cost	Average Total Cost
1,324.5	38.14	7.27	45.41	6.93	45.07
2,569.5	19.66	7.27	26.93	6.72	26.38
3,595.0	14.05	7.27	21.32	6.71	20.76
4,961.0	10.18	7.27	17.45	6.77	16.95
6,079.5	8.31	7.27	15.58	6.82	15.13
7,362.0	6.86	7.27	14.13	7.27	14.13
8,362.0	6.04	7.27	13.31	7.77	13.81
9,362.0	5.39	7.27	12.66	8.27	13.66
10,362.0	4.87	7.27	12.14	9.27	14.14

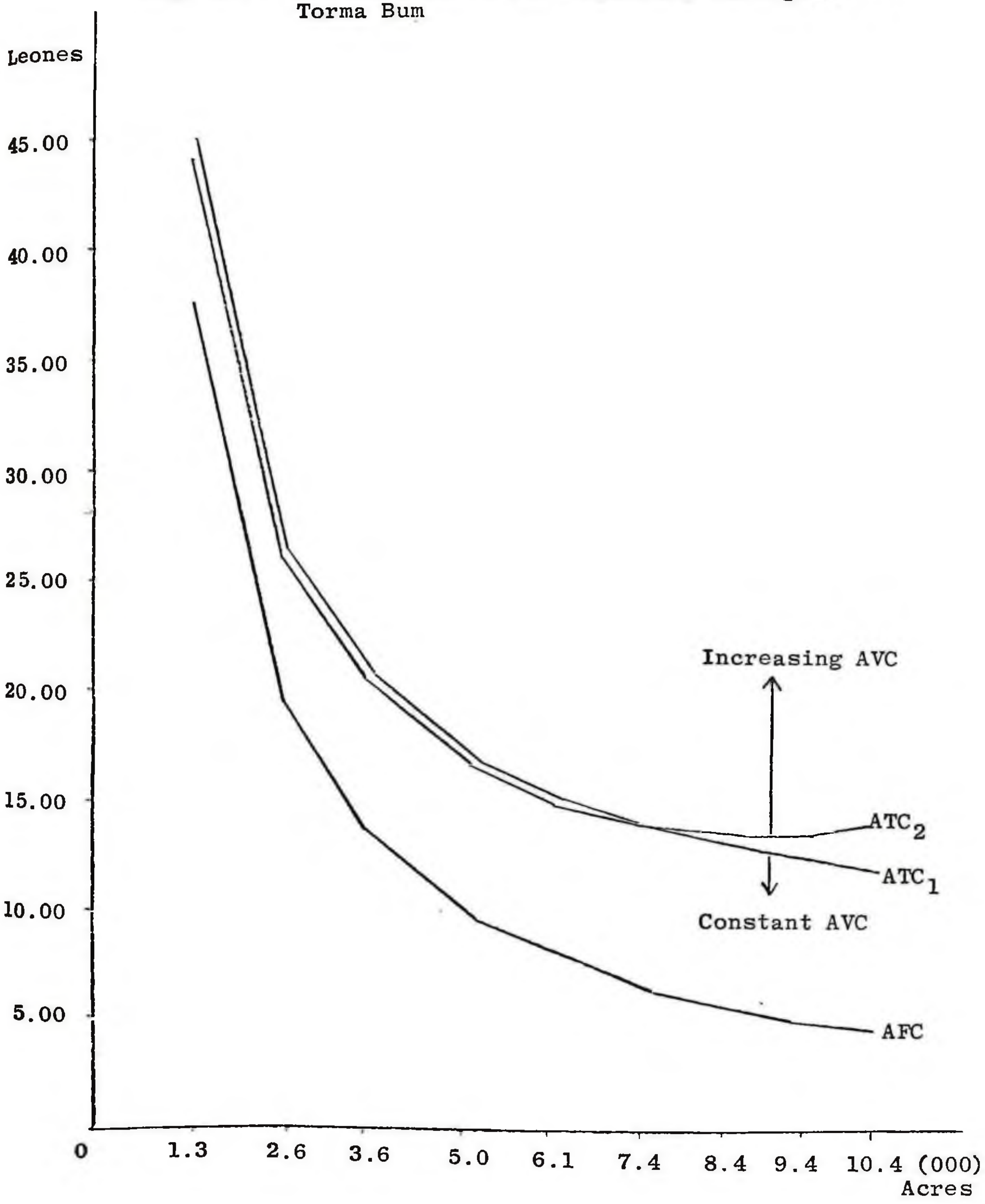
* Assumption number 3 is not shown.

