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Sudan: The Rahad Irrigation Project

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SUDAN: THE RAHAD IRRIGATION PROJECT

PROJECT IMPACT EVALUATION NO. 31

by

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FOREWORD

In October 1979, the Administrator of the Agency for International Development initiated an Agency-wide ex-post evaluation system focusing on the impact of A.I.D.-funded projects. These impact evaluations are concentrated in particular substantive areas as determined by A.I.D.'s most senior executives. The evaluations are to be performed largely by Agency personnel and result in a series of studies which, by virtue of their comparability in scope, will ensure cumulative findings of use to the Agency and the larger development community. This study of the impact of A.I.D. Sudan: The Rahad Irrigation Project was conducted in February 1981 as part of this effort. A final evaluation report will summarize and analyze the results of all studies in this sector, and relate them to program, policy and design requirements.

PREFACE

Large scale irrigated agriculture is at the center of long term agricultural planning in Sudan. The Rahad Irrigation Project to which the United States Government contributed $11 million in 1973 is one of the most recent schemes to develop underutilized water resources and potentially arable land. The A.I.D. contribution, although small in comparison to the eventual cost estimate of $400 million, supplied equipment at a critical time permitting the early start-up of the construction of physical infrastructure. This evaluation is not an examination of any one donor's contribution but is an analysis of efforts to improve the economic and social welfare of well over 100,000 agricultural laborers and tenants under a centrally managed administrative structure. It is hoped that the evaluation will contribute to a further understanding of parastatal* organizations in Sudan as an instrument of change and development.

The evaluation team was composed of three A.I.D. staff, an outside consultant with extensive prior A.I.D. experience in the Sudan and two Sudanese professors from the University of Khartoum. The team purposely blended agricultural economics, engineering, environmental science and anthropology in an interdisciplinary effort. An in-country workshop was held at the outset which involved up to thirty Sudanese policy-makers, technical experts, and managers familiar with Rahad's successes and problems. A week was spent at Rahad interviewing intensively and traveling extensively throughout the scheme. Techniques ranged from analysis of macro-economic data to case studies of household budgets. The comments and recommendations in this report should be attributed to the team alone; certain appendices are the work of single individuals.

The team wishes to express its deep appreciation to the staff of the Rahad Corporation both in Khartoum and in the Rahad project area. Particular thanks should be given to: Sayed Ibrahim Mohamed Ibrahim, Rahad Corporation Executive Director, Sayed Osman Mohamed Beleil, Chairman and Managing Director and Dr. Dafaalla Ahmed Dafaalla, Deputy Managing Director. The team is also grateful to the many tenants, laborers and local government officials who took time from their tasks to teach something about their way of life. The A.I.D. Mission was most helpful in arranging for logistical support.

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* One of a number of public sector enterprises which differ from one to the other in terms of the degree and nature of public versus private control.

EXECUTIVE SUMMARY

A major part of the Sudan's program of economic reform is the continued development of underutilized water resources and arable land. The Rahad Irrigation Project is a key element in expanding the production of export crops through fully mechanized irrigated agriculture. Nearly complete in terms of irrigation works and land preparation, this $400 million investment has as its objectives: (a) intensive utilization of government investments in Nile water management; (b) production of medium staple cotton and groundnuts and (c) improved welfare of up to 100,000 herders and subsistence agriculturalists through increases in incomes, employment and social services. Long familiar with large scale irrigated government schemes, the Rahad Project is intended as an eventual model of full mechanization and 100 percent intensive rotation of cash and subsistence crops guided by government management.

The A.I.D. contribution to the overall Rahad Project began in February 1973 with a $11.0 million loan. This loan supplied heavy equipment and spare parts for construction of the irrigation works and for land preparation. It also provided technical services for the procurement and management of equipment. Recently, through the Commodity Import Program, A.I.D. has supplied mechanical cotton pickers and vehicles to facilitate the mechanization of field operations. The A.I.D. project can be judged successful in meeting an equipment need at a critical time in the implementation of the Project. Effective utilization and maintenance coupled with timely delivery of inputs contributed to substantial progress in the development of Project infrastructure.

Although the Project has just completed its fourth growing season in the more developed southern sections, there are indications of classic problems which might ultimately threaten its social and economic viability. The production system is based upon a standardized family tenancy which is supervised through a Corporation inspectorate system. The system controls product and input prices, water and machine charges, marketing and most decision making. During these few years cotton yields have in fact declined, and incomes have been lower than required to break even. The Corporation has had to cope with problems of the management of mechanized operations, apparent labor shortages, and tenant dissatisfaction with the low quality of health, education and other village services.

In the face of declining incentives to grow cotton, tenants employ various strategies to obtain additional income from other sources. Almost all tenants and laborers maintain livestock and many continue to work away from the Project as wage laborers on other schemes. The added value of off-farm income has not been calculated, but is understood to be critical to Project villagers who increasingly find it difficult to benefit from Project-derived income. The mechanization of field operations also results in less Project-derived income for both laborers and for merchants who normally benefit from a cash flow. The Project mechanization policy is based upon perceived labor deficits and the desire for higher yields

through integrated mechanized operations. It is unclear as to the extent of a real labor deficit in Sudan or whether scarcity is regionally created by less attractive Project wages. Mechanization will, however, displace labor and might further weaken tenant ties to farm management decision-making.

Tenants have indicated the need for several changes. First, a greater degree of tenant decision-making is desired. This is reflected in the tenants' interest in growing groundnuts--where there is freedom to market outside Corporation auspices--and in producing sorghum. Restriction on growing sorghum, the village's basic staple crop, has created a dependence on an inflated private market. The integration of sorghum, vegetables and livestock into tenancies of more managable size would meet a number of tenant demands.

The Rahad Project was conceived of as a community providing a full range of services to its inhabitants. Severe limitations on available local currency have meant that schools, health facilities, and social services have either not been provided on an equitable basis to all eligible communities or, due to inadequate budgets, have not performed at a satisfactory level. The Rahad Corporation is taking measures to accelerate coverage by increasing its social development budget. Tenant dissatisfaction is compounded by what is viewed as a sluggishness to meet recruitment promises for a better way of life.

A diversified economy including adequate off-farm economic opportunities, a mix of occupations and skills and a rich religious, political and educational life will all be needed to retain the semblance of community. Sustainability of the Project will require a permanent population, adequately motivated, with a level of initiative to improve community welfare through community-based participation in conjunction with Corporation guidance.

PROJECT DATA SHEET

Project Title: Rahad Irrigation Project

A.I.D. Project Number: 650-H-019

A.I.D. Loan Number: 650-H-017

Borrower: The Government of Sudan. The Project was implemented by the Ministry of Irrigation and the Ministry of National Planning.

Loan Amount: Total $11.0 Million*

Original: $11.0 million. Loan Agreement signed February 26, 1973

Sudanese Contribution: $235.0 million

Terms:

Maturity of 40 years including a 10-year grace period. Interest at two percent per annum during the grace period and three percent per annum thereafter. Principal and interest to be paid in U.S. dollars.

Terminal Date for Request for Reimbursement and for Disbursement:

April 27, 1979.

Purpose: To supply equipment to the Rahad Corporation and the Ministry of Irrigation Earthmoving Corporation for agricultural development and irrigation works, respectively and for services of procurement services in purchasing equipment.

Accomplishments: The equipment served to assist to complete the irrigation infrastructure for the Rahad Irrigation Project. The equipment was purchased and delivered to site.

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* NOTE : In addition to the original loan of $11.0 million, USAID/Sudan granted, under the Commodity Import Program, $3.3 million (650-K-601) for the purchase of 50 cotton pickers, three 5-ton trucks, and three 4-WD Scouts. All of the above had 17 percent spare parts supplied. There was also a grant of $350,000 (650-K-601) for spare parts for equipment previously procured under the loan agreement.

In addition, there is an approved grant, not yet implemented, for the purchase of 50 additional cotton pickers, appropriate support equipment and spare parts.

CURRENCY EQUIVALENTS

Currency Unit	=	Sudanese Pound LSd (100pt = 1,000mm)
U.S. $1.00	=	LSd .49 (official rate)
LSd 1.00	=	U.S. $2.04 (official rate)

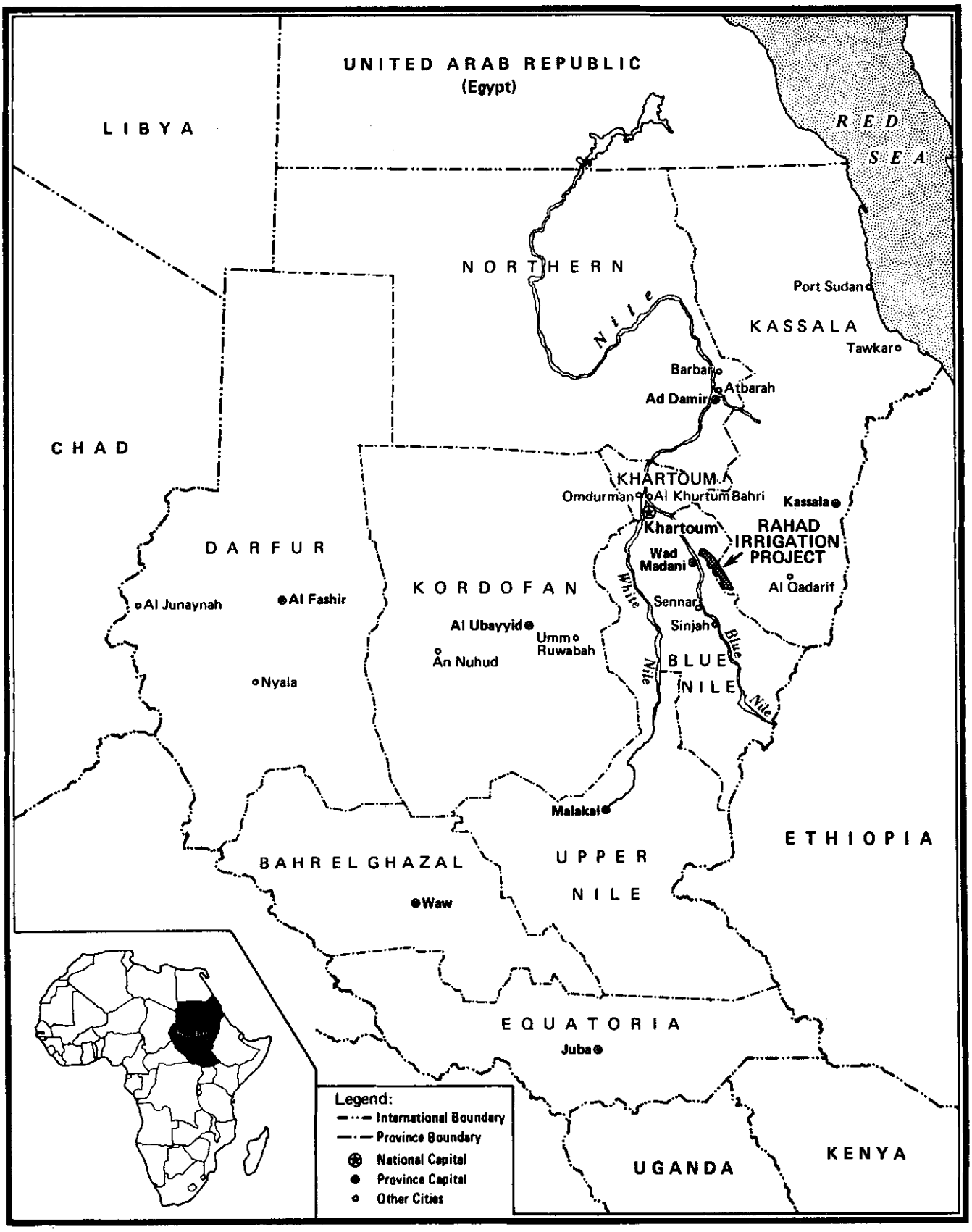
Weights and Measures

(metric and local units)

1 meter (m)	=	39.37 in.
1 kilometer (km)	=	0.62 miles
1 cubic meter (m^3)	====	35.31 cubic feet
1 milliard m^3	====	1,000 million m^3 (810,700 acre feet)
1 m^3/sec.	====	35.31 cubic feet per second (CUSEC)
1 kilogram (kg)	=	2.204 pounds (lbs)
1 metric ton (m ton)	=	2.204 lbs.
1 hectare (ha)	=	10,000 m^2 2.47 acre
1 square kilometer (km^2)	====	100 ha
1 feddan (fed)	=	1.04 acre 0.420 hectares
1 kantar (large)	=	312 lbs. of seed cotton
1 kantar (small)	=	99.05 lbs. of cotton lint
1 kantar	=	100 pounds (lbs)
1 large kantar/fed (kpf)	=	337 kg/ha (300 lbs/acre)
1 kg/fed	=	2.38 kg/ha (2.123 lbs/acre)
1 guffa	=	35 lbs. of seed cotton

Map 1

Location of Rahad Irrigation Project



I. Project Setting

A. Importance of public sector agricultural investments

During the past decade economic development has been the Sudan government's top priority. With an estimated 80 million acres of cultivable land and up to 120 million acres adequate for grazing, self sufficiency in many crops and export potential of others has guided government planning. By the mid-1970s the notion of Sudan as the "breadbasket of the Middle East" became an objective of Arab donors who were concerned about the prospects of a Western food embargo. Under President Jaafar al Numeiry public sector investments in transportation and agriculture have dramatically increased.

Sudan's agriculture and agricultural related industries account for 90 percent of total national employment. As a source of employment and income, and as a way of life, agriculture dominates long term national

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ılture utilizes nearly 85 percent of public investments and percent of export earnings, yet only generates 50 percent of government revenue. Government objectives include plans to intensify agricultural development through mechanizing irrigated and dryland farming. Plans include both increasing productivity in traditional farming systems and developing underutilized water resources and arable land.

B. Contribution of Irrigated Agriculture to Food Supply and Export Earnings

For many years irrigated agriculture has been the centerpiece of agricultural planning in the Sudan. Out of 16 million feddans (fed) of arable land fully one-quarter is under governmental and private irrigation schemes. Irrigated cotton alone accounts for nearly 60 percent of agricultural exports. Public investment in irrigated agriculture is envisaged as a means of generating substantially more government revenue through export crops. Such increased returns to the public sector are utilized in improving basic services and welfare in the disadvantaged rainfed areas of the country, thus furthering the goals of balanced equitable economic growth which is the basis of Sudanese agricultural policy.

The focus on mechanized irrigated agriculture has not been without serious difficulties. First, such mechanized production for cotton, for example, is expensive at an average cost of U.S. $833/fed. Second, the net foreign exchange benefit can be low because of the high import requirements of machinery and spare parts and the amortization of external loans. Third, shortages in fuel and in the availability of seasonal labor have added to both cost and problems of low performance of irrigated schemes. Current policy is to expand the area under irrigation by 1.4 million fed, a process for which extensive foreign assistance will be required along with major implications for already scarce local currency resources.

