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ECONOMICS OF MECHANIZATION IN THE CENTRAL RAINLANDS  
OF THE SUDAN: A RESEARCH PROPOSAL

Plan B Paper

By

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September, 1981

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### Weights and Measurements

1 feddan (fed.)	= 1.038 acre	= 0.42 hectare
1 kilometer (km.)	=	1000 meters (m)
1 metric ton (mt.)	=	1000 kilograms (kg.)
1 sack of sorghum approximately		90 kg.
1 sack of sesame approximately		76 kg.

### Abbreviations

ABS	Agricultural Bank of Sudan
BOS	Bank of Sudan
MANFR	Ministry of Agriculture, Food and Natural Resources
MCPS	Mechanized Crop Production Schemes
MFC	Mechanized Farming Corporation
SGD	Sudan Gezira Board

CHAPTER I  
INTRODUCTION

A. Agriculture in the Economy of the Sudan

Sudan is the largest country in Africa, it covers about 2.5 million kilometers. The population is estimated at 17 million growing at about 2.5 per cent per year, per capita income for 1976/77 was U.S. \$290.<sup>1</sup> Much of the country is sparsely populated. The Sudan has about 85 million feddans of arable land, 240 million feddans of grazing and 60 million feddans of forest.<sup>2</sup> Of the total cropped area only about 4 million feddans are artificially irrigated while the rest of the area is under dry farming. The proximity of the Sudan to oil rich Middle East countries places it in a favorable position for agricultural exports.

Agriculture holds a pivotal position amongst the different sectors of the economy. It contributes nearly 40 percent of GDP, while over 80 percent of the population depends for their subsistence on agriculture and related activities. Agriculture is a major source of exportable commodities, accounting for over 90 percent of the country foreign exchange earnings. Also over 50 percent of the government revenue comes from agriculture and besides that agriculture supplies over 90 percent of the raw material entering the local industries.<sup>3</sup>

Sectorial Composition

The agricultural sector is composed of four main sub-sectors:

(1) the Irrigated Sub-sector: The country has had about 4 million feddans under irrigation which comprises consolidated schemes irrigated by the Nile

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<sup>1</sup>World Bank, "World Development Report, 1978," IBRD, Washington, D.C., 1978.

<sup>2</sup>One feddan = .42 hectare.

<sup>3</sup>The Ministry of National Planning, "The Six Year Plan 1977/78-1982/83." Kartoum, Sudan, April 1977.

waters. Some 2.1 million feddans are managed by SGD making it one of the largest single irrigated projects in the whole Africa. Other big schemes are Kashem el Girba, Rahad, and El Suki. These schemes are undertaken by tenants and share croppers with central management boards for major crop production decisions. The Sudan cannot expand indefinitely in irrigated projects because it is limited by the Nile Waters Agreement of 1959 between Sudan and Egypt. At present Sudan uses 14.2 milliards  $m^3$  out of its share which is 20.5 milliards  $m^3$  of water. The remaining water will only be enough to irrigate about 500,000 feddans.<sup>1</sup>

(2) The Traditional Rainfed Sub-sector: In Sudan, as in most developing countries, the majority of rural population is engaged, or dependent on, some form of traditional farming, some estimates put the figure at about 10 million persons.<sup>2</sup> A family may cultivate an area of from two to eight feddans depending on the size of the family, the quantity of land, the range of crops grown and so on. The government is emphasizing that through tractorization it can modernize this sector and end the dualism of agriculture.

(3) The Livestock Sub-sector: This has an estimated 14 million cattle, 13 million sheep, 11 million goats and 3 million camels. The herds are owned mainly by the nomads. The traditional animal husbandry does not require much investment as herds reproduce themselves naturally. In recent years an increasing attention is given to the development of this sub-sector.

(4) The Mechanized Rainfed Agriculture Sub-sector: This is the more recent sub-sector, located in the central clay plains where the rainfall is between 400 mm in the north and 800 mm in the southern parts of the region.

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<sup>1</sup>ILO, "Growth Employment and Equity," a comprehensive study for the Sudan. Geneva, 1976.

<sup>2</sup>Ibid.

The technique has started in 1944/45 in the Eastern parts of the country with 20,000 feddan and by 1960 it has extended to other areas in the clay land belt. Over 6 million feddans are under this mode today and up to 3 million feddans are planned to follow as early as 1983. Sorghum and sesame are the main crops and their output represent 50 percent and 32 percent of the nation's total production of these crops.<sup>1</sup> The sub-sector has been a means of channelling substantial private savings towards agriculture. The interest of this study is directed towards this sub-sector. This sub-sector characterized by large schemes of 1,000 to 1,500 feddans owned by individual farmers. Land preparation is done by tractors and also the threshing of sorghum. More mechanization to the cultural operations is planned in the near future. The largest of the mechanization programs is to fully mechanize the three main crops--sorghum, sesame and cotton.

#### B. Agriculture in the Economy of the Central Rainlands

The Central Rainlands which run across the central part of the country has been and will remain the basis of the Sudan agriculture. The area of Central Rainlands is estimated to be 100 million feddans and more than half the area is suitable for crop production. More than 50 percent of the irrigated agriculture lies within this zone as well as 90 percent of the large scale mechanized rainfed schemes and a big number of traditional farms. Besides that the majority of livestock in the country, and which is raised by nomads, spend the period between April - June and December - February in this region during their seasonal north - south movement.

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<sup>1</sup>Sorghum is Sorghum valugare, which is locally known as Dura. Sesame as Sesamum orientale which is locally known as simsim.

Most of the marketed agricultural products of the Sudan come from this region. Nearly all the country gum arabic trees are within this region and 80 percent of the sorghum is raised in this region: About 50 percent of cotton and sesame and 40 percent of the groundnut are produced in this region also. The mechanized rainfed farming is the main mode of production in this region.