Variable Costs

It is not possible to say precisely what direction the variable cost per acre will go. Three assumptions are made in order to analyze the average variable cost (AVC).

Constant Average Variable Cost: Such an assumption is quite plausible if only because of the almost flattening nature of the average variable cost curve in Figure 5-1. Under this assumption average total cost will continue to decline, because the average fixed cost is declining, with increases in acreage plowed (Table 5.5, column 4).

Fig. 5-1. Per Acre Costs for Expanding Acreage--Torma Bum



Increasing Average Variable Cost: If average variable cost begins to increase then average total cost will be expected to increase but only after a point is reached where the absolute difference between the increases in the average variable cost exceeds the decreases in the average fixed cost.

Decreasing Average Variable Cost: Suppose that a situation such as decreasing average variable cost prevails; needless to say that, if average fixed and average variable costs are both declining, average total cost will also decline. An illustration of the first two situations is given in Figure 5-1.

Conclusions

On the basis of the analysis of the data for the 1970 plowing operations in Torma Bum, there is conclusive evidence in support of the hypothesis. In particular, there is a strong support in favor of increased acreage from the fixed cost point of view. The results indicate that large savings per acre can be obtained from this category of cost. For example, by expanding acreage up to the 10,362 level, savings per acre of Le 1.99 on fixed cost can be obtained. There is considerable evidence to show that the lifespan of the tractors can be lengthened; the result would be a lower depreciation cost.

In the case of variable cost it is not possible to be precise in regard to the savings per acre. Reduction in variable cost per acre would depend primarily upon the availability of spare parts and the degree of efficiency achieved by supervision (field and administrative). Provision of spare parts would increase the effectiveness of carrying out repairs so that tractors are kept working for a longer period per day. This is a way of increasing the output per tractor (and per worker).

Even in the present situation of shortage of spare parts, there is considerable scope for cost reduction through increased efficiency in supervision. Firstly, sites which are too small to permit economic operation should be eliminated. A great deal of time is spent plowing per acre on such sites, due to difficulty in turning and the slow speed that is usually permitted. On these sites, capital cost per acre is high; operating cost per acre is high. Local conditions around Torma Bum easily indicate what sites are too small. Those below 100 acres should not be operated except where they are adjacent to a much larger one.

It is also through increased efficiency in supervision that the output per worker or tractor may be increased. The amount of actual work per worker per day, the method of field operation, and the length of time spent in assembling and delivering supplies to plowing sites are the responsibilities of supervision (field and administrative). Organization and operation of the transportation system offer opportunities for reducing per acre fuel cost. The direct fuel cost per acre for plowing was Le 1.92; when transportation is added, fuel cost per acre amounted to Le 2.57--a 34 percent increase over direct fuel cost.

The results of the analysis show that there is considerable scope for improving the performance of the tractors--and hence the Mechanical Cultivation Scheme. However, improvements will probably need to be realized on a gradual basis with recognition of local customs and existing attitudes.

Application of Findings to Other Areas

Many of the principles and findings developed herein are worthy of application in other existing or proposed centers of mechanization. The employment of good management principles in ensuring a desirable tractor labor combination is as valid for one single plowing site as it is for all sites in any Circle. To achieve any degree of efficiency in mechanization, therefore, all field operations should be carefully planned in advance to allow for maximum utilization of the existing capacity of tractors and labor for any given Circle. The same factors apply with respect to proper supervision of machinery and labor: the hours of work and idle time, the method and timing of the different operations, and the availability of adequate supplies of fuel, lubricants and spare parts are as relevant to any other Circle as they are to Torma Bum.

The problem of increasing the lifespan of tractors and equipment must be solved countrywide. It has been demonstrated that large savings can be realized by extending the lifespan of tractors through greater care in repairs and maintenance. Fixed costs per acre can be reduced wherever equipment can be used to a greater percent of capacity. In this sense there is much scope for taking advantage of scale economies on a National basis. Adjustments could be made with respect to the total allocation of tractors throughout the country in order to permit greater utilization of these tractors. For example, larger tractors could be allocated to larger sites; wheeled tractors may be placed in the smaller sites and/or allocated to transporting fuel and supplies to plowing sites in general (this would reduce transportation cost).

The matter of selecting the potentially most productive sites warrants consideration nationally. Indeed, this is a sure way to speed up the effectiveness of bringing more land under the Mechanical Cultivation Scheme and to ensure increased rice production on a countrywide basis.