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C. Irrigated Agriculture and the Development of a Comprehensive Nile Water Use Policy

Sudan's most valuable agricultural land lies in the Nile Basin. Until 1959, the Gezira Scheme on the Blue Nile was the only major government gravity-fed irrigation scheme. Numerous private pumping schemes also utilized the waters of the Blue Nile. As a result of discussions to increase the area of irrigated cultivation, Egypt and Sudan in 1959 agreed to increase Sudan's share of the Nile from 4 to 18 milliard m^3. This decision led to the construction of the Roseires Dam with international funding in 1966. The impact of this dam was considerable. By increasing stored water to 3.9 milliard m^3, Sudan was able to (a) expand existing irrigated systems by 1.8 million fed and to eventually bring over seven million fed of new areas under cultivation. The Rahad Irrigation Project was one of a number of projects made possible by construction of the Roseires Dam leading to a more effective use of Nile waters.

D. Why Rahad?

The "Rahad area" is a 300 km long area on the east bank of the Rahad River possessing a number of optimum conditions which make it a prime site for use of the Blue Nile waters. Land was available with uniform topography and slope, good clay soils and with relatively little clearing required. Climate of low average rainfall meant few options to irrigation for more intensive use of the land. An indigenous population of 80,000 people with an unpredictable subsistence-based economy could be benefitted by more intensified cultivation. Lastly, the Rahad River, seasonal as a water resource, could serve as a supplementary source of irrigation water if waters of the Blue Nile were added to the Rahad River through a diversion supply canal. In general, the Rahad area had a high productive potential to use the Roseires water supply.

The basic rationale, therefore, for embarking upon what was to become a major investment (U.S. $400 million) for international donors and for the Government of Sudan included:

-- utilization of government investments in water diversion and storage works at Roseires;

-- to add the export value of medium staple cotton and groundnuts to the GNP;

-- an opportunity to improve further upon irrigation and agricultural technologies;

-- to increase the quantity, quality and value of domestically consumed crops;

-- to improve the welfare of an economically marginal population through an increase in their standard of living (income) and in housing, nutrition, health, education and corresponding changes in attitudes and values;

-- to provide employment for a national agricultural wage labor force; and

-- to provide employment for the Ministry of Irrigation permanent staff and equipment affected by a decline in public sector construction following the completion of the Roseires Dam.

E. Project Chronology

In 1961 the Ministry of Irrigation proposed a simple gravity flow supply canal from the Rahad River to an area east of the river. Due to the seasonal nature of the Rahad River (flow mid-July, flood by late September, and cessation of flow by end of November), such a canal would have had a limited value. Subsequent studies by 1964 changed the source to the Blue Nile and the crop to cotton requiring extended water availability. Sudan approached IDA* in 1965 for Rahad I, a 410,000 fed scheme as a first phaseof a 820,000 fed project. Prolonged discussions over gravity flow versus pumping for the water source led to a decision for the Sudan to independently proceed with the construction of a 190 km supply canal from the Blue Nile. Construction was shortly abandoned and for complicated reasons a decision was taken to change to an electric pumping scheme utilizing an 80 km supply canal which would produce benefits through completing the first part (southern section) one year earlier than the original gravity flow scheme. A proposal was submitted to IDA in 1971.

F. Pre-project Setting (See Annex B)

During the rather long period of conceptualization, a number of socio-economic studies were carried out to determine how and on what basis indigenous cultivators and semi-nomads would be recruited into the Project settlements as tenants (contract holding agriculturalists) and as resident laborers (non-tenants who could at some point obtain a tenancy). The Rahad Irrigation Project, as originally designed, targetted upon the issues listed above, namely, to improve the economic and social welfare of a disadvantaged marginal population. Specifically, an effort would be made to transform farmers dependent upon subsistence level production of rainfed sorghum, vegetables and other crops under rudimentary floodplain irrigation, and animal husbandry. These indigenous livelihoods would be left behind as farmers would be awarded non-mortgagable irrigated tenancies and instructed to grow cotton and groundnuts within a rather precise rotation system.

The irrigation system would provide for a guaranteed supply of water in place of a highly irregular pattern of rainfall. The Rahad Corporation, founded in 1972, would supply equipment, and productive inputs (seeds, fertilizers, insecticides, etc.) on a timely basis in exchange for the ever unpredictable sources of material and finance characteristic of subsistence systems. Government services would market production for the best prices possible guaranteeing that no crops would be left unmarketed.

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* IDA: International Development Association.

The Project would also attend to educational, health, domestic water supply and welfare requirements of a population hitherto unserviced or inadequately reached by State facilities and technical staff.

To accomplish these tasks, major investments would have to be made in terms of capital improvements for physical and social infrastructure, training of staff and tenants in new technologies and techniques of resource use, and above all the installation of a management system which could plan, implement, monitor and evaluate Project activities. The Project would deliver a relatively new way of life for the indigenous population at a rate of development which would make use of resources as quickly as possible. The Rahad Project was viewed as an inheritor of project experience gleaned from years of experience at Gezira and elsewhere. The Project would have a distinct advantage in avoiding the problems of the past, eg., full mechanization and intensive 100 percent rotation as a response to historical problems of inadequate labor supply and low production.

II. Project Description

A. Project Components

The Rahad Project begins almost 100 km away from the Project site in a small embayment on the Blue Nile 200 km downstream of the Roseires Dam. Here at the village of Meina a powerful electric pumping station lifts Nile water into a supply canal at a rate of 105 m^3/sec. From here the canal angles northwest toward the Dinder River where it passes under the bed of the river in an inverted siphon and continues on to the Rahad River where the 80 km canal discharges at a point seven km downstream of the town of Mafaza. One kilometer below the canal outfall is the Rahad Dam. The dam maintains a reservoir water level two meters above the normal flood level of this seasonal river. This is the beginning of the Rahad main canal, 90 km in length with a capacity of 100 m^3/sec. The supply canal feeds 800 km of major canals, 400 km of water courses and 4,500 km of farm laterals which eventually deliver Blue Nile water to furrowed fields and to farm channels feeding numerous basins. The total irrigated area is close to 300,000 fed of alluvial clay soils in an area 25 km wide and 160 km long located 160 km southeast of Khartoum.

The Project area as planned, will eventually consist of the town of El Fau and 46 villages housing up to 100,000 people. Presently there are 38 inhabited villages of which five are pre-existing villages. Villages 39-46 are scheduled for settlement in May 1981. Each completed new village will have, ideally, schools, a health facility, a filtered potable water system, necessary Corporation offices, staff housing, workshops, equipment yards, depending upon the administrative importance of the village. The Project area consists of three Group[1] level divisions, each of which contains five Block[2] divisions (See Map 4). Villages are connected by 80 km of all-

1 Group level: an area of 100,000 fed consisting of three Blocks.
2 Block level: an area of 30,000 - 35,000 fed.

weather spine roads and numerous dirt tracks throughout the area. A cotton ginning complex has been constructed at the Project headquarters of El Fau town. A demonstration agricultural research station and a seed nursery have been recently built.

The Project has been financed by IDA, The Kuwait Fund for Arab International Development, the Saudi Fund, the Arab Fund for Economic and Social Development, A.I.D. and the Government of Sudan. The cost of the project, as estimated in 1977 is LSd 145 million of which LSd 68 million is to be foreign currency. Cost overruns due to delays in construction have significantly increased the cost of the project.

As stated earlier, the goals of the Rahad Project, like other large-scale irrigation schemes managed by a parastatal organization, are both economic and social. If successful, the Project would eventually contribute to generating scarce foreign reserves. At the household level it would increase income and lessen the element of risk in income generation. Effective services would also improve the general quality of life through centrally managed facilities.

In accomplishing these targets it was assumed that the context of economic choice-making, namely the tenancy as a production system, would foster and sustain a high level of commitment and incentives. It was also assumed that tenants would respond well to elements such as full mechanization, a regimented cropping system and centralized management. Most importantly, it was assumed that the new and old populations of Rahad would experience a marked improvement in their economic and social well being through amenities, services and facilities hitherto inadequate or nonexistent.

In many respects, the Project is too new to measure all intended impacts. Villages in the southern part of the scheme have just completed the fourth production season and villages in the north have yet to bring in their crops for the first season. Full mechanization only exists in a few Blocks of southern Group I and mechanical cotton picking, an important impact issue, has yet to complete its first harvest. Rules, procedures, delivery systems and local institutions are new, so to speak still coated with packing grease and yet to be fully assembled.

A fundamentally important element of the Rahad Project is the production relationship embodied in the tenancy. The Rahad Corporation was established by legislation in 1972. Responsible to the Ministry of Agriculture, the Corporation manages the Project except for the operation and maintenance of the main irrigation and drainage systems which are under the Ministry of Irrigation.

From recruiting and settling tenants to their possible eviction due to failure to meet contract conditions, the Corporation maintains strict authority. It provides all agricultural inputs and markets and processes the cotton production. More than this, through controlled monitoring and sanctions it supervises what decision-making is to occur on each tenancy and assesses all costs against profits.

The tenancy is a non-mortgagable, non-transferable, 22 fed farming unit registered in the name of a single responsible individual. Full 100 percent intensive rotation of cotton (11 fed), groundnuts (8 fed) and fodder (3 fed) constitute the basis of the farming system. In addition to approximately 12,800 such tenancies, a second category of tenancy is a five fed vegetable/fruit tenancy. The number of these tenancies is uncertain. Livestock tenancies of 12 fed each amounting to a total of 1,296 fed are being created for meat and milk production. Provision was also made for a non-tenant resident laboring population. Theoretically 1/2 of the Rahad population would eventually fall in this category and constitute a labor pool for tenants. The production system is administered and supervised by a hierarchy of inspectors from village to group level. Distribution of Corporation income is based upon the "individual account system" wherein the tenant is assessed the full amount of imputed costs of production inputs, services, and partial water charges. The tenant receives as profits what remains when costs are deducted from gross product receipts.

III. Project Impacts: Findings and Analysis

A. Production Relationships

The production system as described above is based upon (a) the tenancy which establishes the limits of choice in what is grown and how it is produced, (b) the inspectorate system which guides, monitors and evaluates the level of production efficiency, and (c) the individual account which links outcomes of individual tenant efforts to Corporation variables such as product and input prices, water and machine charges. This system in one variation or another forms the basis of agricultural decision-making for most of the major state-controlled large-scale irrigation schemes in the Sudan.

Experiences with these irrigated systems have made Sudanese managers more aware of the delicate balance which must be achieved between pursuing economic goals of rationalizing mechanized production for export crops and providing for the improved welfare of an impoverished rural population. One of the most critical factors affecting the achievement of either objective is the level of individual and household incentive and commitment prevailing within the production system.

The Rahad Project, although only now completing its fourth production season in the southern part, exhibits many signs of conflict between the goals of productivity and equity and between corporate and individual aspirations. Unlike other schemes such as the Gezira - Managil Project, Rahad is moving sharply toward a policy of 100 percent intensive rotational cultivation and full mechanization of all field operations in cotton and groundnut production and major operations in horticulture. For the most part, with particular reference to cotton and groundnuts, the cultivator's sphere of decision-making has been reduced to activities such as minor equipment inputs, whether he will personally work in the fields or act as an agent of management in hiring labor, and what will be the quality of his

work when and if he is involved. In this context the tenant faces a dual role as a farmer and as an employee, with the latter role characterizing his involvement with cotton production.

With respect to cotton, as a tenant, his performance and outcomes raise some serious issues. In general, yields and thus subsequent income are lower than required to break even. This applies at the household as well as at the Corporation level. Cotton yields have declined from 6.3 kantar/fed in 1977/78 to approximately three kantars/fed in 1980/81. During the same period the area planted in cotton increased from 50,000 fed to 94,000 fed in 1980/81. The cost of production increased rapidly over the same period of time. For example, the nominal cost per fed of one cotton weeding increased from about LSd 25 in 1977/78 to LSd 110 in 1980/81. A Corporation plan to defer a water charge for three years was abandoned in an effort to recover costs. Although water is still subsidized by the Corporation (LSd 1.5 per irrigation/fed or LSd .85 less than actual cost), rising production costs in general in the face of disappointing world market prices for cotton translates into low or non-existent net returns for the tenant.

Low yields for cotton and erratic yields for groundnuts can be attributable to a host of problems which Rahad shares with other such schemes. Of major importance are problems related to agricultural machinery. These include: inadequate quantity of machinery and spare parts, inappropriate types of machinery for field conditions and poor timing in the delivery of mechanized operations. Admittedly, heavy rains have contributed to the late arrival of machinery but the critical problems are those of management and training of field operators. Other agricultural inputs including irrigation water, fertilizers, pest and weed control agents are also not delivered on a timely basis. The availability and cost of labor is very much a part of the background of why Rahad opted for early and full mechanization. Labor shortage is cited as an overriding reason why Rahad needed to fully mechanize its essential export crops--cotton and groundnuts.

Low incentives for growing cotton are reflected in the tenant's interest in groundnuts--where he is free to market outside the Corporation's auspices--and in his continued pressure on the Corporation to introduce sorghum into the rotation. Sorghum* is a major staple of the diet and was a predominant rainfed crop over the area the Project now occupies. The prohibition on sorghum within the Project has thrown many tenants onto the retail market where sorghum is available only at greatly inflated prices. Family labor is disproportionately applied to groundnuts owing to expectations of greater market returns. Also, tenant behavior on the five fed vegetable and fruit tenancies supports the contention that, given appropriate incentives and latitude of decision-making, tenants as

* Sorghum vulgare or dura

farmers can and do work in their fields with care and attention to agronomic possibilities and seek out market outlets for their production.

The inspectorate system is a critical element of the production system. From headquarters, to Group, to Block and down to the village level exists a hierarchical system of supervising personnel and tenant alike, of scheduling field operations and inputs, and of evaluating individual performance with certain rewards and definite sanctions. Furthermore, sanctions can and do lead to dismissal from a tenancy. In this latter fact the Rahad scheme is unique. While this system ideally serves both Corporation and tenant interests, representing tenant claims on the one hand and enforcing Corporation methods and procedures on the other, in practice it tends to be biased against tenant interests. The inspectorate system does little in terms of education and information for improved agricultural practices, as the field inspector is often inadequately trained for this difficult and often contradictory role. Moreover, the dual roles of the inspector as broker for management and as mediator for tenants and laborers weakens his effectiveness.