The most limiting factor to development of the region is unavailability of water in areas away from the rivers and streams. The region contains five provinces, Kassala, Blue Nile, Upper Nile, South Kordefan and South Darfur and extend from east to west across the middle section of the country.

### C. Mechanization and Government Policies on Agricultural Mechanization

The Sudan economy is operating under a central planning system. The need for increased food supplies and increased exports tend to emphasize the key to economic as lying within the area of agricultural production. The strategy calls for horizontal and vertical expansion in production and mechanization is seen as one of the important vehicles to reach this goal. The following is a brief discussion of the key government policies affecting agricultural production in general with special emphasis on the Central Rainlands.

Land Tenure: Most of the land in the Sudan is state owned. This is particularly true for the Central Rainlands which is sparsely populated and all the land is owned by the government. As else where in the country the policy of the government is to retain the land by granting leases. A "Land Allotment Board" has been constituted in every province.<sup>1</sup> The Board is responsible for allotment to persons for the purpose and manner authorized

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<sup>1</sup>The "Land Allotment Boards" are responsible to the Provincial Commissioner for the allotment of unirrigated land. In case of MCPS the Board review applications and submit recommendations to MFC Board for approval.



by the regulations. For MCPS the applicant has to satisfy the following:

- a) He has or can obtain necessary agricultural machinery.
- b) He has sufficient agricultural knowledge experience and managerial ability and time to run the scheme.
- c) He has sufficient capital to finance the scheme.

The term of the lease is 25 years and the area leased is 1,000 - 1,500 feddans per individual. An annual rent of L.S. 0.05 per feddan per year and charged against the cultivated area which should not be more than two-thirds of the area leased.<sup>1</sup> The area of 1,500 feddans was selected because this is thought to be the economical area (cultivable area of 1,000 feddans out of 1,500 feddans) for the 70-75 HP tractors.

The Machinery Import Policy: Sudan imports all its motor-driven farm machinery from abroad. The country has experienced a continuous trade deficit during most of the period after independence. The foreign debts are now estimated to be above U.S. \$4 billion. The foreign exchange is expected to have a considerable influence on machinery imports. Unrestricted foreign exchange allocation at the official exchange rate was available for import of farm machinery until 1972. After that an annual quota is allowed by the commercial importers. For projects where foreign loans are obtained there is no restriction on the amount of machinery imported.

The foreign exchange allocations at the overvalued exchange rate provided an important incentive for importation of farm machinery.<sup>2</sup> Also the foreign donors have a bias to give loans in form of machinery.

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<sup>1</sup>In 1978 the land rent was raised to L.S. D.10 per year and charged against all the area leased.

<sup>2</sup>The official exchange rate remained unchanged for the past decade at L.S. 1 = U.S. \$286. The unofficial rate is L.S. 1 = U.S. \$1.25.

The Credit Policy: The ABS is the main institutional source for agricultural credit in the country. The ABS give medium loans for purchase of agricultural machinery against an immovable collateral whose value is 130 percent of the loan. The loan is given in kind at a subsidized interest rate of 8 percent (while the commercial interest rate is 13 percent) and also a subsidized price which is less than market price of the machinery.

Beside the ABS loans the MCPS farmers are eligible for IBRD loans through the MFC. Hence farmers obtain loans for machinery and schemes development at 9 percent rate for five years. Other forms of credit are also available, namely friends, relatives, village shop keepers and money lenders. These are very important sources of credit for small farmers but cannot provide the large amounts needed for the purchase of agricultural machinery.

The Taxation Policy: Whatever explicit objectives of the tax structure, the distortionary resource allocation incentives exist, and their signalling power are likely to exert increasing influence of the choice of resources. The Sudanese custom tariff duty rates are for nearly 1,100 items, mostly on ad valorem basis. There are 26 different rates of duty ranging from 5 percent to 600 percent. The import tax on agricultural machinery was 20 percent up to 1972 and it was reduced to 12 percent afterward. In addition to import duty tax there is a uniform 15 percent import surcharge and a 2 percent development tax from which the agricultural machinery are exempted.

Other Policies: In 1963/64 the government established the Farm Machinery Training Center for training farm machinery drivers and mechanics. The students receive free training and boarding plus pocket allowances. Also the government has established workshops and spare parts stores in all the production centers. The maintenance costs and the spare parts are all subsidized. The government also provides infrastructure in the area of MCPS in the form of water storages reservoirs, paved roads and medical care. Also farmers in MCPS can receive subsidized seeds.

#### D. Problems Facing Agricultural Mechanization in the Central Rainlands

The mechanized rainfed farming in the Central Rainlands has been promoted because of its potential contribution to the food supplies for domestic consumption, and foreign exchange through export. Mechanized rainfed farming is currently the most dynamic sub-sector in the Sudanese agriculture. It is also credited with the advantage of putting vast plains which are sparsely settled under crop production. It attracts the private investment and grows rapidly compared to the other agricultural sub-sectors.

The policy behind the encouragement of mechanization is that it is assumed that it will increase agricultural production, by increasing yields and the area under cultivation. It is also expected that mechanized farming will increase farm income, employment, sorghum, sesame and cotton exports and the addition of new crops such as sunflower, safflower and corn.

Mechanized farming is experiencing a number of problems. One of the most important problems being raised is the suitability of the wide level disc as land preparation and sowing implement in the clay plains of the Central Rainlands. The wide level disc has been found to penetrate only the top 2-3 inches of the soil and, as a result, a hardpan is created which hinders water and root penetration and results in the exhaustion of the top soil. The clearing of vast areas from trees and the land preparation practices resulted in the changing of topography and this coupled with the increase in the run-off lead to massive erosion. Also as a result of the existing cultural practices the weeds density increase and new varieties of weeds which are harder to control appear. This increases the costs of production and lowers the quality of the produce. Farmers who are pursuing short run profit maximizing strategies are neglecting the maintenance of soil fertility. There is a real danger that if farmers continue disc plowing it may render large areas of arable land to be useless for crop production in the future.