Finally, the problem associated with lack of standardization of tractor-makes could be greatly minimized on a National basis if only one or two different makes were allocated to a particular Circle. Such a policy would facilitate storage and inventory management in stocking spare parts, the replacement of worn out or obsolete equipment, and the provision of adequate shop equipment and tools and training of fitters.

CHAPTER 6

SUMMARY OF FINDINGS AND THEIR IMPLICATIONS

Rice production in Sierra Leone has not been sufficient to meet domestic demand despite intensive efforts by the National Government to increase production. Since 1950 special attention has been devoted to areas where mechanical cultivation is necessary, for there are potentially many acres of such land. Nevertheless, imports of rice have been made in each of the past 20 years. An in-depth analysis of the mechanical cultivation operation at Torma Bum in 1970 has been the focus of this study.

Objectives

The objectives of this study are:

1. To identify the farming systems in the Torma Bum area and interpret their interrelationships.
2. To identify important factors favoring or hindering the expansion of the Mechanization Scheme.
3. To determine feasible ways of reducing unit costs so as to make the operations more efficient and economical.
4. To develop possible generalizations which can serve as the basis for planning and organization of mechanical cultivation elsewhere in the country.

Hypothesis

The general hypothesis of the study is that cultivation costs per acre in the Torma Bum Scheme can be substantially reduced.

Theoretical Basis

Production theory furnished the economic framework for the analysis of the data. Costs of mechanical cultivation result from the utilization of many factors of production. Determination of the relationship of cost relevant to the use of each factor depends upon an understanding of the principles of production. Based on these principles a division of those costs which are fixed and those which are variable was made. The division relates to the concepts of short-run and long-run. Roughly, the short-run costs are associated with the degree of utilization of the fixed assets, while the long-run costs encompass changes in the size and type of assets. Strictly speaking, the distinction is based upon the degree of adaptation of all the factors to the rate and level of acreages cultivated. Occasionally there have been difficulties in maintaining a sharp distinction between these two types of cost; often such distinction depended on the particular circumstances being evaluated.

Findings and Conclusions from This Study

A general description of the two farming systems in the Torma Bum area (the mechanical cultivation system and the upland river levee system) revealed that important complementarities exist between them. People from the upland river levee areas supply labor for weeding and harvesting rice; they bring palm oil and cassave, all of which are exchanged for rice and cash with those who are engaged in mechanical cultivation.

A review of the history of the Mechanization Scheme revealed that collecting fees has been a difficult and continuing problem. A more effective method of fee-collecting is required.

There appear to be present some functional inefficiencies in the organizational setup and in the line of instruction. At the top levels, the staff seemed quite insensitive to the serious field problems, the effective solution of which often requires direct action. On the other hand, the direct administrative staff possessed relatively little or no operational authority, consequently it had to refer every small detail to top officers.

Costs associated with operating 33 tractors on 35 plowing sites were determined. The plowing cost per acre was calculated to be Le 14.13 based on 7,362 acres plowed during the 1970 season. Harrowing and seed harrowing were done to the extent of 5,416.5 and 4,140.0 acres, respectively; their costs per acre were determined to be Le 4.75 and Le 4.69, respectively. The fixed costs per acre for plowing were Le 6.86, while those for harrowing and seed harrowing were Le 2.61 and Le 2.58, respectively. Variable costs were also computed for each of the six components. Among them, fuel and lubricants showed the highest per acre cost (Le 2.57 for plowing, Le 0.50 and Le 0.49, respectively, for harrowing and seed harrowing). It is likely that the process of improvement in organization and management will find acreage plowed directly dependent on the utilization of labor, especially tractor operating labor.

The analysis revealed that operating costs per acre were high because of the high incidence of tractor breakdowns which may be traced partially to inadequate supervision. While this latter cause may not be due to lack of properly trained supervisory staff, it may be traceable to certain local customs and unwritten principles. For example, tractor drivers (and to a certain extent, plowboys) expect a season's employment each year. To discharge a driver prior to the end of the season, for a simple reason that (his) tractor is inoperable, would engender undesirable sentiments against the Agricultural Officer, especially from among the farmers. This could result in serious repercussions for this officer. However, the analysis has demonstrated that the Scheme could reduce costs if it were socially (or psychologically) expedient to effect a retrenchment whenever this is deemed necessary. But a more important justification for retaining tractor drivers rests upon the fact that it may be difficult (or impossible) to find a driver as the urgency of the situation may require. Under the Torma Bum situation it seems wise, if there is a possibility that the tractor being repaired will return to work within a short time, that the driver be given another assignment temporarily.