B. Income and Wealth

In many respects, the uniformity of the production system, the tenancy, serves as a leveling mechanism in terms of its fixed features. Income differentials occur mainly with respect to crops which are freely marketed and with assets in the form of animals or holdings outside of the scheme. Maximizing individual gains with cotton production is becoming increasingly difficult. In Block 1 during the 1979/80 season, of 1,379 tenants only 20 percent reputedly ran a positive profit margin. For these individuals gross receipts totalled LSd 360. For the remainder, cash advances were not adequate for field operations even after diverting off-farm income into cotton production. In the case of groundnuts gains were high when crops were privately sold. However, positive returns to the tenant resulted only when Corporation contributions were not repaid. In many cases, Corporation cash advances lagged behind cash needs related to operations forcing tenants to rely on money lenders to meet production costs. The volume of private loans has not been estimated but is widely practiced throughout the scheme. Villagers limited to assets derived from agriculture alone are, in many cases, in a worse manner than they were prior to joining the Scheme.

Almost all tenants and laborers maintain small herds of cattle, sheep and goats. Although animal husbandry has yet to be integrated into the rotation system, livestock are grazed within the scheme, on ranges peripheral to the scheme and, in many cases, in the vicinity of villages from which villagers originate. The added value of livestock to the income of tenants and laborers has not been calculated, although field interviews suggest as much as 30-40 percent of total income is so derived. The size of herds, the market prices of meat, and the proclivity to apply available cash profits to the purchase of animals as liquid capital suggest that animals provide needed alternative income and a cushion for periodic crop

failure. The majority of tenants maintained considerable herds in their original villages and many were semi-nomadic before settling on the Rahad Scheme. Without explicit Corporation policy, villagers have already devised means to integrate livestock into a crop rotation which is supposedly 100 percent intensive .

The original plan for the Rahad Scheme projected for each village a population of 300 tenants and 300 resident laborers. Although resident labor does not begin to approach 50 percent, certain villages do have a high percentage of non-tenants. These individuals, along with seasonal laborers who could amount to about 60,000 annually, perform hand labor tasks throughout the scheme. Wage rates are high due to an apparent labor shortage and tend to be constant except for times when tenants compete for scarce available sources. Resident labor during the cotton harvest can earn as much as LSd 200 to 500. Seasonal labor, also paid by amount picked, earns LSd 50-100 plus allowances of sorghum and other food. A number of tenants also enter the wage labor market as laborers on neighboring schemes.

Mechanized field operations have begun to displace labor, particularly in the southern Blocks where cotton picking machines have been introduced. The goal of full mechanization will reputedly leave sufficient work for the resident non-tenant labor force. Few individuals, however, have been able to either document labor scarcity or to quantify just how large of a labor force will be required. In terms of income, however, full mechanization or even something approaching effective mechanization, would affect the rate and direction of cash flow on the scheme. Without monied laborers, for example, merchants, marketeers and craftsmen would be adversely affected. There are relatively few off-farm employment opportunities at Rahad. Corporation personnel, ginning work force and construction crews consist largely of individuals from outside the scheme. As resident labor is affected by mechanization, new strategies will have to be devised to seek income from outside the scheme. Seasonal labor already has the word that Rahad is becoming mechanized and holds diminishing attraction for the future.

C. Labor and Employment

The availability of labor and the quality of hand labor versus mechanized operations are issues of major importance to irrigated schemes such as Rahad. The proliferation of large scale governmental agricultural schemes in underpopulated rainfed and irrigated areas over the past ten years has generated high demands for rural labor. During its first year of production in 1977/78, the Rahad Project ideally required 57,000 seasonal laborers to supplement tenant and non-tenant resident labor. Corporation efforts to recruit this level of additional labor failed due to communication problems, the shortage of transport vehicles and fuel, and perhaps relatively low wage rates. Problems have persisted and during each subsequent year the Corporation and tenants have had to face critical labor shortages despite increases in wage rates. Such increases seem not to be competitive enough in a national setting although they appear high for the tenant relative to returns on cotton.

As originally envisaged, the scheme was planned for 50 percent tenants and 50 percent resident labor. Resident labor falls well short of this goal forcing tenants to rely heavily upon outside seasonal labor. A second important factor is that many tenants, particularly those who were semi-nomadic prior to settling on the scheme, prefer not to work in their own fields. The lack of prior agricultural experience and the dislike for particular field operations such as cotton picking has generated extra labor demands. It might well be that the size of the tenancy, 22 fed, is too large for the average household size of five individuals (See Table 6). Corporation officials also believe that increased educational opportunities for children, particularly for boys, decreases the amount of effective available family labor.

The scheme now attracts about 50,000 to 60,000 seasonal laborers of whom 95 percent originate from the western regions of Kordofan and Darfur. In this sense, Rahad earnings do impact favorably on impoverished populations elsewhere in the Sudan. A typical laborer from weeding and cotton picking can earn up to LSd 125 over a three month period. Additional post-harvest work in clearing cotton stalks from the fields can add as much as LSd 66 for 33 fed of cotton. Although seasonal laborers receive some food from tenants, daily expenditures for a range of goods and services can total as much as 1/2 to 2/3 of daily earnings. Such laborers do not have access to educational and health facilities and often are encamped far from village standpipes of filtered water. Representation depends upon the degree to which laborers are organized. Group elected shaikhs and/or labor patrons often represent laborers in village councils and production committees when particular problems arise such as negotiating special wage rates. In general, it is a seller's market for labor and in such an atmosphere of competitiveness laborers have a distinct advantage in their relations with tenants.

Permanent resident labor maintains more extensive relations with tenants. Many such laborers are hopeful of eventually obtaining tenancies. Residing in the same village, tenants and resident laborer families enter into mutual aid relationships in activities such as house construction, field operations and in moments of family crisis. Such relations--nafir--transcend tribal and place of origin differences.

The key labor issue is that of displacement by mechanization. Rahad is to become as fully mechanized as possible, a policy assisted by recent A.I.D. grants under the commodity import program for the purchase of 50 cotton pickers with 50 more planned for fiscal year (FY) 1982. The basis of this policy is (a) perceived labor deficits and (b) higher yields through integrated mechanized operations. Tenant responses have been very mixed. For those tenants whose own labor is underutilized and who do not care to work with cotton production, mechanization lessens their responsibility for labor recruitment and supervision and possibly leads to lower input costs. Other tenants are extremely dissatisfied with the poor timing of mechanized inputs and with the quality of results of mechanized operations. These tenants claim that they are forced to rely upon an uncertain and expensive labor market despite newly introduced mechanization efforts. Many village leaders interviewed expressed unhappiness with the cotton picking machines because resident non-tenants were put out of work. In trying to make its policy of mechanization more effective, the

Corporation has not faced the need to develop agricultural labor policy. Under optimum mechanized conditions, a goal which will take time to achieve, there will be a need for hand labor. To what extent resident labor can fill this need is uncertain.

D. Welfare

The Rahad Project was designed with the provision of complete services and facilities in mind. A resettlement and social development fund attempted to provide, during the initial years of development, adequate funds to (a) relocate population, (b) prepare village sites, (c) extend funds to settlers to constuct a grass hut, and (d) provide an elementary school, "dressing station" (basic first aid and referral service), security and a filtered potable water supply for each village. Forty-six villages were envisaged, of which five villages would be existing villages incorporated into the scheme, encompassing an eventual population of 80,000 to 100,000 individuals. Village construction and settlement began in the south, a process which in fact transferred people from villages with relatively few services to villages with services. As the Project proceeded from south to north, capital development funds for social services began to dwindle. Recruitment continued apace despite the lack of local currency budgetary support. Contrary to the situation in the south, villagers were recruited from villages with services in the northern area of the scheme into new Project villages without basic services due to budgetary constraints.

The Corporation recognizes that tenant and laborer discontent stems not only from the trials and errors of the first one to two growing seasons but also from the expectations for family welfare which, for the moment, are unfulfilled. For existing villages which have been incorporated by the Project, the situation is also serious. Provincial government support for these villages has decreased on the assumption that the Corporation would look after the maintenance of services. In these communities, for example, school teachers normally receive salaries from the provincial government and allowances from the Corporation. A number of such teachers have left schools because (a) allowances have not been forthcoming and (b) they feel that they should not have to live in grass huts while colleagues in the southern villages live in better appointed quarters. Health facilities within the older villages also have experienced a diminution of provincial support which in any case was barely adequate. The Corporation faces a number of conflicts:

-- how to consolidate by making existing communities (in the south) function more effectively while honoring commitments to those being settled in unserviced northern villages;

-- how to turn over Corporation-financed social services to the provincial governments at a time when provinces are underfunded, (the Scheme straddles two provinces) within a year of completion;

-- how to retain existing services and meet their recurrent costs when the Corporation's scarce social development funds in terms of equity, should be used to complete the development of facilities throughout the Scheme; and

-- how to encourage village level self-help to make up for the short-fall in Corporation resources at a time when the Corporation's relationship to villagers is all encompassing and paternal.

The 1980/81 social development budget submission of LSd 3.2 million was cut to LSd 250,000 to meet salaries and operating costs of offices and vehicles only. An additional LSd 100,000 was allocated to complete services at the headquarters, El Fau, and one other village. Beginning with the new fiscal year, July 1, 1981, the Corporation intends to capitalize a social development fund of LSd 1 million derived from 2 percent of the Project's annual profits. This will be used to help narrow the gap between expectations and inadequate services although such improvements will do little in the near future to increase incomes.

Physical welfare in terms of nutritional status and morbidity/mortality indices has not been recorded. Although it is likely that the physical quality of life has not markedly improved in contrast to pre-project conditions, it is also clear that the Project as an irrigation system has not developed the classic problems of greatly increased incidences of schistosomiasis and malaria.

Social welfare in terms of educational attainment is obvious where schools exist by self-help or through the Corporation (See Map 5 for inventory of services). Although school enrollment data could not be collected for this study, it is clear that participation is high, albeit for boys as a rule. Female enrollment in mixed schools is low and there are only a few separate facilities for girls. The presence of a school says little about the quality of education. Generally, school teachers interviewed were dedicated individuals but were greatly concerned by the low quality of their quarters, the lack of school materials and supplies, the infrequency of their allowances, and the expense of living in villages dependent on the market. School attendance seems to have an impact on the size of family labor. In justifying full mechanization, the Corporation points to a diminishing supply of family labor and a concurrent increase in the dependency ratio due to increased participation in primary education.

E. Institutional Development for Decision-Making

The tenancy, inspectorate system and the individual account together constitute an integral institution with prescriptive rules and procedures. Within this institution, the cultivator has a narrow range of choice yet a full range of responsibilities. Through the field inspector, the tenant, on an individual basis, can make known his problems in cultivating his tenancy. There are, however, numerous occasions when the tenant, as a member of a community of tenants with common problems, needs to express his objectives to improve his position within the production system.

Local level decision-making within the context of the village community takes place through the village council, the Sudanese Socialist Union and the production council. Some of these institutions are new to villagers, others are a part of Sudanese rural life within a new setting--the Rahad Project. All represent the development of local government, a phenomenon

which is supported by the Government of Sudan and assisted by the Rahad Corporation.

Village councils exist throughout rural Sudan and are the inheritors of traditional forms of local leadership such as the sheikh. In their modern form, these councils are linked to provincial government through a hierarchy of rural and district councils. They existed in old villages in the Rahad area and with the assistance of the Commissioner of Rahad are being encouraged in both new communities and in existing communities annexed by the Project. Although hampered by a lack of a budget, such councils are encouraged to articulate community needs for services and, most importantly, to organize self-help activities. As discussed earlier, self-help is an increasingly important means of compensating for an inability of the Corporation to provide needed services. Within the context of the Rahad Project the village councils are faced with the dual task of exacting support from both provincial government and from Corporation management.

The production council in many ways is a more critical link between villagers as tenants and the prime source of resource allocation--the Corporation. Here the focus is on the production system itself. Complaints about resource use, pricing policy and economic returns are channeled through the council to the tenant's union, an executive body representing tenant interests throughout the scheme. In many respects the effectiveness of these institutions is greatly diminished by the low level of choice as an element in the tenancy system. None of the key agricultural operations are decentralized. Tenant recommendations and complaints continue to work against the background of central management knowledge, attitudes and practices. Decentralized operations involving equipment use, delivery of inputs, financing production and marketing output are absent. There is some discussion but little action concerning the need for cooperatives to handle activities related to crops that are less controlled than cotton. This process is impeded by the lack of an extension system which could provide training for cooperative endeavors and by a shortage of reasonable financial assistance.

As village and production councils struggle without funds and with a minimum of authority to identify and resolve problems, the Rahad Corporation, as an institution, faces problems of management as an effective agent of change. In a sense, the Corporation is not a new institution but a recent example of a parastatal organization. It was largely founded by the senior management of the Gezira Scheme who applied their experience in recreating the management structure of the Gezira. These administrators, where possible, attempted to improve upon the Gezira in areas such as mechanization and production relations. The problems of the Rahad Corporation in managing a technical and administrative staff, in attending to problems of training and adequate supervision and in maintaining an effective delivery system of facilities and services are, however, remarkably similar to the Gezira Scheme--a historical prototype.

F. Environmental Concerns

The Rahad Irrigation Scheme provides an early example of a large scale international development project which was subjected to an

ecological/environmental assessment by the donors during the project design stage and implementation. Environmental aspects of the project were examined by the World Bank, these findings were later reviewed and incorporated into the Project Paper prepared by A.I.D. (1973, Annex VIII). It should be noted that the ecological/environmental examination was prepared prior to the development of formal procedures for the environmental review of projects by the World Bank and A.I.D. The following environmental issues were identified as of potential concern at the time: (a) creation of vector habitat for water borne diseases (malaria, schistosomiasis), (b) management of agricultural chemicals (insecticides, herbicides, etc.) for crop protection, (c) health aspects of Alflatoxin (a fungus-related substance) on groundnuts and (d) disruption of migratory routes of native game to and from the Dinder National Park. Potential impacts on the Dinder Park were reviewed by the Game Department and technical experts provided by the United Nations Development Program (UNDP). These concerns were reviewed by the Government prior to the signing of the project agreements, which included a condition requiring the Government to develop a program for the control and treatment of schistosomiasis and malaria in the project area acceptable to the donors.

Project implementation resulted, as anticipated in the advance study, in the creation of significant environmental management problems with regard to the prevention of water-borne diseases and agricultural chemicals. Alflatoxin on groundnuts, as predicted in the advance study, did not develop into a problem due to the local techniques utilized in groundnut harvesting.

Direct negative impacts on Dinder National Park were significantly reduced by adoption of the option of supplying irrigation water by construction of a pumping station at Meina rather than by a gravity flow from Roseires Dam. This design change, made on the basis of economic evaluation, resulted in shifting the water supply canal to the north which greatly reduced disruption of native game migratory routes.