Rural Employment generation is the second major problem to be addressed. With relatively poor prospects for expanding the demand for employment in urban areas the government has decided it should promote rural employment generation strategies, but at the same time, through programmes and institutional conditions is pushing for full mechanization. The state farms are the leading innovators in the Central Rainlands. Now nearly all the operations in the state farms are mechanized except the weeding of sorghum and sesame. The harvest of sesame is also still manually done although there is a constant drive to mechanically harvest it. The MCPS are now a source of employment for large numbers of seasonal labors who perform the weeding and harvesting of the three crops sorghum, sesame and cotton. The majority of the labor force migrate from neighboring areas and the poor regions of the West and the South to work. Also besides that labor comes from neighboring countries as seasonal labor or refugees and work in these schemes. The laborers work under a very hard condition and for very long hours. Also they are paid at a much lower rate than the urban wage rates which is governed by the minimum wage act of 1972.

The third problem is the seasonal labor shortage. In the last decade there is a preceived belief that there is a seasonal labor shortage and that quick actions have to be made to smooth the labor bottlenecks. The government has adopted policies that encourages full mechanization which is also seen as an important step in agricultural modernization. All the policies which are described before are in full swing to promote full mechanization. Also a number of multi-national corporations are a pushing force in the direction of full mechanization. They are now running a massive effort of adaptive research and are providing the government farms with free implements and performing different tasks without charges. Unfortunately no studies have been done to deal with any of these serious matters. The basic data about the labor force, seasonal labor requirement by crop are needed.

The fourth problem is rural income distribution with emphasis on whether mechanization reduced or widened income disparities in the central Rainlands. It has been assumed the MCPS would give opportunities to a larger sector of rural population in these regions achievable comparable incomes to the urban dwellers incomes. Also it was thought these schemes will generate a source of income to the local governments. But the ILO (1975) contends that the mechanized farming may be making "the rich richer". The ILO reports that in 1975 an average operator of 1,500 feddans may make between L.S 3,500 to L.S. 4,000 and year before taxes. This is considered to be a high income under the Sudanese conditions. Because of the conditions set for the eligibility to be a scheme owner nearly all the schemes owners are urban residents and the government programmes appear to be subsidizing the urban rich. The incomes generated in these schemes and the income distribution have not received any attention from the government. The distributional impact of mechanization in the Central Rainland is a very critical matter. The fact that the benefits from MCPS accrue to larger urban farmers, those who command the resources necessary to purchase equipments is a very serious matter socially and politically. Equity, employment and production cannot be separated.

E. Objectives of the Study

1. To provide a descriptive analysis of the public and private sector mechanized farming in the Central Rainlands, including the historical development and present status of mechanized farming.
2. To identify and measure the effect of the mechanization potentials on farm output, income and employment.
3. To compare the financial and economic costs and benefits of mechanization in the Central Rainlands.
4. To analyze the impact of mechanized farming on farm income distribution in the Central Rainlands.
5. To derive policy implications and programs for the development of the Central Rainlands.

CHAPTER II  
THE NATURAL RESOURCES, AND THE MECHANIZED  
FARMING SYSTEM IN THE CENTRAL RAINLAND

A. Historical Background<sup>1</sup>

The development of mechanized agriculture in the Central Rainlands of the Sudan can be divided into three phases. (See Map 1). The criteria for this division include a) the type and rate of development, b) production relations and c) degree of government investment and control.

The First Phase (1945-1954): In 1944 the government started a project of mechanized crop production of sorghum in the Gadarif area in eastern part of the country. Judging from the experience gained during the first two seasons it was found that complete mechanization of sorghum was impossible and hand labor was needed for weeding and harvesting. The answer was participating farmers who were given up to 240 feddans each. In 1949/50 some <sup>??</sup>notables and merchants were given up to 240 feddans, machinery was hired to these farmers. The total area cropped area reached 31,000 feddans by 1954.

The Second Phase (1955-1968): As a result of the recommendations of a working party appointed by the government, a pilot farming started in different locations of the district to study the problems of the mechanized farming. At the same time new land was opened by government and distributed to the private sector.

The Third Phase (1968 up-to-date): This phase aimed at providing credit in form of agricultural machinery and equipment and in the form of credit for

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<sup>1</sup>This part draws from MFC annual reports (1974-1978).

tree clearance. The plan also aimed at strengthening extension services, roads, water supplies and crop protection.

The Mechanized Farming Corporation was established to be responsible for mechanized rainfed farming in the Sudan. The objectives of the MFC was stated as preparation of land for purpose of mechanized farming and granting necessary loans subject to terms prescribed by the MFC. When the MFC was established there were 1,410,000 feddans already under production in Kassala, Blue Nile and Upper Nile provinces. The first plan executed by MFC was the five year plan (1970/71-1974/75) under which 2.7 million feddan were distributed as follows:

- a) Private sector--self-financed 1.8 million feddans.
- b) Private sector--World Bank financed 600,000 feddans.
- c) Public sector--state farms 400,000 feddans.

During the six year plan (1977/78-1982/83) the MFC was given the responsibility of opening another 3 million feddans. Most of the new expansion is to be in the western and southern regions of the country. Also during the same period 2 million feddans will be developed by big companies and foreign investors. Some of these projects have already started and there is now about 3/4 million under production.

Besides these planned developments during the last two decades the unofficially opened areas reach about 2 million feddans. The government failed to control the unplanned rainfed farming and it is now trying to legalize it by granting leases to the farmers in these areas.