It became quite evident during the progress of this study that many of the plowing sites now being operated are of but marginal value to the Cultivation Scheme. There are indications that many sites are too small to permit economic operations, coupled with the long distances from the workshop and difficult accessibility conditions restricting effective supervision and delivery of production requisites. These sites should be eliminated so as to permit concentration on the larger ones. The better farmers in the now eliminated sites could be allocated larger plots on the larger sites where they would find it even more profitable. The farmers should be able to adjust easily to this because many of the participants in the Torma Bum Scheme are already absentee farmers.

The Scheme has continued to be a high-cost operation because of fundamental weaknesses in organization and management, ineffective use of capital in providing serviceable tractors and equipment, and failure to provide adequate supplies of parts and servicing facilities. Due to all these defects, output per tractor as well as per worker has been quite low--representing just 43 percent of their existing potentiality. The analysis demonstrated that acreage can be increased at a significant reduction in cost per acre. Significant savings to the Scheme could result through a reduction in depreciation cost by extending the useful lifespan of the tractors. A lifespan extension of two years would provide savings in excess of 21 percent per acre on depreciation cost of plowing. These findings from the analysis which have National applicability, provide evidence in support of the general hypothesis stated earlier.

Implications

The Matter of Subsidy

The results of the analysis unfold a number of implications. Firstly, one of the most germane concerns over the Mechanization Scheme is the question of Government subsidy. In particular, how much and for how long should a subsidy be given? To formulate satisfactory answers to these questions, a recapitulation of the possible cost situations is useful. It was pointed out that the capital (tractors and equipment) used represent different sizes (physical and in terms of leones); plowing sites are also of different sizes (acreages). In adjusting the quantities of special, labor and management services, a true scale relationship (simultaneous increase or decrease of all factors) is not likely to be maintained; management is not easily adjusted. The problem of acreage maximization (or cost minimization) can therefore be handled equally well through the means of short-run and long-run cost curves (bearing in mind that the latter is composed of a family of the former). It was also shown that larger acreage causes declining average total cost per acre as long as the decline in average fixed cost per acre is greater than any increase in average variable cost per acre. This is a short-run situation. However, in the long-run, all costs being variable, there will be only one average cost curve and it will represent both the average variable and average total costs. This long-run average cost curve possesses segments showing decreasing, constant and increasing costs per acre. How low the cost per acre can go therefore depends upon the segment of the long-run average cost curve relevant to the level of acreage being plowed. For example, if acreage being plowed is in the decreasing cost segment, then lower costs per acre would result by increasing the acreage until this segment is exhausted. In the constant cost segment, additional acreages have no effect on per acre cost. Generally this segment will tend to hold for some wide range of acreage. Increasing cost per additional acre appears at very large acreages.

Given the cost situations, the question of subsidy must be resolved in terms of the Government's objective. A flexible method of granting subsidy appears to be most desirable. This method can be divided into two phases. The first or average total cost phase falls on all acreages below the minimum point on the long-run average cost curve. Under this phase, Government may choose to give full subsidy (that is to say, subsidy will equal to average total cost); or it may choose to give a fixed percent of the average total cost. In either case, plowing fees charged to farmers would be variable rather than fixed as at the moment. The second or marginal cost phase falls on all acreages above the minimum point on the long-run average cost curve. There would be no subsidy in this phase; plowing fees would be set at the level of marginal cost.

There is one important restriction to the implementation of this principle. A functional limit must be established (to protect the farmers). It is not possible to say what the curvature and the exact level of average variable cost will be. The study demonstrated that had there been available spare parts and a more effective use of tractors (and drivers) acres plowed would have ranged between 9,384 and 17,120. Cost per acre would have been greatly reduced had it been possible to plow even 13,000 acres--in fact, it would fall just around Le 10.00 per acre. Government may find it desirable to set a minimum output expectation of acres to be plowed. Given the conditions which existed in the 1970 season for example, factor prices, number of tractors, etc., 15,000 acres would have been a reasonable limit. In other words, a subsidy would be granted only if the Government fails to plow and harrow 15,000 acres during the season. Above this acreage, farmers would be expected to pay an economic price for the service of mechanization. There is a further difficulty in establishing the actual fees to be charged each year that this target has been achieved. Since exposte measurements are made for each season's operations, it should be convenient to establish next year's fees on the basis of this year's costs (recognizing the possibilities of changing prices with respect to labor, capital and servicing). This principle of flexible subsidy would keep the plowing authority more attentive to good management principles in the day-to-day operations. It would also provide the Government with some extra funds during the good years to assist in off-setting subsidy obligations in the poor years. Furthermore, the flexible subsidy method in effect represents the Government taxing itself for its own inefficiencies at lower acreages and encouraging the farmers to cultivate more rice at larger acreages. Both the level and period of the subsidy depend on the Government's ability to plow a sufficiently large acreage which can enable farmers to operate on farms large enough to realize marketable rather than subsistence production. The Torma Bum Scheme has been subsidized for the twenty years of its existence; how much longer this will continue depends on Government's earnestness in implementing many recommdnations of experts that have been made from time to time.