Previously unidentified secondary impacts, predominantly outside the area under jurisdiction of the Rahad Agricultural Corporation, include: (a) displacement of traditional nomadic herdsmen and their livestock, resulting in displacement of native game and overgrazing in areas adjacent to the water supply canal and irrigated area; (b) creation of a market for wood (for structural and fuel use) and charcoal with resulting localized degradation of available resources adjacent to the development area; and (c) creation of an incremental increase in development pressure on Dinder National Park through items (a) and (b) above. Unanticipated environmental benefits of the project include (a) the creation of extensive bird habitat in the irrigated area; (b) creation of fish habitat in the irrigation canal system; and (c) a reduction of grazing pressure from traditional nomadic herdsmen within the Es Souki Irrigation Scheme and adjacent non-irrigated lands.

The Rahad Irrigation Project represents a case where despite the identification and recognition of the major environmental problems in advance by the donors and host country, the Project design and implementation plan was unsuccessful in addressing these problems through effective mitigation measures. Notable success has been achieved in the

reduction in the incidence of malaria and in the prevention of the spread of schistosomiasis within the Project area, however, this has been principally the result of timely external intervention of the Blue Nile Health Project (World Health Organization/Government of Sudan (WHO/GOS)) rather than as the result of project design. The limited development of an institutional capability within the Project area to: (a) control water-borne diseases; (b) provide for environmental sanitation; and (c) assure the safe supply of potable water have been most noteworthy and problematic.

The failure of the initial environmental analysis to review systematically crop protection techniques and alternatives resulted in a long term commitment to large scale chemical control in the project area. Use of agricultural chemicals in the project area is extremely high and represents a major element of production cost (approximately 30 percent for the 1980-1981 production year) which is principally a foreign exchange cost. During the recent growing season most cotton fields were treated 11 times with aerially-applied insecticides; tractor-applied herbicides were used to control weeds, while areas to be mechanically harvested were treated two times with aerially-applied defoliants. Horticultural plots were treated with insecticides and fungicides on an individual basis by tenants utilizing knapsack sprayers.

The extensive utilization of agricultural chemicals in the project area presents a special public health problem in terms of direct/indirect exposure of crop protection personnel and agricultural workers. Application of agricultural chemicals in addition presents concerns relating to (a) maintenance of safe potable water supplies, (b) impacts to livestock and (c) impacts to aquatic ecosystems, especially fish in the canals. Improper storage of chemicals also poses a hazardous situation.

The Rahad Irrigation Scheme represents an excellent opportunity to examine the rapidly evolving "state of the art" in the ecological/environmental assessment of large scale development projects and provides for analysis of techniques for the implementation of environmental design and mitigation components. The Project clearly illustrates the existing gap between the ability to identify environmental problems and to successfully design solutions to them. It should be noted that the critical environmental problems of the Project have resulted from the inability of the Corporation and Government of Sudan to institutionally manage them and inadequate allocation of capital/operational funds to the responsible organizations.

G. Sustainability of the Production Model

The durability of the production system followed at the Rahad Scheme will largely depend upon the social and economic viability of production relationships viewed at the level of the household. Where the Project has fallen short of meeting macro-economic objectives it has in many cases provided improved economic welfare for families which hitherto had survived at the margin of economic well being. For other tenants less interested in cotton production, the tenancy has provided a base around which multiple income generating strategies are employed, eg. animal husbandry, wage labor, commerce. Although data are inconclusive, horticultural tenancies are also beginning to show some positive signs of profitability.

There are a few obvious areas where Corporation efforts can greatly affect the level of tenant satisfaction. First, sorghum, a mainstay in the rural Sudanese diet, should be introduced into the rotation system in a three fed allotment. Before the Project, sorghum was grown throughout the Project area. Although yields varied due to irregular rains, each family could rely on enough sorghum to tide them through each agricultural season. Sorghum today is no less a necessity but is no more a part of the household's production system. Restoring sorghum into the subsistence system would help to elevate a flagging commitment to remaining with the Rahad tenancy.

Second, the rotation system could be modified even further to develop a policy of integrating livestock into the agricultural cycle. Each family maintains livestock despite a 100 percent intensive crop rotation system through an intricate set of agreements with fellow tenants for grazing areas.

Despite the intensity of livestock within the scheme, which probably exceeds provincial average densities by several fold, there is, as yet, no explicit policy to help develop dairy and meat production and marketing cooperative activities. Tenants have demonstrated that it is not antithetical to the existing production system to keep livestock, but they have yet to convince Corporation management that livestock could become an integral part of the production system.

Third, again within the production system, tenants are orienting groundnut production toward private markets. Groundnut marketeers have been able to offer an attractive market alternative to the Corporation. Corporation advances, however, are not being repaid due to the Corporation's inability to control groundnut sales. A modified policy of cost recovery for groundnuts, e.g., enforcement of sanctions for non-payment of advances, coupled with an encouragement for private marketing could also serve to increase the incentive system of tenants.

Fourth, the tenant as villager is experiencing a serious problem with the low quality and/or lack of services such as education, health, home economics education, skills training, etc. Although certain services have been constructed and staffed in the southern part of the scheme, more than 1/2 of the villages lack necessary services at a time when the Corporation also lacks capital improvement funds. Tenants and non-tenants alike were recruited to the scheme on the assumption that full community services were, or would shortly be, available to all residents. As pointed out earlier, many villagers came from well serviced communities only to face deficits and disappointments in their new settings. For many, frustrated expectations for a reasonable level of quality of life reinforce already low commitment to and discontent with the Project as a way of life. More than anyone, the Corporation is aware of the relationship between tenant dissatisfaction with services and agricultural efficiency.

The Rahad Project area constitutes not only an agricultural system but a socio/cultural community. Agricultural pursuits account for only a segment of overall community objectives and needs. A diversified economy including sufficient off-farm employment, a range of individual skills which entail artisan, mercantile, and administrative functions, a rich religious, political and educational life will all be required to develop a

psychological sense of belonging to Rahad as a community rather than as a wage employer. Sustainability refers not only to the production model and the making of a social class called "tenants", e.g., a group of cultivators who recognize common bonds and interests between themselves and with the Corporation whose interests might or might not be the same. Sustainability will also be a reflection of the permanency of the population, the attitudes of a second generation of tenants and non-tenants and the initiative shown in improving community welfare through the voluntary investment of community resources.

IV. Lessons Learned

1. More analysis needs to be applied to the economic and practical problems involved with 100 percent mechanization as a management policy. The present world inflation and resulting rising cost of inputs, and logistical support have contributed, to a large extent, to the low marginal returns to the production of cotton. An effective economic planning unit could help by collecting and analyzing data that would give a clear picture of cost relationships. Such analysis could also show the impact of alternative combinations of labor and mechanization.

2. An extensive training program for training of an agricultural engineering staff should have been initiated at least one year before the projected date for the delivery of machinery. It is apparent that most of the problems with the delivery of machine services originate from inadequately trained staff.

3. More supervisory positions are needed at the Block and field level. Farmers complained of the quality and timeliness of the mechanization input. The Block level agricultural engineer is asked to supervise the machinery input for a 30,000 acre farm with insufficient numbers of supervisory staff to assist him.

4. The tenant farmer has little role in the decision-making process, contributing to low production efficiency. In order that the farmer develop his managerial skills, he should have been included in the planning process from the beginning. "Top down" farm management structures sacrifice the benefit of critical knowledge inputs from practicing husbandmen. In other words, tenants and members of other collective schemes will opt for "tending their gardens" rather than following officially established incentive systems.

5. As a corollary to the production lesson, scope for choices is indispensable to small farmers in order that they may maximize net income. Husbandry tasks must be carried out by people who have a stake in the outcome and who understand the local conditions of production.

6. Labor shortage at "peak harvest" should be viewed relative to prevailing wage rates. The well-being of labor, particularly that of available resident labor, in the short run should be carefully considered prior to pursuing a mechanization process. Mechanized cotton picking, subsidized in price, does not appear justified on economic or social grounds. A labor policy should be developed for resident labor who are adversely affected by both increasing mechanization and the introduction of non-resident labor.

7. There is a need to establish a social development unit at the Rahad Project to improve planning and monitoring of community-based activities such as health, education, welfare and other basic services. Such a unit, adequately funded with a small share of the Corporation's profits from general cotton shares, could meet many community needs which presently are not met. Demographic analysis and community needs assessment are two critical tasks which require Corporation attention.

8. There is a need to conduct and utilize comprehensive environmental analysis in the design and implementation of irrigation projects for the examination of both direct and indirect impacts. The analysis should be developed on the basis of field examination and literature review. The involvement of host country experts and institutions should be sought to the fullest extent reasonable. Analysis should examine programmatic and technical alternatives to the proposed project and identify realistic and implementable mitigation (corrective) activities. Institutional requirements and capital/recurrent costs should be critically reviewed when examining alternatives or proposing mitigations. Provisions and funding should be included in project design for environmental monitoring and evaluation.

9. Especially in the case of multiple donor financed projects a specific delegation of authority and responsibility for oversight of environmental concerns should be made to a specific host country technical organization/specific donor or to a joint technical committee. The responsible party should assure that environmental concerns are addressed in the course of project implementation, that monitoring is adequately conducted and that interim evaluations are utilized in fine tuning the project. Financial responsibility for environmental mitigation activities, in terms of capital and recurrent costs should be clearly specified in project documentation. Technical assistance and training provided by donor organizations should be selected on the basis of appropriate organizational experience or predominate capability of international/national institutions.

10. Preventative programs for the control of water-borne diseases for capital and operational costs must be coordinated in the project design process and directly funded by the project. Programs must be carefully designed in coordination with authorities responsible for (a) public health, (b) irrigation system design, (c) settlement siting and development, (d) potable water supply, (e) crop protection and (f) aquatic weed control. Foreign exchange costs should be carefully reviewed to assure they are adequate for the provision of necessary inputs for project success. Critical inputs include the procurement of drugs, control chemicals, application equipment, support vehicles (including spare parts and maintenance), technical training and advisory services. Administrative capability and the provision of funding for interrelated activities should be recognized as the major constraint to successful implementation of control programs in the face of dual Corporation/province authority for the provision of public health services.

11. There is a need to review systematically crop protection techniques prior to the design and implementation of irrigation projects. Feasible alternatives to tradtional chemical control techniques based upon an integrated pest management strategy (biological control, crop hygiene, crop

rotation, etc.) should be critically examined for each pest/crop by a select technical committee composed of representatives of both host country and donor organizations. Specific crop protection/pest control research and experimentation programs to address both short and long term needs should be identified. It is recommended that such programs be integrated directly into the project design and be funded either directly as a project component or as a complementary project/subproject. Crop protection authorities should coordinate closely with project economic research units to conduct evaluations of cost effectiveness of alternative techniques of crop protection.

12. Crop protection programs must be designed and implemented with the full coordination and assistance of public health and potable water supply authorities to assure the safety of specialist personnel, agricultural workers and human water supply. Public health authorities should be supplied, by the crop protection authority on a regular basis, information of agricultural chemicals currently in use, descriptions of their clinical symptoms and recommended antidotes. It is also necessary to design crop protection programs in coordination with the assistance of authorities responsible for animal production, fisheries and aquatic weed control to minimize direct and indirect impacts on these biological systems. Coordination must be institutionally designed within the context of the project and if necessary required under conditions in the loan/grant agreement with the host country.

Supporting Materials

I. Summary Tables on Scheme

Table 1. Summary of Settlements in the Project Area.

Table 2. Summary of Social Services in the Project Area.

Table 3. Summary of Tenancies and Estimated Population in the Project area.

Table 4. Permanent Government Employees in El Fau.

Table 5. El Fau Market, Inventory of Enterprises and Employees (February 1981)

Table 6. Demographic Survey Data, Villages 4 and 16 (1980)

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TABLE I. SUMMARY OF SETTLEMENTS IN THE PROJECT AREA

Settlement (Village No.)	Status	Location Group	Location Block	Common Name	Tribal Affiliations	Date of Settlement	Date Initi Produc	Type of Government Organization
el Fau	Project Headquarters	-	-	el Fau	Corporate Staff, various tribes	1976	-	Local Government System, Regional Rural Council, People's Local Council
1	-	South	1	El Sharfa	Kenana Mix	4/1977	7/1977	Village Council, Production Council
2	-	South	1	Wad Awad	Kawahla	4/1977	7/1977	Village Council, Production Council
3	Block Headquarters	South	1	Tenedba	Eshraf Galeen Masalama Falata	4/1977	7/1977	Village Council, Production Council
4	-	South	1	Lwisa	Agateen Arakeen	4/1977	7/1977	Village Council, Production Council
5	-	South	1	Nur Eldin	Arakeen Falata Agaleen Rofaieen	4/1977	7/1977	Village Council, Production Council
6	_	South	2	Elheriej	Debaseen	4/1977	7/1977	Village Council, Production Council
7	-	South	2	Wad Elkahom	Gallen Kawahla Mix	4/1977	7/1977	Village Council Production Council
8	-	South	2	Abu Eshish	Shukria Kawahla	4/1977	7/1977	Village Council, Production Council
9	-	South	2	Malik	Galeen	4/1977	7/1977	Village Council, Production Council

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10	Group Head- and Block Head- quarters	South	2	New Elmafaza	Galeen, Kawahla	4/1977	7/1977	Village Council, Production Council
11	_	South	3	Wad Eshran	Shukria Debaseen	4/1977	7/1977	Village Council, Production Council
12	-	South	3	Khatmia	Rekakia mix	4/1977	7/1977	Village Council, Production Council
13	Block Head- quarters	South	3	El Sherief	Ashef	4/1977	7/1977	Village Council, Production Council
14	-	South	3	El Doma	Rekakia	4/1977	7/1977	Village Council, Production Council
15	-	South	3	Sharab	Shukria	4/1977	7/1977	Village Council, Production Council
16	-	Middle	4	Elbania	Rekabia	4/1977	7/1977	Village Council, Production Council
17	-	Middle	4	Elbowdra	Shukria Masalamia Ashraf	4/1977	7/1977	Village Council, Production Council
18	Block Head- quarters	Middle	4	Aloka	Rekadia	4/1977	7/1977	Village Council, Production Council
19	-	Middle	4	Khairi	Halaween	4/1978	5/1978	Village Council, Production Council
20	-	Middle	4	Elregail	Lahaween Kawahla	4/1978	5/1978	Village Council, Production Council