## B. Natural Resources

### Physical Environment

The Location: The Central Rainlands occupies the central part of the country and they extend from the borders of Ethiopia in the east to Central



Africa in the west. They lie between latitude 10° and 14° north. The width of the plains is estimated to 160 kilometers in the average comprising an area of 100 million feddans.

The Topography and Soils: Most of the region is approximately 600 m above the sea level and flat plains with a gentle slope of 0.5 percent to 1.0 percent. There are few scattered mountains and hills in the region, except in the Nuba mountains and where the southern part of the plain is dominated by series of mountains with average heights of 500 m above the plain.

The soils are predominately deep, dark colored, cracking heavy clays. In most of the region the clay fraction varies between 60 - 75 percent and occasionally calcium carbonate is found in variable quantities in the top horizon. These soils are generally alkaline. Potassium and phosphorous seem to be present in adequate quantities but nitrogen may become deficient under the present cropping system. These soils disperse and swell when wet and harden and crack as they dry out. The soils are self-mulching and develop into a friable condition during the rainy season.

The Climate: The area lies within the tropical semi-arid zone. The central rainlands lie between 400 - 800 mm rainfall isohyets which run in a southwest-northeast direction. The wet season extends from June through September or early October. During this period the precipitation exceeds the potential evapotranspiration. The monthly temperature ranges from 30° C to 40° C most of the year with April being the hottest month and January the coolest. The relative humidity rises to 70 percent within the rainy season and drops to around 20-30 percent during the dry season.

The Water Supply: In general the central rainlands are short of domestic water supply. The underlying geology of the area is said to have no underground

water supplies. The surface water disappears completely by the harvest time (October/November) and does not reappear until the next rain season six to eight months later. The general method of providing water is to dig large reservoirs (hafiers) fed from the natural drainage. The large scale movement of nomadic herds at the beginning and the end of the rainy season put an additional strain on the scarce water supplies as well as being a cause for destruction to the crops.

### C. The Farming System

**Cultural Practices:** The mechanized crop production system currently in general use is based on wheel tractors of 70-75 HP and wide level disc with seeder attachment. The wide level discs in use have 24-32 relatively low concavity discs which are 45-60 cm in diameter. The seed box is mounted on top of the main frame and from it seeds are fed down flexible tubes.

A first discing is carried out after sufficient rain has fallen to germinate the weed seeds and to soften the soil; this is usually toward the end of June. The second discing is carried out shortly afterwards and the crop is sown at the same time using the seeder attachment. Sometimes when there is high population of weeds after the first discing a second discing is carried out before sowing. This technique results in uneven, shallow seed bed of poor tilth causing poor and uneven germination and shallow root growth. No fertilizers are used.

When the crops emerge the area is weeded manually once or twice depending on the amount of weeds. Seasonally hired labors who use hoes are hired to do the weeding. The labourers who usually work in groups of 3-7 are paid by area rather than daily wages. The cost of weeding vary depending on the area and weed type and density. The farmer also supplies food and drinking water for

the laborers. The critical period to do the weeding is found to be during the first weeks after sowing.<sup>1</sup>

The three crops grown have different harvesting requirements. Combinable varieties of sorghum are grown in the state farms where combine harvesting is done and substantial losses during the harvesting are noticed. For the private sector the general practice is to cut the crop heads, pile them in heaps and then feeding them to a stationary combine harvester. Hand harvesting starts earlier than machine harvesting and result in a more clean product. Substantial numbers of laborers are hired and paid on per area basis. Harvesting of sesame is totally by hand labor. The laborers also work in groups and they are paid on per sack of sesame seeds harvested. The harvesting of sesame is done in two steps, first the crop is cut and stalked and when it dries it is shaken to release the seeds. The cotton crop is hand picked and the laborers are paid by weight. After the harvesting cotton labor is also used to chop the stalks as a plant protection measure.