Conflicts between Departments

The apparently inefficient organization and supervision demonstrated by the analysis of the data seem to be part of a more widespread problem. Since the history of the Mechanization Scheme showed that the Central Plowing Authority changed hands twice in three years (Ministry of Agriculture to Rice Corporation in 1965; Rice Corporation back to Ministry of Agriculture in 1968) without any improvement in organization and management, it becomes evident that there is a great scarcity of good managers and administrative staff in the country. It is usually quite rare that any large scale operation or business is not susceptible of inefficient personnel, so that whenever improvements become desirable by reorganizing such operations or business, personnel previously responsible for directing them would be changed. The Mechanical Cultivation Scheme is an exception. Agencies which were created to furnish complementary services started to provide competitive services. In fact, the observation is that these agencies trap the farmers in their rivalry with each other. The need for institution building appears to be quite urgent.

Increasing the Effectiveness of Direct Management

The problems of field operations including movement of tractors from site to site and workshop problems of spare parts unavailability require a type of management having effective authority. This organization is effectively illustrated by the situation in Makeni Circle where the Principal Agricultural Officer, being directly involved with field operations, is able to take effective action to ameliorate many situations which could cause delays for several days. For instance, work is not held up because a gallon or two of gasoline or a fan belt did not arrive from Freetown. This officer has sufficient authority to make such simple purchases locally. The Agricultural Officer in Torma Bum has no such authority; he must wait or make a visit to Bo, which is 60 miles away. It is believed that the serious problems of spare parts and supplies are traceable to the fact that the authority is too far removed from the actual situations in the field; being isolated from these day-to-day frustrations, they are unable to appreciate the full impact of these problems. The chain of command should be shortened to provide for a more direct and effective (local) management.

Increasing the responsibility of the Agricultural Officer could very well lead to increased efficiency. Indeed, it is no exaggeration to state that the viability of the Scheme is highly dependent upon the element of management. With effective management such details as outlined below could be dealt with more efficiently. The steps include:

1. Carefully select plowing sites on a basis that minimize costs of plowing additional acreages as needs occur.
2. Make intelligent anticipation of needs for parts, fuel and lubricants through detailed plans made before the season begins.
3. Have sufficient quantity of spare parts on hand at the start of the season and during the off-season as well.
4. Attend to the efficient servicing and repairs of tractors and equipment, both in the field and workshop.
5. Ensure that fuel and lubricants are sufficient and available to the plowing sites.
6. Recruit and train tractor drivers and compensate them on a basis commensurate with their performance.
7. Have on hand a reasonable amount of funds for emergency situations.

Marketing and Infrastructure

But there are broader implications arising from the expansion by sowing the entire acreage mechanically plowed. Sierra Leone has been accurately described in the earlier chapters as an agricultural country. However, mining has been the chief source of Government revenue and for earning foreign exchange capital. Improvements in agriculture of an economic nature have been spotty--occurring in a few scattered towns. By and large, the agricultural sector, peopled by over 80 percent of the population, has been unaffected by these improvements. Indeed, even in the mechanical cultivation areas, where the use of capital per farmer (as evidenced by the cost of machinery) is very high, cash incomes are barely marginal and farmers live a subsistent existence. An urgent problem facing the Government, therefore, is to guide the agricultural sector into the cash economy by assisting the farmers to produce more and ensuring at the same time their accessibility to available markets to sell the surplus production. It is important to emphasize the necessity for supporting these improvements with simultaneous improvements in roads and transportation. This is an important way to transform areas of subsistence agriculture into commercial agriculture; it also gives Sierra Leone farmers better and cheaper access to markets within and outside the country.