21	-	Middle	5	Aen Elewega	Kawahla, Galeen	old	5/1978	Production Council
22	-	Middle	5	Wad Elmadeh	Kawahla	old	5/1978	Production Council
23	Group Head-quarters and Block Head-quarters	Middle	5	23	Kawahla, Rufaahn	4/1978	5/1978	Production Council
24	-	Middle	5	Elmasarhen	Daberia, Lahaween, Shukria	old	5/1978	Production Council
25A	-	Middle	5	Babanosa	Ashraf, Galeen	old	5/1978	Production Council
25B	-	Middle	5	Sherif Yagub	Masalmia, Galeen, Agleen, Shukria, Kawahla	old	5/1978	Production Council
26	-	Middle	6	26	Galeen, Fadnia, Shukria, Galeen, Masalmia	4/1978	5/1978	Production Council
27	Block Head-quarters	Middle	6	27	Masalmia, Kawahla, mix	4/1978	5/1978	Production Council
28	-	Middle	6	Gaafra	Gaafra, Kawahla, Takbab	4/1978	5/1978	Production Council
29	-	Middle	6	29	Shukria mix	4/1978	5/1978	Production Council
30	-	Middle	6	30	Shukria, Bataheen, Agleen	4/1978	5/1978	Production Council

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31	-	North	7	Gefara	Shukria, Lahwin, Masalema, Arakeen, Ashraf	5/1980	5/1980	Temporary Production Council
32	-	North	7	Rogwa	Shukria, Masalama, Halawin, Arakeen	4/1980	5/1980	Temporary Production Council
33	Block Head-quarters	North	7	Grabih	Kawahla, Shukria	5/1980	5/1980	Temporary Production Council
34	-	North	7	34	Shukria, Kawahla, Ashraf	4/1980	5/1980	Temporary Production Council
35	-	North	7	Mehela	Galeen	4/1980	5/1980	Temporary Production Council
36	-	North	8	Amara	Galeen, Shukria	4/1980	5/1980	Temporary Production Council
37	-	North	8	Awlad Awn	Kakakesh, Galeen, Shukria, Rekabia	4/1980	5/1980	Temporary Production Council
38	-	North	8	38	Arakeen, Bataheen	4/1980	5/1980	Temporary Production Council
39	-	North	8	39	Not settled			
40	Group Head-quarters	North	8	40	Not settled			
42	-	North	9	Wad Elobeid	Ashaf	old	planned 7/1981	
42A	-	North	9	Dahwi		old	planned 7/1981	

Table 1-4

42 B	-	North	9	Rogwa	old	planned 7/1981
43	-	North	9	Teiba	old	planned 7/1981
44	Block Head-quarters	North	9	Abdella	old	planned 7/1981
45	-	North	9	El Nagi	old	planned 7/1981
46	-	North	9	Falg	old	planned 7/1981

Source: Data compiled from Social and Economic Research Unit, Rahad Agricultural Corporation

Table 1-5

TABLE 2 . SUMMARY OF SOCIAL SERVICES IN THE PROJECT AREA

Settlement (Village No.)	Schools	Health Services	Water Supply	Market Place	Other
el Fau	2 mixed primatry schools 1 Elementary School for Girls 1 General Secondary School School	Hospital (60 beds) and Dispernsary	Water Treatment Plant, Household Connections, Public Supply	General Market (see Table 5), Animal Market	Police Station, Post Office Cooperative Shop, Flour Mill
South Group Block 1					
1	Mixed Primary School	Dressing Station	Slow Sand Filter, Public Standpipes	-	
2	Mixed Primary School	Dispensary	Slow Sand Filter, Public Standpipes	Market	
3	Mixed Primary School	Dispensary	Slow Sand Filter, Public Standpipes	Market	
4	Mixed Primary School	Dressing Station	Slow Sand Filter, Public Standpipes	Market	
5	Mixed Primary School	-	Slow Sand Filter, Public Standpipes	-	
Block 2					
6	Mixed Primary School	Dressing Station	Slow Sand Filter, Public Standpipes	-	
7	Mixed Primary School	Temprorary Dressing Station	Slow Sand Filter, Public Standpipes	-	
8	-	Temporary Dressing Station	Artesian Well, Public Standpipes	-	
9	Mixed Primary School	Dressing Station	Slow Sand Filter, Public Standpipes	-	
10	2 Primary Schools (Boys/Girls) 1 Secondary School (Boys)	Health Center, working as a Dispensary	Slow Sand Filter, Public Standpipes	General Market, Animal Market, Crop Market	Temporary Police Headquarters for Flour Mill

Table 2-2

Block 3					
11	Mixed Primary School	Dressing Station	Slow Sand Filter Public Standpipes	-	
12	-	Temporary Dressing Station	Slow Sand Filter, Public Standpipes	-	
13	2 Primary Schools (Boys/Girls)	Dispensary	Slow Sand Filter, Public Standpipes	Market	
14	Mixed Primary School	Temporary Dressing Station	Slow Sand Filter, Public Standpipes	-	
15	Mixed Primary School	Dressing Station	Artesian Wells, Public Standpipes- to be converted to Slow Sand Filter	-	
Middle Group Block 4					
16	Mixed Primary School	Dressing Station	Slow Sand Filter, Public Standpipes	-	
17	-	-	Slow Sand Filter, Public Standpipes	-	
18	Mixed Primary School	Dispensary	Slow Sand Filter, Public Standpipes	Market	
19	Mixed Primary School	Dressing Station	Slow Sand Filter, Public Standpipes	-	
20	-	-	Slow Sand Filter, Public Standpipes	-	
Block 5					
21	Mixed Primary School	Dressing Station	Artesian Well, Public Standpipes	-	
22	Mixed Primary School	Dressing Station	Artesian Well, Public Standpipes	-	
23	Mixed Primary School	Dispensary, Planned to be Health Center	Artesian Well, Public Standpipes	General Market, Animal Market, Crop Market	Flour Mill

Table 2-3

24	Mixed Primary School	Dressing Station (Preproject)	Artesian Well, Public Standpipes	-
25A	Mixed Primary School	Self Help Dressing Station Under Construction	Artesian Well, Public Standpipes	-
25B	2 Mixed Primary Schools 2 Elementary Schools (Boys/Girls) (All Preporject)	Dispensary (Preproject)	Artesian Well, Public Standpipes	-
Block 6				
26	-	Temporary Dressing Station	Slow Sand Filter, Public Standpipes	-
27	Mixed Primary School	Dressing Station, Dispensary (Under Construction)	Slow Sand Filter, Public Standpipes	Market
28	-	Temporary Dressing Station	Slow Sand Filter, Public Standpipes	-
29	-	Temporary Dressing Station	Slow Sand Filter, Public Standpipes	-
30	-	Temporary Dressing Station	Slow Sand Filter, Public Standpipes	-
North Group Block 7				
31	-	Temporary Dressing Station	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	-
32	-	Temporary Dressing Station	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	-

Table 2-4

33	School Under Construction	Dressing Station (will be upgraded to dispensary)	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	Market	
34	-	-	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	-	
35	-	-	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	-	
Block 8					
36	-	Temporary Dressing Station	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	-	
37	-	Temporary Dressing Station	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	-	
38	-	-	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	-	
39	-	-	From Canal (Slow Sand Filter and Public Standpipes Under Construction)	-	
40	-	Temporary Dressing Station (will be upgraded to Health Center)		Market	

Table 2-5

Block 9				
41	2 Primary Schools (Boys/Girls) (Preproject)	Dispensary (Preproject)	Artesian Wells (Public Standpipes Under Construction)	-
42A	-	-	Artesian Wells (Public Standpipes Under Construction)	-
42B	-	-	Artesian Wells (Public Standpipes Under Construction)	-
43	-	-	Artesian Wells (Public Standpipes Under Construction)	-
44	3 Schools (Preproject)	Dispensary (Preproject)	Artesian Wells (Public Standpipes Under Construction)	-
45	Mixed Primary School (Preproject)	Dressing Station (Preproject)	Artesian Wells (Public Standpipes Under Construction)	-
46	Mixed Primary School (Preproject)	Dressing Station (Preproject)	Artesian Wells (Public Standpipes Under Construction)	-

Source: Data Compiled from Social and Economic Research Unit, Rahad Agricultural Corporation

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TABLE 3. Summary of Tenancies and Estimated Population in the Project

Settlement (Village No.)	Government Employees	Cotton Groundnut Tenancies	Horti-cultural Tenancies	Estimated Tenant Population	Estimated Resident Non-Tenant Population	M: L: (1	:y :r	Estimated Resident Population (1981)
El Fau	3780	None	None	None	None	None		15,000
South Group								
Block I						2,340		
1	-	361	17	1,890	1,890	-		3,780
2	-	243	17	1,300	1,300	-		2,600
3	-	310	34	1,720	1,720	-		3,440
4	-	212	17	1,145	1,145	-		2,290
5	-	252	17	1,345	1,345	-		2,690
Subtotal	-	1,378	102	7,400	7,400	2,340		14,800
Block 2								
6	-	215	17	1,160	1,160	-		2,320
7	-	262	17	1,395	1,395	-		2,790
8	-	371	17	1,940	1,940	-		3,880
9	-	215	17	1,160	1,160	-		2,320
10	15	316	34	1,750	1,750	-		3,500
Subtotal	Profes-sional 15	1,379	102	7,405	7,405	1,519		14,810
Block 3								
11	-	248	17	1,325	1,325	1,208 -		2,650
12	-	248	17	1,325	1,325	-		2,650
13	-	266	17	1,415	1,415	-		2,830
14	-	169	34	1,015	1,015	-		2,030
15	-	271	17	1,440	1,440	-		2,880
Subtotal	15	1,222	102	6,620	6,620	1,208		13,240
Total South	15	3,979	306	21,425	21,425	5,067		42,850

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Table 3-2

Middle Group						2,136	
Block 4							
16	-	268	17	1,425	1,425	-	2,850
17	-	345	17	1,810	1,810	-	3,620
18	-	218	34	1,260	1,260	-	2,520
19	-	390	17	2,035	2,035	-	4,070
20	-	317	17	1,670	1,670	-	3,340
Subtotal	-	1,538	102	8,200	8,200	2,136	16,400
Block 5						3,973	
21	-	303	17	1,600	1,600	-	3,200
22	-	115	17	660	660	-	1,320
23	15 Profes-sional	239	34	1,365	1,365	-	2,730
24	-	231	17	1,240	1,240	-	2,480
25A	-	267	17	1,420	1,420	-	2,840
25B	-	152	17	845	845	-	1,690
Subtotal	15	1,307	102	7,130	7,130	3,973	14,260
Block 6						None	
26	-	235	17	1,260	1,260	-	2,520
27	-	375	34	2,045	2,045	-	4,090
28	-	290	17	1,535	1,535	-	3,070
29	-	290	17	1,130	1,130	-	2,260
30	-	228	17	1,225	1,225	-	2,450
Subtotal	-	1,337	102	7,195	7,195	-	14,390
Total Middle Group	15	4,182	306	22,525	22,525	6,109	45,050

North Group						1,915	
Block 7							
31	-	299	17	1,580	1,580	-	3,160
32	-	231	17	1,240	1,240	-	2,480
33	-	191	34	1,125	1,125	-	2,250
34	-	201	17	1,090	1,090	-	2,180
35	-	200	17	1,085	1,085	-	2,170
Subtotal		1,122	102	6,120	6,120	1,915	12,240
Block 8						947	
36	-	284	17	1,505	1,505	-	3,010
37	-	289	17	1,530	1,530	-	3,060
38	-	279	17	1,480	1,480	-	2,960
39	-	278	17	1,475	1,475	-	2,950
40	15 Professional	382	34	2,080	2,080	-	4,160
Subtotal	15	1,512	102	8,020	8,020	947	16,140
Block 9							
41	-	167	17	460	460	-	920
42 (A&B)	-	176	17	925	925	-	1,850
43	-	Shared with village 41	Shared with village 41	460	460	-	920
44	-	318	34	1,760	1,760	-	3,520
45	-	202	17	547	547	-	1,094
46	-	Shared with Village 45	Shared with Village 45	547	547	-	1,094
Subtotal	15	863	85	4,699	4,699	-	9,398
Total North Group	3,825	3,497	289	18,839	18,839	2,862	37,778
GRAND TOTAL		11,658	901	62,789	62,789	14,038	140,578

Source: Data compiled from Social and Economic Research Unit, Rahad Agricultural Corporation

Table 3-3

TABLE 4. Permanent Government Employees in el Fau

A.	Rahad Agricultural Corporation	
	Senior Management	4
	Administration	6
	Agricultural Experts	81
	Engineers	10
	Agriculturalists	22
	(Shampot High Institute/Graduates)	
	Officials	758
	Ginnery	136
	Skilled Labor	1102
	Unskilled Labor	1291
B.	Rural Council	50
	(teachers, police, etc.)	
C.	Ministry of Irrigation	200
D.	Ministry of Public Works	120
	TOTAL	3780

Source: Social and Economic Research Unit, Rahad Agricultural Corporation

TABLE 5. El Fau Market, Inventory of Enterprises and Employees* (February 1981)

Type of Enterprise	Number of Shops	Number of Employees	Number Employed in Type of Enterprise
Restaurant	6	6	36
Barber Shop	2	3	6
Dry Goods	12	5	60
Shoe Makers	8	1	8
Produce Sellers	8	2	16
Meat Sellers	7	4	28
Flour Mill	1	3	3
Bakeries	2	10	20
Bread Sellers	4	1	4
Other	5	1	5
TOTAL	-	-	186

* All employees in the market are currently living within its confines and have not secured permanent housing.

Source: Field Survey Data collected by AID Impact Team.

TABLE 6. Demographic Survey Data, Villages 4 and 16 (1980)

	Number of Households			Average Age, Head of Household		Average size of Household	
	Tenant	Non-Tenant	Total	Tenant	Non-Tenant	Tenant	Non-Tenant
Village 4 South Group Block 1	227	3	230	37.7	--	5.00	--
Village 18 Middle Group Block 4 (Block Headquarter)	358	185	543	38.7	33.1	4.89 (5.04)*	3.44 (3.90)*

	Number of Unmarried Head of Households		Average Number of Dependents Per Household		Population		
	Tenant	Non-Tenant	Tenant	Non-Tenant	Tenant	Non-Tenant	TOTAL
Village 4	5	1	--	--	1137	6	1143
Village 18	21	48	.14	.45	1805	722	2527

Source: Compiled from raw data of the Social and Economic Research Unit, Rahad Agricultural Corporation.