#### The Crops Grown:

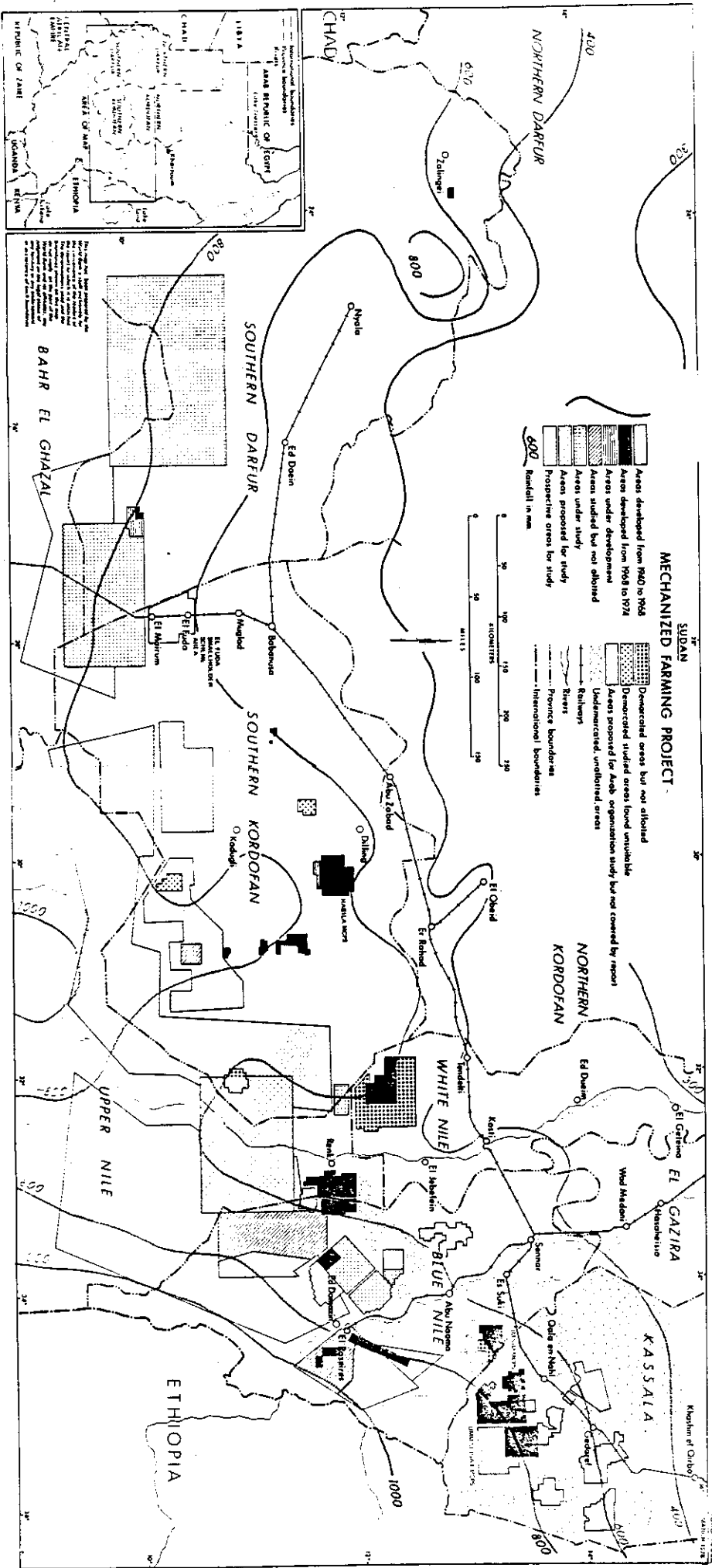
**Sorghum:** This is the most important cereal in Sudan and a major staple diet. The mechanized rainfed schemes produce about 50 percent of the nations and that amount to over one million metric tons. Most of the marketable portion of the crop and all the exports come from this source. The area under sorghum increases from 1.492 million feddans in 1969/70 to 3.015 million feddans in 1976/77. About 80 percent of the area under crops in MCPS is devoted to sorghum. The yield ranges between 256 kg/feddan and 388 kg/feddan which is far away from the world average of 455 kg/feddan.

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<sup>1</sup>Kenana Research Station recommendations.

Sesame: Sudan exports from sesame represents about 50 percent of the world exports, and Sudan produces about 13 percent of sesame produced in the world. The MCPS produces about 32 percent of the country production and that amounts to around 100,000 m.t.

Cotton: Cotton is the major exportable crop in the Sudan. Most of varieties which are grown in the irrigated scheme are long staple, but in MCPS short staple varieties are grown. The areas under cotton in MCPS decreased from 64,000 feddan in 1969/70 to 28,000 feddans by 1976/77. This because the private sector gave up producing cotton due to sharp increase in the cost especially pest control costs.



Map No. 1

### CHAPTER III

#### THE ROLE OF MECHANIZATION IN AGRICULTURAL DEVELOPMENT IN THE THIRD WORLD: A LITERATURE REVIEW

A review of some of the major studies will help to set the objectives of the study and give an indication to some of the issues involved.

Dawlaty (1971) in his study of the effects of tractors on farm output, income, and employment found that at the early stages of mechanization in Afghanistan the amount of labor replaced by machines is relatively small. An important effect to mechanization in Afghanistan found by Dawlaty was the shift in tenure patterns. The shift from "independent"(Ejaradar) tenants to tenants who are less involved in decision making. Landlords who had previously rented all or most of their land have become more involved in their farm management affairs. Large landholders were found to become more likely attuned to scientific methods and more aware of economic market forces when they own tractors. It was also found by the study that tractor use increased cultivatable land areas, particularly in the irrigated areas. Tractor use in Afghanistan was also found to result in increased crop yields in most instances. This increase in yield was found to result in increase for labor in operations which were not done by tractors. Also it was found that mechanization led to diversification of farm operations by some farms as a result of increased farm size to include more labor intensive enterprises. The data for the study was collected through interviews to tractor owners and was not checked with any other source of

information. One will expect a large bias in the data. Another drawback in the study is it did not pursue a policy question in the objectives and the author did not explore the question whether the mechanization program is beneficial to the country as a whole or not.

Singh (1971) studies the effect of technology on farm employment in the states of Punjab and Maharashtra in India. The basic approach used in the study to attempt a measurement of potential impact of HYV and other important technological changes on farm employment. In Punjab where HYV of wheat had spread rapidly, wheat threshers were extensively used. It was found that the HYV have increased the demand for labor by themselves but the pump-sets, threshers and tractor have reduced the demand such that the overall demand was reduced. It was projected by the study that by 1983/84 the cropped area will expand by 14 percent and the farm labor force will increase by 10 percent in Punjab, reflecting a slight decrease in the worker/hectare ratio and an increase in the work duration of a farm laborer from 120 days to 130 days per year. The study showed that the natural growth of the labor force in Maharashtra will provide a surplus of 4.5 million workers by 1983/84. The labor displacing impact of pump-sets, threshers and tractors in this state will not be of sufficient magnitude to counter-balance the additional demand for labor resulting from increase in the area under HYV. But this increase in demand will be too small to have any marked effect on employment of the rapidly growing labor force. With limited scope for irrigation land multiple cropping on the one hand and rapid growth of population on the other hand, the man/land ratio will be high and the annual average working time of a farm laborer will decline. The impact of the technological changes in the two states studied was found to be widely uneven and different. The study made no

attempt to go into the impact of development in agriculture on employment in the non-farm sector.