The agricultural sector on balance could be self-sufficient in food, especially in rice--the major staple. In this way the country would save over two million leones annually in foreign exchange by eliminating rice imports. Sierra Leone has a vast potential to produce rice through mechanization. In addition to unused acreage in the Torma Bum area, there are numerous inland swamps offering significant possibilities as complementary sources of supply. Some of the management techniques developed in one area would find applicability elsewhere.

Many studies have shown West African farmers to be responsible to price (and income) incentives; nothing would stimulate increased rice production among farmers more than higher prices and/or lower production costs. West Africa as a whole is a rice deficit area, and Sierra Leone is well located to exploit the possibilities of that market. In fact, this location is one of Sierra Leone's strong claims for desiring that the West African Rice Development Center be located there.

Apparent Bottlenecks

Progress in the Mechanical Cultivation Scheme could be impeded by certain apparent bottlenecks, such as labor for weeding and harvesting, where there is no immediate possibility for the use of mechanical equipment; both have to be done by hand labor. Control of weeds must lie with the proper preparation of land through plowing and harrowing, and with the timing of sowing. Usually one weeding is done per season, although on many sites the rice crop came off without any weeding.

In regard to harvesting, new methods can be introduced which will permit the available labor to cope with any immediate increases in acreage of rice grown. A good illustration of a new method is the use of a scythe, a hand tool (used extensively in parts of Asia and East Africa) which is three to four times as efficient as the sickle (another hand tool). The sickle, which has not yet been used in Sierra Leone, is much more efficient than the knife blade. Observation is that the potential labor supply appears to be adequate to cope with possible acreage expansion for some time yet. If later, either by the introduction of a different variety of rice that does not lodge, or a suitable harvester so that the harvesting can be mechanized, then the future of the Scheme, at least in this respect, would be assured.

There is a possibility that processing could offer resistance to increased rice production but this operation can be mechanized quite easily and therefore does not require much elaboration.

One of the most important impediments limitng the efficient organization and operation of the Mechanization Scheme pertains to a multiplicity of socio-political factors. These are numerous and quite difficult to understand; they express themselves in several forms. The objectives of people in terms of social customs, attitudes and political aspirations in many instances conflict with economic objectives. The employment of unsuitable personnel because of nepotic reasons, and the opening of plowing sites in areas quite unsuitable for mechanical operations purely for social and political ends, are the chief examples.

These practices are quite unlikely to serve the best use of scarce capital and management resources. These costly resources should be placed in their most profitable use and allocated to the potentially most productive areas in order to achieve maximum output. In this way, their contribution to increased incomes will confer a larger benefit which will through time flow in part to the less productive areas.

Conclusion

Very significant opportunities exist for expanding mechanical cultivation of rice on the deep-flooding grassland plains in the Torma Bum area. Effective exploitation of this possibility requires considerable planning, organizing, directing and controlling. These requirements, in conjunction with socio-political, marketing and infrastructure problems, greatly obstruct the application of the most technical and economic methods of production. An integrated approach to all these related problems will ensure a good future for the Mechanization Scheme.

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APPENDIX A

FORM-A

MECHANICAL CULTIVATION SCHEME

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

NJALA UNIVERSITY COLLEGE

TRACTOR UNIT: TOTAL NO. OF TRACTORS: NO. A NO. B

Date	Site and Village	A - TRACKLAYING				B - WHEELED				Type of Operations	Signature of Agricultural Instructor
		Make and Type/ Size	Hours Worked	Acres done	Driver's Name	Make and Type/ Size	Hours Worked	Acres done	Driver's Name		

APPENDIX B

FORM-B

MECHANICAL CULTIVATION SCHEME

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

NJALA UNIVERSITY COLLEGE

TRACTOR DESCRIPTION:

Date	Village/ Site	Time Start	Time Stop	Hours Worked	Hours Lost	Operation	Acres Done	Name of Driver	Remarks	Signature of Agricultural Instructor

APPENDIX C

FORM-C

MECHANICAL CULTIVATION SCHEME

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

NJALA UNIVERSITY COLLEGE

WORKSHOP BASE:

NUMBER OF TRACTORS STATIONED HERE:

Date	Serial No. (Reg. No.)	Size/ Make and Type	Nature of Breakdown	Hours in Shop	Cost of Repairs					Driver's Training	No. of Tractors in running order	Distance from Shop to place of work	Remarks	Signature of Mechanical Superintendent
					Labor Used	Cost of Labor	Parts Used	Price of Parts	Cost of Parts					