* Includes dependents

SUPPORTING MATERIALS

II. Maps*

Map 2 General Map of the Rahad Irrigation Project

Map 3 Map of Infrastructure and Settlements in the Rahad Irrigation Project

Map 4 Map of Administrative Units in the Rahad Irrigation Project

Map 5 Map of Distribution of Schools in the Rahad Irrigation Project

Map 6 Map of Distribution of Public Health Services in the Rahad Irrigation Project

Map 7 Map of Distribution of Village Water Supply Systems in the Rahad Irrigation Project

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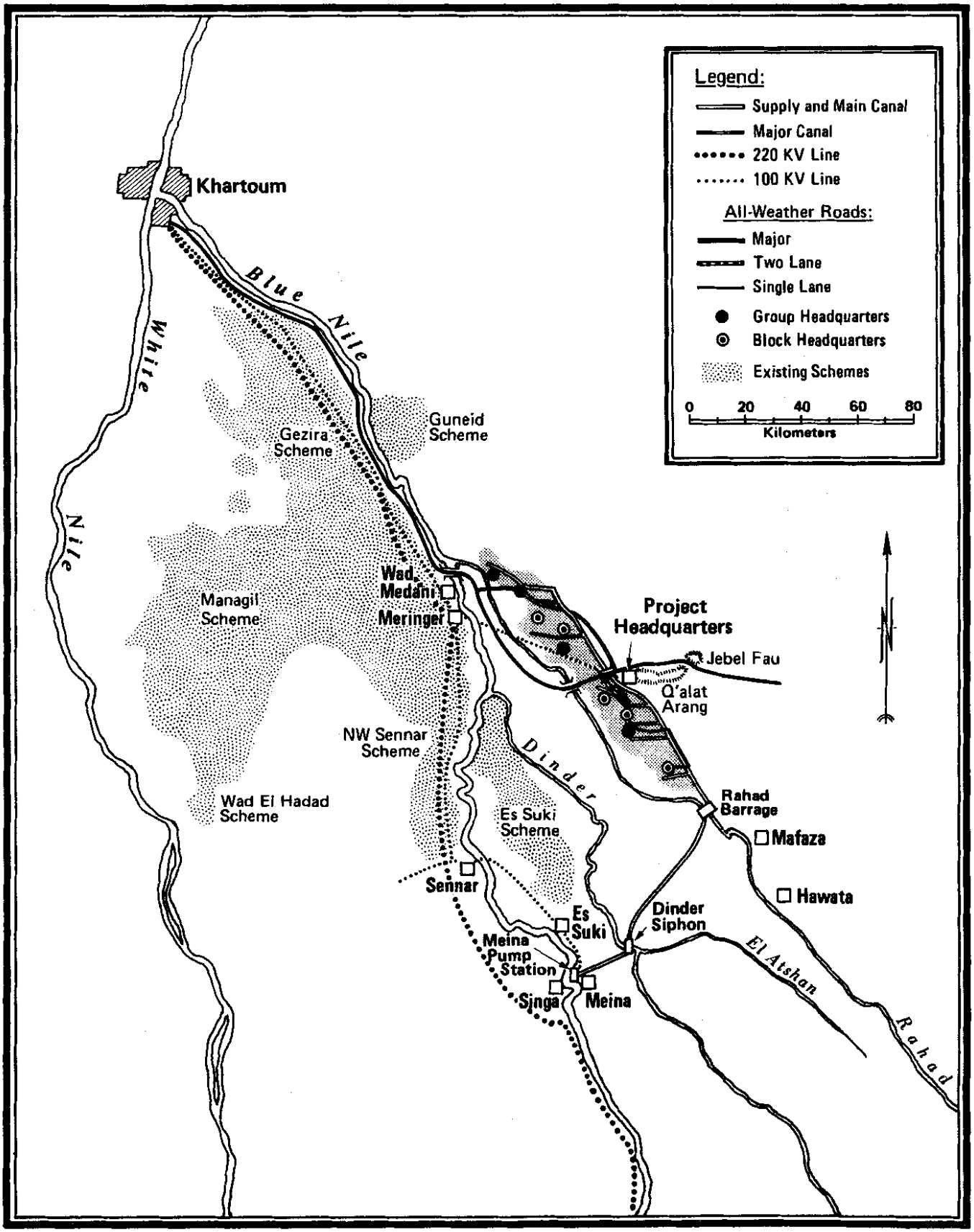
* Map 1 Location of the Rahad Irrigation Project has been included as page vi.

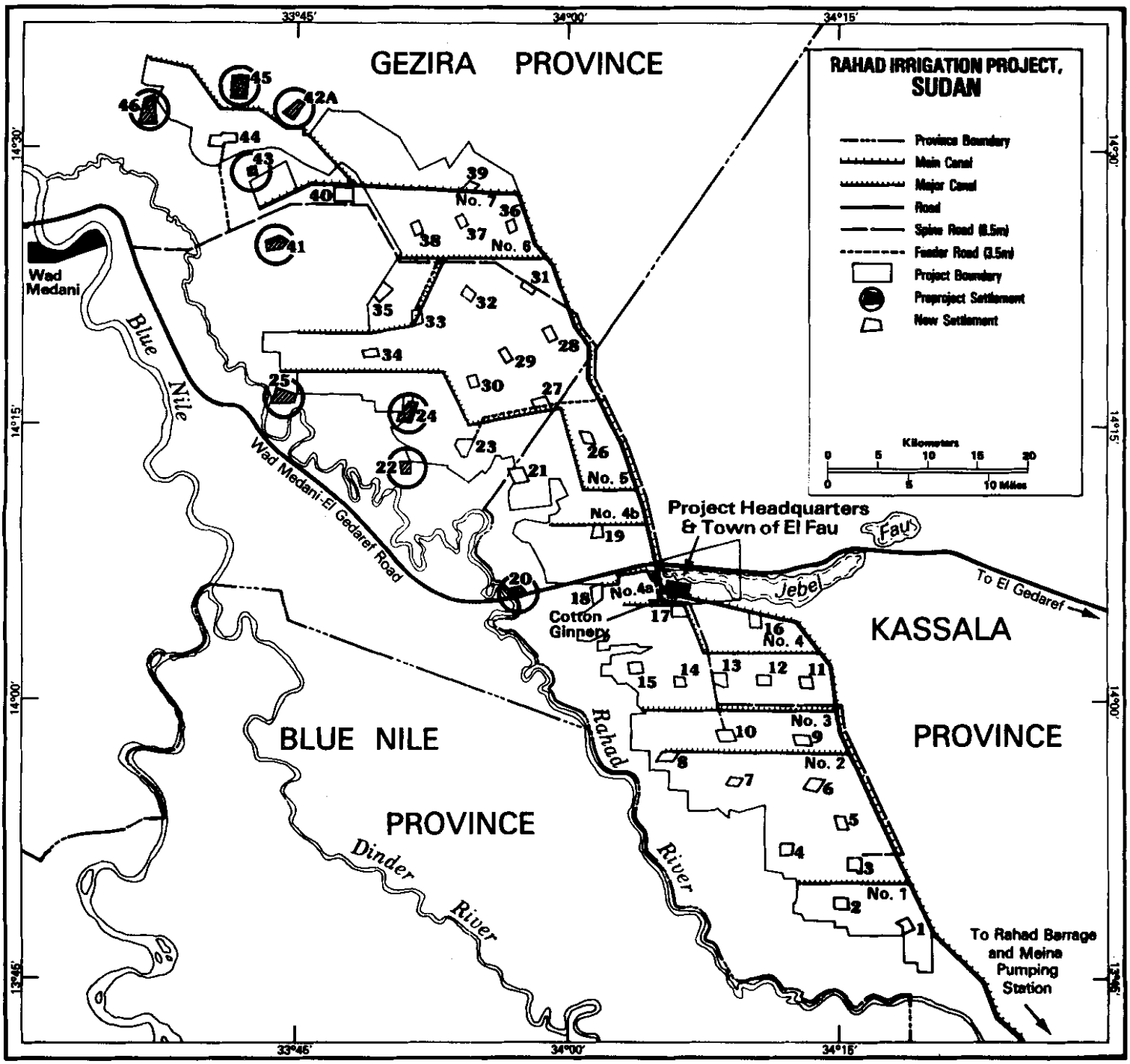
Map 2

General Map of the Rahad Irrigation Project



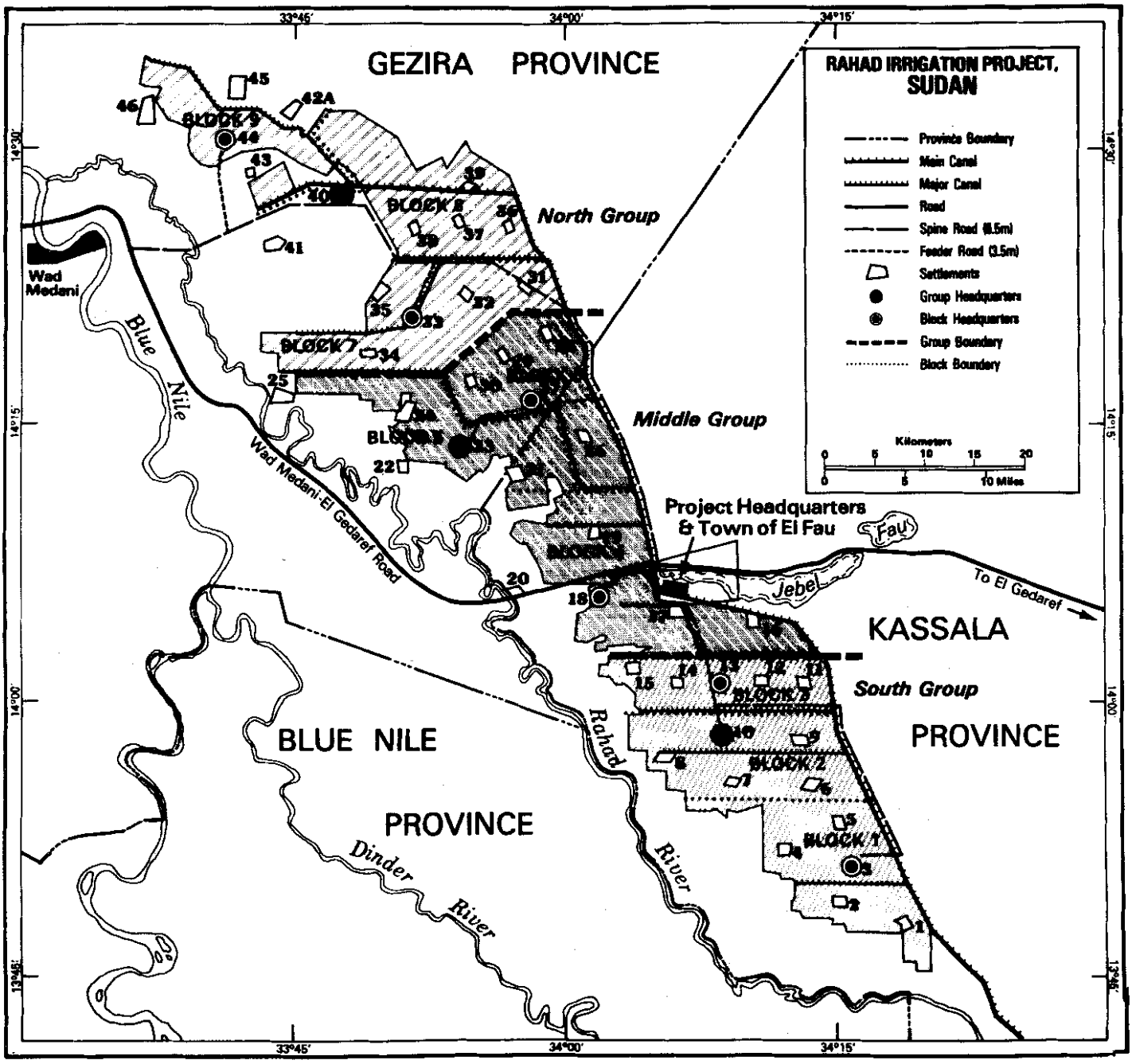
Map 3.

Infrastructure and Settlements



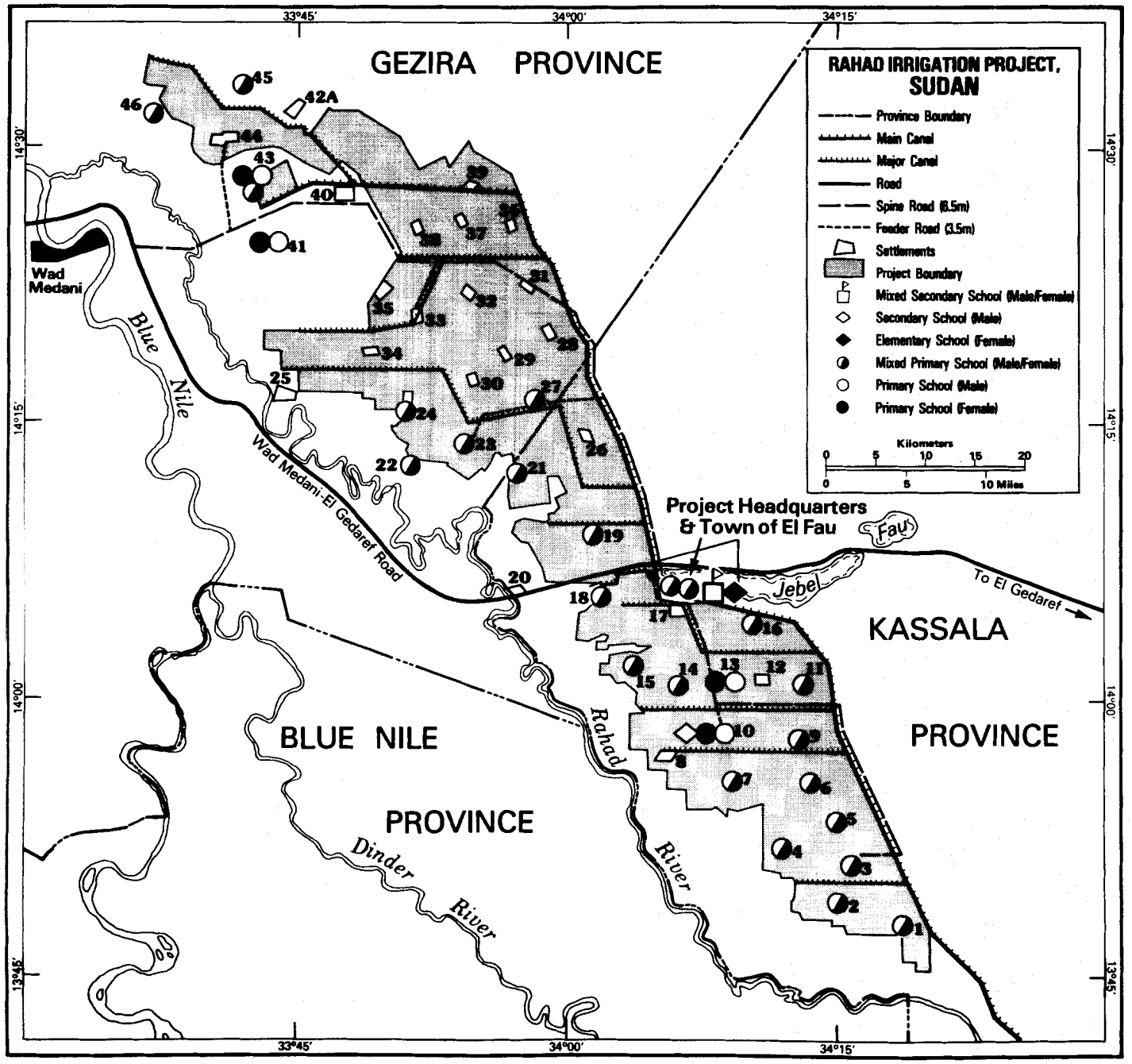
Map 4.