Green (1971) studied four different case studies of mechanization in different parts of Ethiopia using secondary data supported with informal interviews. The cases were described and analysed for potential benefits, costs and compatibility with some objectives selected from the Ethiopian third five-year plan. Benefit-cost analysis was used to test the financial profitability of mechanization in the four districts studied. He made some assumptions with regard to crop yields, population growth, labor efficiency, price etc. on which he based his calculations. Budget models were used to generate data for benefit-cost analyses for the strategies suggested in each of the four cases. For Agnale village only one form of hand-powered technology strategy was studied. High and low production level models were tested. The analysis showed there are high potentials for increasing net returns by introducing unsophisticated improvements into hand powered systems. Analyses of employment requirements indicate a decline in labor due to improvements assumed to follow in labor efficiency. For Chilalo Awraja case an eight hectare was selected as representative of the district. Two strategies were studied, the present bullock technology either to improved bullock technology or tractor-hire. Benefit cost analyses of two strategies indicate a modest net return for high production levels and negative returns for low levels. The analysis suggested in this system, where farms are small and fragmented, the bullock option is more appropriate. The bullock option requires less government investment and provides more employment. Benefit-cost analyses of two strategies contained in Setit-Humera for which an 800 hectare was selected as representative farm indicate high rates of return for both



assumed level of production. The strategies compared were the existing labor intensive technology to more machine intensive technology. The returns to the labor intensive technology were found to be lower than the machine intensive, due to additional economies facilitated by the higher level of mechanization, but this achieved at the expense of a lower level of employment. The Tendaho case was for large-scale commercial plantations. The two strategies considered here, Strategy I was based on the assumption that the plantations produce and sell raw cotton. Strategy II assumed the cotton is also ginned before selling. In this case returns to Strategy II were found to be higher than those for Strategy I, and also more labor will be employed. Green fully tested the financial analysis of the four cases but gave a little interest in the economical analysis. Green's thesis did not reach national policy conclusions.

Ahmad (1972) investigated the economic and social impacts of tractor mechanization in the Punjab Province of Pakistan. He analysed the influence of mechanization on cropping intensities, yields, cropping pattern and rate of return on investment. The social aspects include influence of mechanization on employment, tenurial relationships and farming structure. Ahmad used secondary data and a cross-section survey of 50 farmers in three districts of the Punjab Province. He used LP model to analyse the data. Ahmad showed that government programs can act as price distortion and result in misallocation of resources. Ahmad LP model showed that the incentive to tractorization was very great. Farms with tubewells get higher returns to mechanization such that the financial rate of return was 46 percent while it was only 3 percent without. The increase in returns with tubewells was due to the increasing cropping intensities which can be reached. He concluded that for farmers with tubewells mechanization is

profitable even all price distortions were removed. Ahmad found that tractor farms had relatively less family labor but more hired labor per acre compared to bullock farms. Tractorization also cause tenant ejection and increase in landholdings of the tractor owners. As policy implication for his research Ahmad recommended encouragement of threshers instead of tractors in areas without tubewells. In areas where tubewells exist he suggested the judgement to be against the foreign exchange savings, improved off-farm linkages and less tenants displacement. Ahmad sees technical change as critical to agricultural modernization and should be considered as a bundle of inputs rather than using an individual input, e.g., tractors only.

Clayton (1973) studied the impact of mechanization on employment in East African agriculture namely in Uganda, Kenya and Tanzania. Clayton attempted to assess the income and employment impact of various mechanization programmes in the three countries. About mechanization programmes in Uganda he concluded that they should not be encouraged because they had proved to be uneconomic and labor-displacing. He suggested that the government should not subsidize farm machinery. He argued that there was no indication that tractorization has raised over-all agriculture or labor productivity. Clayton claimed that ". . . the indications are that mechanization has decreased the demand for labor and is thus an employment destroyer."

Clayton found that in Kenya mechanization is financially viable in large farms, but considering the social cost and benefits of mechanization it was undesirable to both types of farms large or small. Clayton estimated the absorption in case of tractorization as 80 employed persons per 1,000 hectares compared with over 1,000 on peasant small holdings. Clayton

advocates mechanization in family farms in coffee/tea, prethrum/coffee and coffee ecological zones, particularly when these are near towns or it is physically possible to plough with a tractor. In Tanzania Clayton suggested that tractor cultivation was uneconomic although no data to support that was presented. He approved the government policy to encourage ox plough cultivation and he considered the continuous increase in the number of ox ploughs purchased as an indication of its profitability.

Abercombie (1973) reviewed the mechanization situation in Latin America and its impact on employment. He characterized Latin American countries as having a high unemployment rate and in agricultural sector underemployment was more serious than open unemployment. Abercrombie, using data for Colombia, noted that the impact of tractors on employment varies with farm size. He estimated that as many as 18.9 workers could be displaced per tractor on the average for farms in the 50 to 199 cultivated hectares range. For farms with over 200 cultivated hectares, however, the substitution ratio drops to 2-3 workers per hectare. For Colombia he estimated the introduction of one tractor resulted in a reduction of average labor requirements for major field crops of 5-7 man years. This compared with 4.1 man years in Chile and 6.8 man years in Guatemala. The reduction in Chile was less than the other two because of the higher proportion of irrigated crops and greater use of animal power. His estimates were based on labor requirement rather than actual figures. Abercombie estimated the employment in off-farm employment due to agricultural mechanization in machinery manufacture, distribution, maintenance and repairs for eleven LAFTA countries in 1968 to be less than 150,000. Although these jobs were at a much higher productivity and income level than agricultural jobs they only represent 0.2 percent of total employment

and about 0.5 percent of the number of persons employed in agriculture. Using data from Brazil and Argentina, Abercombie estimated that an investment of up to US \$10,000 was required to create one job in tractor manufacturing which would produce two to five tractors each year. The problem here each tractor has the potential to reduce farm employment by five man years during each year of operation. The labor displaced differ substantially from crop to crop and also the greater displacement occurs at the early stages of mechanization which is just the opposite from Dawlaty's findings in Afganistan. Abercombie stated that most of agricultural machinery in Latin America is owned by large-scale private farmers. They choose mechanization because it has proved profitable and convenient to them. This was due to the distortions in factor prices which lend the capital cost less than its opportunity cost to society. Abercombie asked the governments of Latin America to stop policies which encourage more mechanization and instead follow selective mechanization policies as to ensure employment opportunities for their growing labor force.