APPENDIX C-1

FORM C-1

MECHANICAL CULTIVATION SCHEME

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

NJALA UNIVERSITY COLLEGE

Date	Petrol Fuel (Gal.)	Diesel Fuel (Gal.)	Lubricant: Oil 30/40, 90/140	Lubricant: Grease	Hours Worked	Acres Done	Site/Village	Serial No.	Make/Type Tractor

APPENDIX B

Acres plowed per week by tractors--Torma Bum, 1970

		Week ending																									
		February				March				April				May					June				July			
		7	14	21	28	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	4	11	18	Total
RCT-50	Massey Ferguson-175	35.0	50.0	--	42.0	38.0	50.0	21.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	236.5
RCT-52	Massey Ferguson-175	11.0	38.0	28.0	28.0	67.0	37.0	19.0	2.0	2.0	18.0	18.0	25.0	60.0	18.0	9.0	--	16.0	--	--	20.0	7.0	6.0	4.0	4.0	437.0
RCT-56	Massey Ferguson-175	10.0	24.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	34.0
RCT-60	Massey Ferguson-175	10.0	22.0	10.0	35.0	45.0	42.0	17.0	28.0	48.0	40.0	22.0	17.0	12.0	--	35.0	35.0	35.0	--	--	--	--	--	--	--	453.0
RCT-61	Massey Ferguson-175	--	7.0	2.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9.5
RCT-1	Richard Continental	6.0	23.0	25.0	30.0	30.0	30.0	16.0	17.0	10.0	12.0	35.0	22.0	22.0	--	22.0	22.0	24.0	--	--	--	--	--	--	--	346.0
RCT-2	Richard Continental	7.0	9.0	12.0	8.0	--	--	7.0	8.0	21.0	43.0	22.0	14.0	13.0	--	18.0	--	15.0	--	--	--	--	--	--	--	197.0
RCT-3	Richard Continental	18.0	18.0	18.0	18.0	17.0	30.0	20.0	21.0	23.0	26.0	20.0	10.0	--	--	--	--	--	--	--	--	--	--	--	--	239.0
RCT-4	Richard Continental	9.0	16.0	6.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31.0
RCT-6	Richard Continental	--	22.0	41.0	43.0	20.0	15.0	12.0	15.0	--	--	--	--	--	--	--	11.0	--	--	--	--	--	--	--	--	179.0
RCT-7	Richard Continental	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11.0	--	--	--	--	--	--	--	11.0
RCT-9	Richard Continental	7.0	12.0	14.0	--	12.0	14.0	19.0	42.0	10.0	--	--	19.5	9.0	--	--	--	--	--	--	--	--	--	--	--	158.5
RCT-12	Richard Continental	--	12.0	2.5	30.0	18.0	18.0	14.0	14.0	10.0	30.0	--	15.0	15.0	--	17.0	21.0	12.0	12.0	--	--	3.0	8.0	8.0	10.0	269.5
RCT-13	Richard Continental	18.0	5.5	2.0	14.0	20.0	25.0	20.0	10.0	12.0	23.0	19.0	16.0	9.0	19.0	20.0	14.0	9.5	--	--	--	--	--	--	--	256.0
RCT-14	Richard Continental	5.0	12.0	16.0	--	21.0	4.0	--	16.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	74.0
RCT-15	Richard Continental	8.0	12.0	25.0	--	20.0	12.0	28.0	45.0	4.0	35.0	18.0	44.0	17.0	12.0	8.0	9.5	10.0	--	--	--	--	--	--	--	307.5
RCT-16	Richard Continental	--	--	10.0	8.0	11.0	15.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	44.0
RCT-17	Richard Continental	10.0	25.0	23.0	--	5.0	--	--	38.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	101.0
RCT-18	Richard Continental	9.0	11.0	24.0	--	29.0	34.0	35.0	50.0	25.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	217.0
RCT-19	Richard Continental	--	15.0	6.0	14.0	36.0	24.0	20.0	8.0	15.0	15.0	--	--	24.0	9.0	25.0	--	--	--	--	--	--	--	--	--	211.0
RCT-20	Richard Continental	--	--	45.0	21.0	35.0	33.0	34.0	25.0	25.0	30.0	20.0	31.0	27.0	26.0	28.0	25.0	25.0	--	--	--	--	--	--	--	430.0
RCT-21	Richard Continental	8.0	10.0	17.0	11.0	--	--	6.0	16.5	19.0	25.0	25.0	8.0	--	--	19.0	23.0	25.0	--	--	--	--	--	--	--	212.5
RCT-22	Richard Continental	--	8.0	5.0	24.0	52.0	24.0	24.0	24.0	--	--	--	--	--	--	--	--	14.0	--	--	--	--	--	--	--	175.0
RCT-23	Richard Continental	8.0	30.0	35.0	4.0	32.0	20.0	18.0	7.0	5.0	40.0	--	50.0	28.0	5.0	27.0	--	20.0	--	19.0	20.0	11.0	12.5	9.0	6.5	407.0
RCT-24	Richard Continental	7.0	18.0	29.0	3.0	27.0	21.0	18.0	30.0	4.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	157.5
RCT-25	Richard Continental	11.0	15.0	--	4.0	28.0	21.0	18.0	26.0	16.0	22.0	--	12.0	--	14.0	8.0	--	12.0	12.0	--	--	--	--	--	--	219.0
RCT-26	Richard Continental	--	--	21.0	--	--	--	--	--	--	19.0	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--	48.0
RCT-91	Caterpillar D4	7.0	7.0	65.0	51.0	51.0	18.0	20.0	34.0	33.0	33.0	33.0	47.0	34.0	20.0	--	33.0	38.0	--	--	--	--	--	--	--	524.0
DA 75	Caterpillar D4	--	--	--	--	27.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27.0
DA 76	Caterpillar D4	5.0	14.0	16.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	35.0
DA 90	Caterpillar D4	30.0	26.0	44.0	43.0	36.0	27.0	40.0	47.0	38.0	50.0	25.0	12.0	53.0	41.0	37.0	29.0	27.5	--	--	--	--	--	--	--	605.5
DA 87	International BTD6	--	6.0	76.0	70.0	67.0	59.0	26.0	26.0	--	35.0	23.0	49.0	30.0	4.0	--	--	15.0	5.0	12.0	--	--	--	--	--	503.0
DA 44	Fowler Mark VFA	--	--	--	--	--	--	--	--	--	--	26.0	41.0	19.0	21.0	21.0	24.0	4.0	25.0	12.0	11.0	3.0	--	--	--	207.0
	Total	239.0	467.5	618.0	501.0	744.0	573.0	452.5	549.5	320.5	496.0	314.0	432.5	372.0	189.0	294.0	246.5	313.0	54.0	43.0	51.0	24.0	26.5	21.0	20.5	7362.0
	Cumulative	239.0	706.5	1324.5	1825.5	2569.5	3142.5	3595.0	4144.5	4465.0	4961.0	5275.0	5707.5	6079.5	6268.5	6562.5	6809.0	7122.0	7176.0	7219.0	7270.0	7294.0	7320.5	7341.5	7362.0	