Administrative Units



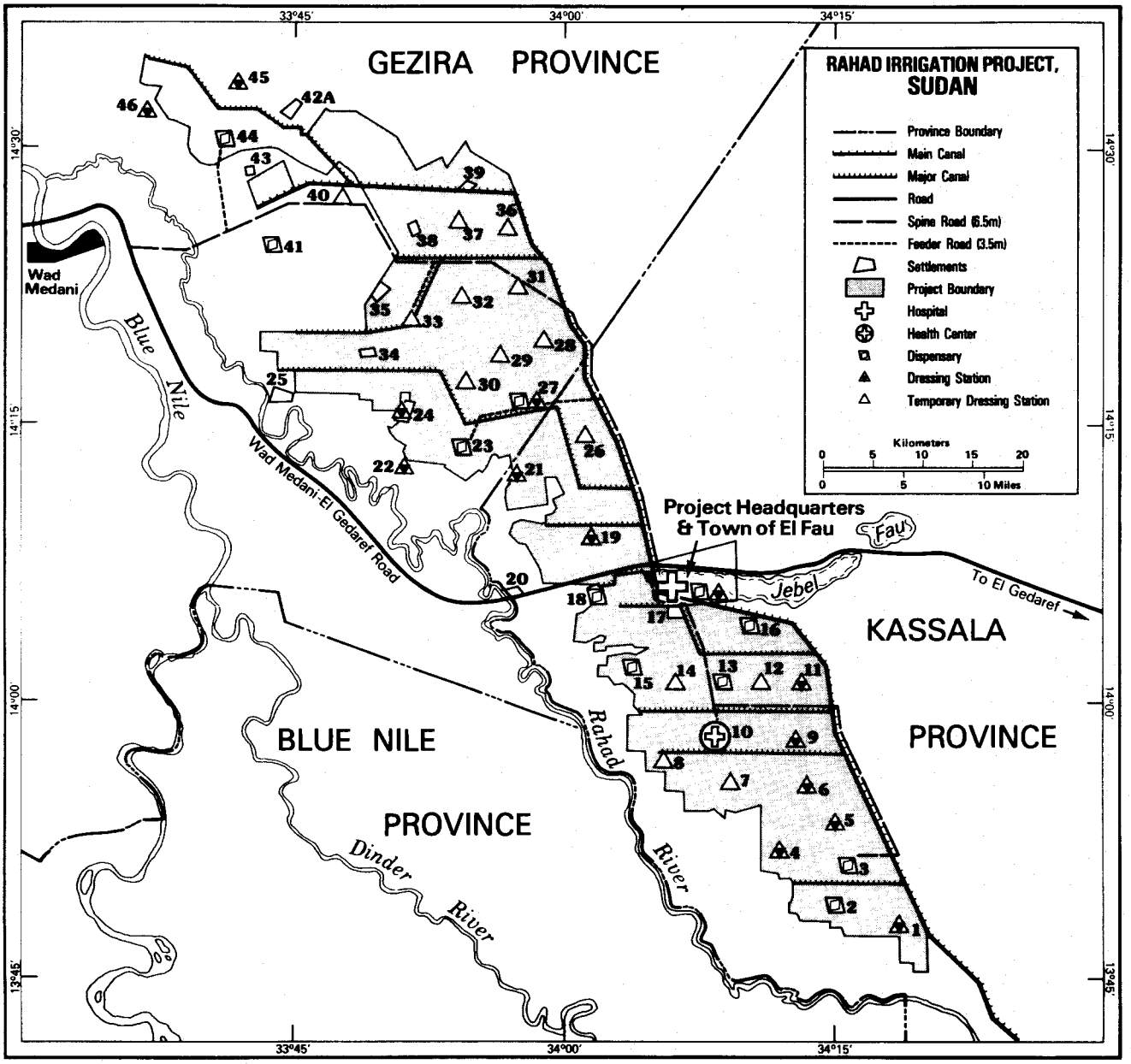
Map 5.

Distribution of Schools, 1981



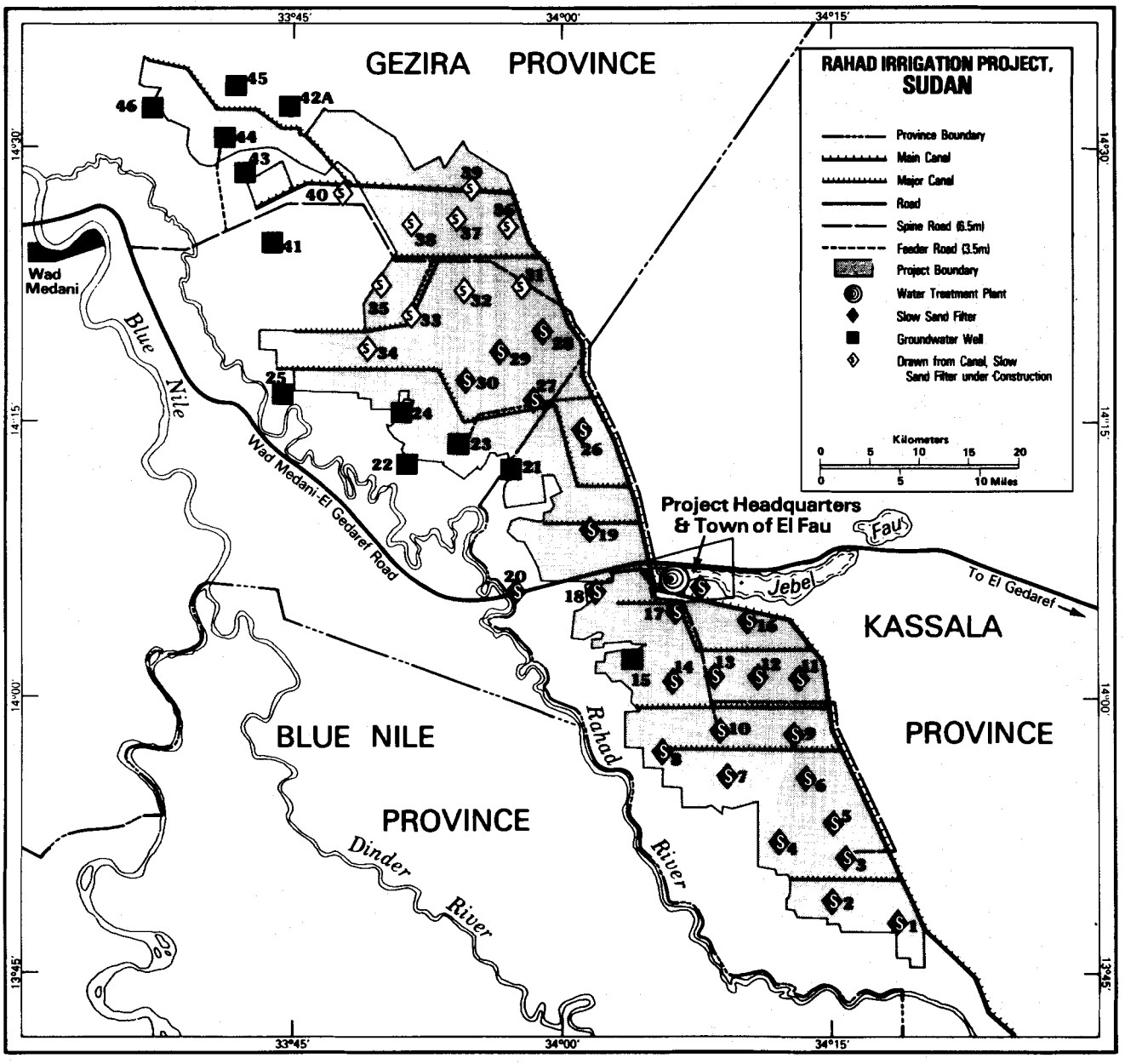
Map 6.

Distribution of Public Health Services, 1981



Map 7.

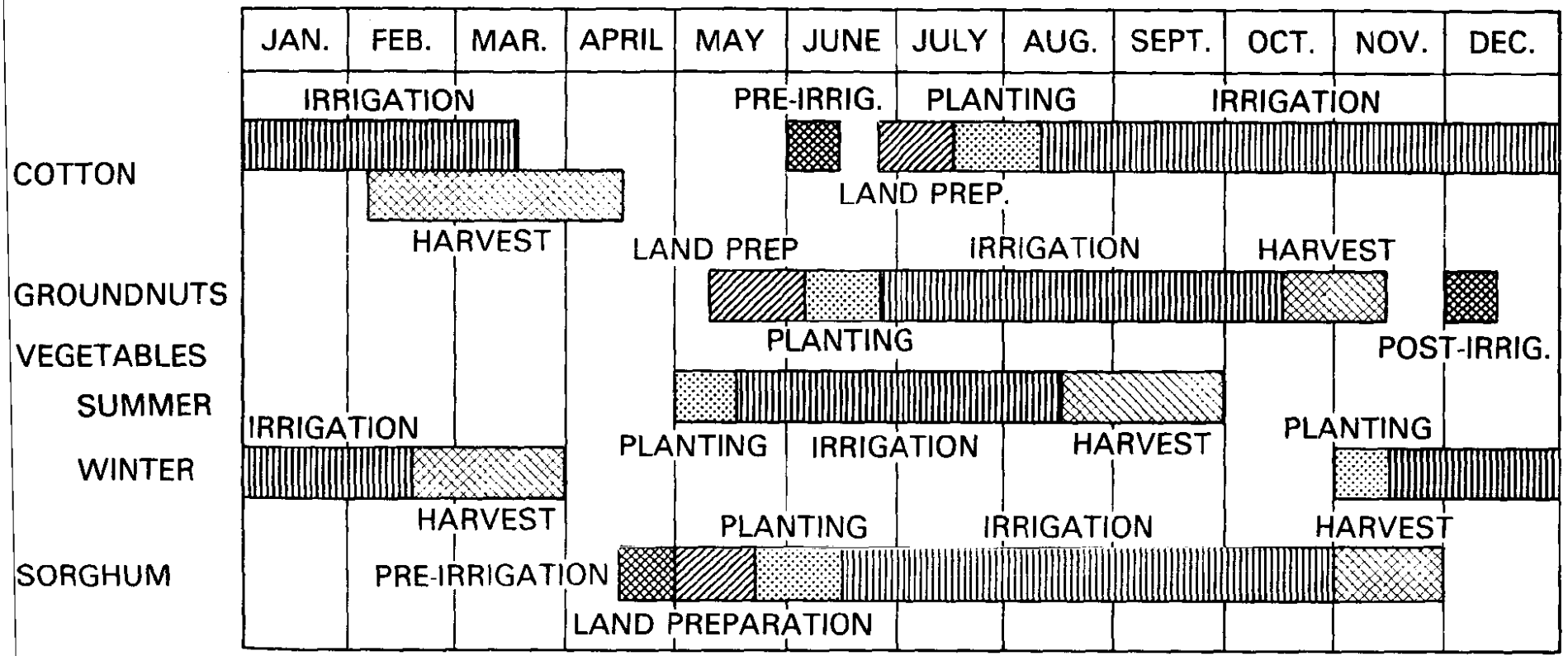
Distribution of Village Water Supply Systems, 1981



SUPPORTING MATERIALS

III. Chart 1. Annual Cycles for Crop Production

Chart 1:
Annual Cycles for Crop Production



A.I.D. Sub-Project

I. PROJECT DESCRIPTION

The Rahad project was authorized in February 1973 as an $11,000,000 loan for the procurement of equipment and related services in support of the development of 300,000 fed into irrigated agriculture along the Rahad River in Eastern Sudan. The initial cost estimate for the project was $99 million, with the World Bank (IDA) and Kuwait providing $42 million and $11 million, respectively. The major components of the project include a pumping station at Meina on the Blue Nile, an 85 km supply canal from Meina to the Rahad River; a dam on the Rahad River, irrigation infrastructure for distribution and drainage for 300,000 fed; construction of headquarters, maintenance facilities, offices and houses; village infrastructure (including health and education); a road network; storage and processing facilities for cotton and groundnuts; an electrical system; seed production and research farms; and feasibility studies for a Phase II project.

II. A.I.D. CONTRIBUTIONS

The A.I.D. Portion of the project supplied equipment to the Rahad Corporation and Ministry of Irrigation's Earthmoving Corporation for agricultural development and irrigation works, respectively. About $10 million of A.I.D. funds were disbursed between 1974 and 1976 for earthmoving and agricultural equipment, and for the services of Louis Berger, Inc., to assist the GOS with procurement.

In general, the A.I.D. contribution to the project achieved and is continuing to achieve its purpose of supporting irrigation works and agricultural development in the Rahad project. Some vehicles and heavy equipment have worn out as a result of the rough conditions which prevailed during the initial stages of the project.

Of 392 pieces of A.I.D.-financed equipment, approximately 47 percent is operating, 24 percent is not operating but repairable, 13 percent is not repairable due to cannabalization, and 16 percent is expended or has completed its useful life. Heavy equipment generally has not been used to its potential due to lack of spare parts; therefore, significant life remains in most heavy equipment units. Generally, the equipment provided was suited to the work required. Shortages of some essential spare parts contributed to the decline of some of this equipment and continues to constitute a major problem. Some of the equipment particularly that procured for the Earthmoving Corporation no longer is required for the Rahad project and can now be utilized for other development activities in Sudan.

It is significant that the major portion of A.I.D.'s contribution to the project was delivered relatively promptly and efficiently. A.I.D.-financed equipment was the first equipment available to the project and it

contributed to the early start-up of construction. Sudanese officials who were interviewed acknowledged the critical role of A.I.D. inputs.