Gostch (1973) in his study of mechanization in Pakistan concluded that it was a result of government subsidies biasing the private profitability of technology in socially undesirable direction. In addition to that the institutional conditions would lead to the same results even if resources were valued at their opportunity costs. In Punjab province, which is ecologically suitable for mechanization, he estimated that over five tractor horse power per 100 cropped acres was available in Central Punjab. This concentration was related to the significance of irrigation as nearly 75 percent of privately owned tractors were located on farms that has tube-wells. A second reason related to the farm sizes. Gostch concluded that tractorization in Pakistan was following a familiar pattern,

the larger farmers were doing the innovating. Government policies provided different kinds of incentives to mechanize. He suggested a policy which would reduce the divergence between net social cost and net private benefits by pricing capital at its opportunity cost. Added to that institutional changes that would lessen the incentives to mechanize. Gostch did not see these changes as a way to improve the income distribution or increase employment but they may lead to continued agricultural growth and a slow rise in farm wages sufficient to give the masses at least a nominal participation in the Green Revolution. Gostch reached the conclusion that the social net benefits from mechanization were negative. He also believed that large landlords and urban residents get any possible benefit from mechanization, while the tenants and the landless were the adversely affected group.

Gemmill and Eicher (1973) reviewed mechanization in Asia, Africa and South America and divided studies into short-term static studies, medium term dynamic studies, and long-term perspective studies. The short-term studies mostly include cost-benefit studies concerned with one locality. The short-term studies tend to be focus on a particular machine. The medium term studies are less popular of the three types of studies and tend to be carried out at the regional level. The long-term studies usually carried out to explain historical process of mechanization. Eicher & Gemmill observed that government programmes and policies mechanization can be divided into short and medium, and long term policies. Researchers have generally concentrated on short and long term policy questions. They noted

that researchers have often reached unjustified regional and national conclusions from studies in limited geographical areas. They saw as a drawback in many studies of farm mechanization was their failure to pursue a clearly specific policy questions. They believe that the question of mechanization is an empirical one and should not be solved by rules of thumb, and that the most acceptable mechanization policy would involve a compromise between alternative goals such as food production, export crop production, employment, income distribution.

Merril (1975) reviewed a large number of mechanization studies in developing countries. He thought the farmers decision to substitute machinery for labor or animals depended on the relative prices of inputs or changes in production function that increases the marginal productivity of machinery. His review showed that there is no way to prove or disprove general claims such as mechanization increases agricultural output and employment. From the review of the studies he concluded that when mechanization replaces animal power it results in a reduction in labor inputs. The degree to which the labor input will be reduced depends on the crops in question, the farm size, the extent and type of mechanization. Mechanization in its early stages may be associated with a slight increase in cropping intensity and crop yields and type of crops grown. Merrill thought that unless there were government policies mechanization may result in an increase in landholdings and tenants displacements. His review of the studies also that the non-agricultural employment generated by mechanization replaced only a small part of the displacement in on-farm employment resulting from mechanization. He concluded that mechanization

of agriculture is a continuous and inevitable process in economic development but its speed and direction can be altered by public policies and programs.

Merril recommended that governments should not subsidize mechanization in the way that benefited large farmers but it should support development of agricultural machinery which can be used by small farmers and to large extent produced locally. He viewed mechanization as a part of modern agriculture which includes new biological and chemical technologies.

Stavis (1978) gave a detailed analysis of how China faces the political and social dimension of mechanization. He discussed how China through conscious policies followed mechanization programmes that contributed to greater food production and equitable food distribution, and significant job enrichment. The Chinese leadership uses mechanization to accomplish broader goal of social transformations. Stavis showed how mechanization policies developed in China and how the sociopolitical context shaped agricultural mechanization. Of these the fact that China has no seasonal internal migration and mechanization is needed to break the labor bottlenecks which results from multiple cropping. Another context is the conscious policy to improve the rural living standards and make it more equal to urban conditions. Mechanization was also used to free labor to other jobs, soil reclamation, irrigation projects etc. Mechanization is also used as a means to strengthen the economic foundations of large-scale collective agriculture.

Stavis saw the striking aspect of agricultural mechanization in China is that its benefits are shared widely throughout the community of the institution of collective ownership. This is one dimension in which China is different from many other places. A dominant feature of the China

mechanization programme is the concentration on small-scale labor-intensive agriculture.

Binswanger (1978) reviewed over 20 empirical studies on the economics of tractors in the Indian sub-continent and compared their reported results. Most of the studies reviewed has been cross-sectional comparison of various types of bullock operated farms with tractor operated farms. Other studies have compiled data for tractor farms only and have judged the impact of tractorization on the basis of before and after comparisons. Cropping intensity was the first performance measure considered. In areas where few opportunities exist for area expansion, the effect of additional power on cropping intensity is often regarded as a major potential benefit. However the studies taken together gave a little support to the hypothesis that tractors are an important factor in crop intensification. Substantial differences exist where they correspond to larger differences in irrigation facilities or in case of larger tractor farms as in Nepal. When considering the yield effect of tractorization out of 118 cases only there were five or six instances in which larger yield differences remain in the absence of equally large differences in fertilizers used. In overall the studies failed to provide much evidence for the yield increasing effect of tractorization. Another essential gain of mechanization which was considered was timeliness. No conducive evidence was reached when all the studies were considered. Also in overall the studies have not given strong evidence of cropping pattern shift. On the effect of mechanization on labor displacement Binswanger's review showed that as long as the wage rates remain low there was little reason to expect tractors to gain comparative advantage in labor intensive operations. The basic conclusions reached by Binswanger was that tractor



surveys failed to provide a convincing evidence for substantial increases in intensity, yields, timeliness and gross returns due to tractors use. Likewise the evidence on labor displacement was far from conclusive.