VITA

Victor Augustus Whittaker was born at Watson Town, St. James, Jamaica on November 17, 1931. He received his primary education at the local school and his secondary education at Holmwood High School, Christiana, Manchester, where he was the 1947 Trelawny Scholar.

In 1950, he was awarded an Agricultural Scholarship to the Jamaica School of Agriculture, from where he graduated with a Diploma in Agriculture in July, 1953.

In August, 1953, he was appointed to the position of Agricultural Assistant in the Ministry of Agriculture, Jamaica, and served for nearly four years on the Experiment Stations.

Resigning from this position in September, 1957, he entered the Agricultural and Technical State University of North Carolina, Greensboro, to pursue further studies. In June, 1959, he graduated from this institution with a B.S. degree in Agriculture. In that same year, as the recipient of a research assistantship, he entered the University of California at Berkeley to pursue studies at the graduate level. He received the M.S. degree in Agricultural Economics in 1961.

He worked as a Statistical Analyst with the California Mutual Fund Insurance Company in San Francisco from August, 1961 to September, 1962. In October, 1962, he obtained a four-year contractual appointment as a Senior Agricultural Statistician in the Federal Office of Statistics, Nigeria. During this period he did part-time lecturing at the University of Nigeria, Nsukka. At the expiration of this contract in September, 1966, he entered the University of Illinois, on the award of a research assistantship, to work toward the Ph.D. degree in Agricultural Economics. He taught for one term at Njala University College, Sierra Leone, during his sojourn in that country (September, 1969 to July, 1970) for the purpose of collecting data relevant to his dissertation, "The Economics of Mechanical Cultivation of Rice Lands in Sierra Leone."