Summary: The review of mechanization studies indicate that different conclusions have been reached with regard to the impact of mechanization on employment, financial profitability and output. The differences in conclusion are expected from the different forms of mechanization considered, crops under question and difference in macro policies, land tenure, water supply and farm sizes.

An important point which should be considered in mechanization studies it should be within very wide limits to suit society needs. The consequences of changing farm power for agricultural and rural people have not always been beneficial. The effect of the institutional behavior on mechanization was documented by most of the studies. The decision taken by farmers to use farm machinery or else is very complicated and complex, but the government policies has greater impact on that decision. Farm mechanization can be viewed as a continuous adjustment process involving people and institutions.

From the review of the studies it is clear that the influence of mechanization on output or employment will depend on the type of machines used and the operations performed.

It is also clear from the review that mechanization studies should follow a more dynamic setting by considering more than one crop and more than one operation in order to determine the influence of mechanization on employment or output. Conclusion from mechanization studies are usually limited for the area of the study due to difference between regions as regard to many variable considered, irrigation, topography weather, population density, etc.

## CHAPTER IV

### METHODOLOGY OF THE STUDY

This chapter will cover the scope and purpose of data collection and research design. The analytical procedure that will be adopted will also be explained.

#### A. Sources of Data

Primary and secondary data sources will be used in this study. The major data of the study will be primary data that will be collected from the four main areas of mechanized farming in the Central Rainland. These areas are Gaderif, Damazine, Renk and Habia. The reason for collecting data from the four areas is due to differences in locations, climatic conditions and ethnic groups inhabiting each area. The sources for secondary data will include:

- (a) Feasibility studies for the different projects in the Central Rainlands.
- (b) Mechanized Farming Corporation records and reports.
- (c) The Agricultural Bank of Sudan publications and records for the Central Rainlands.
- (d) Information that is supplied by Ministry of Agriculture and its departments.
- (e) Local governments.
- (g) Other sources, e.g. other government agencies and departments records and publications, unpublished research documents etc.

Data will be collected from private mechanized farms, state farms and also from traditional farms over a whole season which extends from June to March of the following year. There is only one state farm in each area and the data will be collected from all the four farms. In each area a random sample will be selected from the private mechanized farms and traditional farms. The number of farms selected for the survey will be determined after the total number of farms is determined. Detailed farm management and resources utilization data will be collected twice or three times a week over the whole period and the intensity will increase during the farm operations period. A socio-economic survey will also be carried out.

The Mechanized Farming Corporation will sponsor this research study and its resources will be used in the data collection. The enumerators and the supervisors will be selected from the MFC staff. The enumerators are secondary school graduates who work in the data collection units of the MFC, a short training course will be held for the enumerators before the actual survey. The supervisors will be university graduates with B.Sc. degree in agricultural economics. The questionnaires and data collection format will be discussed extensively with MFC staff and so the detailed data collection methods have to await further discussions with MFC, which will sponsor this study.

#### B. The Analysis

The data after being collected it will be coded and brought to MSU for punching, cleaning and the computer analysis. The first objective of the study will be met through obtaining sufficient information that will be collected to describe the system as it actually exists. The second objective will be met through the use of linear programming. LP will be used to predict output income, and employment and consequences of the alternative crop production system. The third objective will be met through the use of budgeting to determine the financial and economic costs and returns of the different crop production

alternatives. The results from all the techniques will be used in the final analysis to reach the policy recommendations of the study.

The linear programming technique will be used to find the optimum combination of machinery and labor which maximize farm income for a given price, input-output coefficients and resource constraints.

The mathematical formulation of the model =  $\text{Max } Z = C^1 X$

subject to:  $A X \leq B$

and  $X \geq 0$

where  $Z$  = objective function to be maximized

$C$  =  $n$  by  $1$  vector prices

$X$  =  $n$  by  $1$  vector of activity levels

$A$  =  $m$  by  $n$  matrix of input-output coefficients

$B$  =  $m$  by  $1$  vector of available resources

The objective function of the model is to maximize the net revenue of the farm subject to technical constraints of the production function and the available resources level. A basic model(s) representing the existing farms in the Central Rainlands will be developed. Three types of farms will be considered, mechanized private farms, state farms and traditional farms. The model has two types of activities; the crops grown and resources augmenting activities. The selection of the crops grown will be based on the results of the surveys in the four areas. The augmenting activities include machinery, labor and rainfall quantities.

The constraints of the representative model farm has one fixed amount of land, rainfall, equipment and labor. Special constraints will also be added such as the importance of timeliness and the rate of farm operations. Modifications of the model through the introduction of new activities and technology and through variation of some resources and prices in a number of LP exercises

to stimulate and examine partial mechanization will be done.

Budgeting technique: Budgets are prepared primarily to evaluate the efficiency of a particular farm or group of farms within a prescribed accounting period--budgeting allows the basis for comparing and evaluating the profitability of alternative investment. Data will be used to determine which set among several set of assumptions will be most profitable. Two types of cost-benefit analysis financial and economical. The financial profitability of mechanization to the individual farmer will be considered and also the economic profitability to the whole country will be determined. In the economic analysis shadow prices or the opportunity cost will be used for all input and output prices. The factor price distortions which is not counted for when the profitability of the technology to the individual is analysed which will be corrected when doing the economic analysis.

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