III. PROCUREMENT PROBLEMS

By early 1977, about $10 million was disbursed and the remaining $1 million committed. At this time A.I.D. considered de-obligating the remainder of the loan since all essential equipment in the loan agreement had been procured. However, the Rahad Coproration developed a plan to use the remaining funds for spare parts and other items. Therefore, the Berger procurement contract was briefly renewed during 1977. Despite three extensions in the terminal disbursement date (TDD), through April 1979, only a total of $10,348,047 was disbursed, largely because suppliers failed to make final deliveries, and/or Letters of Credit were not extended for a sufficient length of time. In addition, small cost-savings occurred in numerous orders. The committed but undisbursed amounts were not fully analysed and acknowledged until late February 1979. Thus, major project implementation emphasis was placed on keeping Letters of Credit and Letters of Commitment extended rather than on placing new orders. Some dealers apparently no longer intended to make deliveries by the final stages of the project, even though Letters of Credit were open. Thus, the $651,943 which remained undisbursed as of April 27, 1979, were de-obligated. The items which were not delivered include six Ford trucks, a low-boy trailer, a tanker and various spare parts and tools.

A.I.D.'s contribution would have been enhanced by further disbursements for essential spare parts, minor equipment and additional vehicles. While the Berger contract fulfilled, in general, the services it was expected to provide, neither Berger, A.I.D. nor the Government were effective in identifying the cause for slow disbursements during the final years of the project. Unfortunately, it is the fledging Rahad Corporation which bears the consequences of this inability to disburse the entire loan.

IV. CURRENT STATUS OF RAHAD PROJECT

The current status of the Rahad project (apart from A.I.D.'s contribution) is approximately three years behind schedule, and is expected to be completed by June 1981. The pumping station and main canal have been functioning for nearly three years, and the third crop on about 200,000 fed was harvested in early 1980. Contractors are completing housing and administration infrastructure, the road network and the electrical network. In view of the complexity of the project, implementation has been commendable. The World Bank loan of $62 million is all but about $8 million disbursed, with only $1.9 million uncommitted. Construction cost overruns have been primarily local costs and are being provided by the GOS. The primary outstanding problem is to obtain local currency and limited foreign exchange to complete the project.

The managerial and financial aspects of the project also require attention. The World Bank provisionally estimates operating losses for the

Rahad Corporation of LSd 10 million in 1979, LSd 12 million in 1980, and LSd 7 million in 1981 and 1982, respectively. These losses do not take into account the amortization of investment costs. The World Bank is planning to extend technical assistance in finance and accounting, supplies, maintenance and operations in an effort to render the Rahad Corporation more viable financially. Since the Corporation was founded in 1973 and is still making the transition in emphasis from construction activities to agricultural production, considerable improvement in its operations should be forthcoming in the early 1980s.

TABLE I

PROJECT COST ESTIMATES

(in million U.S. dollars)

	Original	Revised-1975	Revised-1979
IDA	42	62	67
Kuwait Fund	11	50	50
USAID	11	11	11
Arab Fund	--	9	9
Saudi Fund	--	28	28
Gov. of Sudan	35	80	235
TOTAL	99	240	400[1]

1 Estimated by World Bank. Of this amount, about $16 million represents foreign exchange requirements. Assuming that the World Bank provides $5 million as part of the $60 million Irrigation Subsector Project proposed for 1980, the government will require foreign exhange of about $11 million from other sources.

The cost estimate includes inflation through the final construction phase of the project, June 1981. Currently, local funds are available to complete 60 percent of the remaining work by June 1980, leaving less than 10 percent of the total project area to be completed during the last year of the project.

V. ADDITIONAL EQUIPMENT PURCHASE

After the crop year of 1980/81 when there were difficulties encountered in obtaining sufficient laborers for hand picking of cotton and a resulting loss of cotton in the field, the Corporation requested a grant under the Commodity Import Program for the purchase of 50 mechanical cotton pickers, appropriate support equipment and spare parts. The request was approved and the mechanical pickers have now operated one season.

The supplier agreed to supply service and training of operators for three seasons. Fifty drivers have been selected and trained in the fundamentals of operating the machines. Mechanics have also been selected and gone through one year of training.

The tenant farmer claims that the machines leave from 15 to 40 percent of the crop. The Block and field inspector claim losses of 10 to 15 percent. The technicians from the supplier and the Corporation agricultural engineering department estimate after a careful count that the loss, the cotton that is not picked, is between five to 10 percent. Only time will tell the overall effectiveness of these machines.

Present Condition of Agricultural Machinery and Heavy Equipment

Financed by USAID/SUDAN

	Type & Name of Machine	No. of machines received	In good Order	Out of Order	Remarks
1.	Crawler Tractors (Fiat - Allis 16-B)	12	6	6	-
2.	Farm Tractors (Ford 5000-W)	30	-	30	-
3.	Motor Grader - (WABCO 555 & 444)	9	3	6	-
4.	Lub & Compressor Units	12	2	10	
5.	Heavy - Duty Disc Harrows (Rome)	6	6	-	
6.	H. Duty Disc Harrows (Taylor - Way)	6	6	-	
7.	Offset Disc Harrows (Allis Chalmers)	10	-	20	
8.	Offset Disc Harrows (Bush Hog)	10	-	10	
9.	Abu XX Ditcher (Eversman)	4	3	1	Received with missing parts

Institutional and Social Change in the Rahad Area: Controlled Resettlement and Annexation

I. INTRODUCTION

From its inception the Rahad Irrigation Project envisaged a process of deliberate social planning involving controlled resettlement of a part of the indigenous population outside the scheme and an annexation of communities located within the Project area. Several socio-economic surveys of the Project area and its immediate environs provided useful data to the committees responsible for addressing issues such as land tenure rights, intertribal relations, the matching of services between community of origin and new Project communities, and the awarding of land tenancies.*

The Rahad Corporation benefitted from decades of experience in resettlement on the Gezira-Managil Scheme and other irrigated schemes. Many of the key managers responsible for setting policy at Rahad were in fact se zira Board. In practice this led to the establishment of e recruitment eligibility requirements. Other differences between Rahad and Gezira can be noted in production relations, the structure of management and the degree of mechanization. Such differences were deemed necessary in order to quickly achieve high production outputs of priority export crops.

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II. PRE-PROJECT SETTING

A. Physical and Climatic Conditions

The "greater Rahad area" is a 300 km zone on the east bank of the Rahad River. Located in the central part of the Sudan, it is situated in a vast clay plain at an elevation of 400-430 meters above sea level. Deep clay soils coupled with an average low rainfall of 350 mm in the north of the area and 650 mm in the south play a major role in limiting rainfed crop production to the short period of late June to early October. The properties of the soils, i.e. high water holding and low permeability, provide both positive and negative factors for the development of the scheme. The clay plain makes it easy and cheap to irrigate with unlined canals and little seepage. On the other hand, traditional cultivators familiar with the growing of rainfed sorghum (dura) need to learn water management techniques to cultivate within a very narrow moisture range to avoid water logging and subsequent harmful clay expansion.

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* Two important surveys are Muh. El Awad Galal El Din. The Human Factor in the Rahad Project Area. Ministry of Agriculture, Food and Natural Resources, 1975 and M. H. Satti. Rahad Irrigation Project. Health Aspect - With Special Reference to Environmental Factors. National Council for Research, 1974.

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The pre-project vegetation varied from open grassland with isolated scrub in the north to savannah and dense Acacia thickets in the south. Traditionally, cultivators of dura would burn off grasses and low scrub, sowing wherever the terrain would permit. Ample range existed for herds of camel, cattle, sheep and goats. The relative openness and flatness of the plain meant that scrub clearance and land preparation for the Project was not difficult or expensive. In the short period of the Project, however, major modifications to the fragile ecology of grasslands, savannah and bush adjacent to the Project area can be observed.

Overgrazing due to a high percentage of livestock belonging to (a) nomads, (b) Project villagers and (c) Eritrean refugees as well as fuelwood gathering are leading to major environmental modifications. (See Annex F for details.)

B. Population Distribution and Characteristics

Population for resettlement within the Project was drawn from villages situated on both sides of the Rahad River, from selected villages near the Dinder River and from an area north of Wad Medani where the Rahad River joins the Blue Nile. (See El Din: 1975 for a complete listing). These villages differ from one to another in terms of size, services, amenities, economic structure, tribal composition and proximity to major transportation routes and larger provincial centers (eg., Wad Medani). Although population data for this region are poor, the study by El Din in 1975 does provide a basis for comparison between communities which provided residents for the Project. Briefly, the major contrast seems to be between communities in the northern part of the area and those in the South. The sample was 142 villages totalling 82,190 people. Specifically:

1. The northern half of the area to the west of the Project area contained 2/3 of the sampled population. Seventeen out of 21 villages over 1,000 in population are in this area. Many of these larger communities continue to have a more diversified economic base and effective economic and social linkages with Wad Medani.

2. The distribution of communities in the South still tend to be concentrated along the Rahad River with the exception of a few communities in the Fau hills area clustered around bore wells. In the North due to the presence of more extensive groundwater, communities tend to be more widely dispersed in areas where rainfed cultivation of dura was practiced.

3. Tribal complexity is greater in the South. Villages tend to be constituted by a single tribe, and many more different tribal remnants are found here than in the North (See Table 1). The Fellata (groups from west and central Africa) constitute 33 percent of the southern tribes. Northern villages show less diversity and a number of communities have different

tribes living together in close proximity. During the resettlement process, much attention was given to tribal identity and cooperation between tribal groups. A policy was followed to relocate people according to their prior social situation (social homogeniety and/or willingness to live adjacent to different groups)--an attempt to reconstruct community cohesion.

Despite such guidelines, subsequent circumstances required new social groupings. Some groups first refused to join the Project only to later apply for settlement rights. Having missed an opportunity to settle with other groups from their village, they had to take tenancies elsewhere when available. Both nomads from outside the area and individuals from other parts of Sudan were also interspersed throughout the Project constituting a new social element. Beyond these contrasts there are major differences in familiarity with agricultural practices which, within the context of the Project, led to different paths of adaptation to Project agricultural requirements.

In terms of other relevant population features, it must be pointed out that the population throughout the area is rather young (50 percent under 15 years of age); the dependency ratio high (average family size is 5.5 individuals) and the mean age of marriage for females is 16 years. Inadequate quantity and quality of health facilities is suggested by high infant mortality 70-200/1,000 and a crude death rate of 16-20/1,000.

C. Livelihood

The most significant pre-project condition targeted by the Project was that of subsistence-level economic activities. Most families had mixed income from animal husbandry (more in the South), rainfed sorghum cultivation (more in the North), riverine horticulture, and seasonal labor. Major activities included:

1. The cultivation of rainfed sorghum throughout the area but predominantly in the North. This staple food and source of animal fodder was cultivated without mechanized operations. The area cropped and yields varied widely from year to year due to unpredictable rainfall. The average area cultivated per household is reputed to have been about 20-22 fed.*

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* For example, 1967 was a good year with a maximum area cropped (319,000 fed) under 86 percent sorghum, eight percent sesame and four percent other. In 1971, plagued by inadequate rain, only 1/4 of this area was cropped and yields were only 1/2 of 1967. (See: Pre-Investment Survey Report No. 2 - Rahad Project. Ministry of Finance and Economy). The annual value of agriculture was reputed to be only LSd 65/family of 5.5 persons.

2. In riverine areas along the Rahad and Dinder Rivers "gerrif" farmers cultivated sides of the rivers as flood waters receded. Crops grown on these rich soils with rudimentary irrigation included tomatoes, beans, potatoes, cucurbits, melons, groundnuts and dukn (Pennisetum typhoideum). Most production was limited to household consumption and many of these families maintained large amounts of livestock.

3. Animal husbandry was practiced by almost all families either by grazing long distances or along riverine areas. The Project area lies astride a major east-west nomadic route. The Rufa and Kinana tribes annually move from the Botana Plain to the Rahad and Blue Nile. Many beneficial symbiotic relations are formed between nomads and settled agriculturalists. A large number of villages have been settled in the last 20-50 years by nomads. Thus, a semi-nomadic mode, or at least a heavy reliance upon animal production, dominates village economies. Further, animals remain a fairly reliable source of liquid capital for cultivators who must depend upon irregular rainfall.

4. It is likely that nearly a tenth of the indigenous population was landless (i.e. few if any titled rights to land). For this population and for a large number of cultivators in the North, wage labor was crucial as a source of income.* Several distinct patterns of seasonal labor continue to exist in the area:

-- To Gezira: During January - March entire families traveled to the Gezira-Managil Scheme to pick cotton on nearly 500,000 fed. There the family was provided food, fodder plus 15 pt for each guffa (35 lbs.) of picked seed cotton. The major opportunity cost for such families was the value of needed subsistence food and dry season cash income.

-- To Gadaref: Slightly earlier than the Gezira cotton harvest, adult males could travel to Gadaref to participate in the harvest of sorghum on mechanized schemes.

-- To Wad Medani and Khartoum: Villagers in the North, particularly, could obtain work as casual workers (porters, vendors, hawkers, marketeers) in larger provincial towns.

-- To Mafaza: Villagers in the South from January - June could work under contract for merchants to cut and produce charcoal. Much of this activity was in theory illegal as forests are owned by the government and cannot be cut without permits.

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* Although all land in the Project area was and is considered government land, individuals over time developed rights, eg., (a) grazing, woodcutting, usufruct rights established after five years of use and (b) registered title following 20 years of use. The 1970 land reform law permitted the Corporation to obtain full use of the land in the Project area.

Family income has not been adequately research in the pre-project area. El Din's 1975 study does sample some households but provides little information except for aggregate figures. He reports that family income in poorer villages is as low as LSd 87-100 annum. In sampling families in larger communities with a more diverse economic base El Din reports family income of LSd 188/annum. This range would tend to be normal for national income figures.

D. Services

Contrasts between northern and southern communities is most pronounced in terms of services. Larger communities and those close to Wad Medani have a wider array of educational, health and administrative functions. This is also matched by a greater diversity of small scale commercial and artisan activities in the northern area. During the initial period of resettlement when the social development capital budget was adequate, an effort was made to match services in the new community based upon survey results.

El Din's pre-project survey points out major differences in literacy between North and South. Where schools exist and access is not a problem, literacy is calculated at an average of 34.3 percent for Abu Shara, a large village, but only 13.5 percent for Abu Al Hassan and less than one percent in Um Tartara within the same general area. Everywhere literacy for females is only a small fraction of that of males. Where mosques exist, the khalwa or Koranic school provided lessons in reading to a limited number of males and females. Such opportunities for females are less where khalwas do not exist and where elementary schools do not provide separate facilities for females.

These inter community differences in services and facilities have become a critical issue in the resettlement of population. Many residents of northern villages, used to services, have been settled in new Project villages totally lacking services due to insufficient Corporation funds. Established communities in the northern area annexed by the Project find that provincial government budgetary support is dwindling as the Corporation is increasingly viewed as the responsible agent. Unfulfilled expectations is a major factor in tenant-Corporation relations.

In summary, in achieving its economic and welfare objectives, the Project had to cope with the following areas of change:

1. To introduce cultivators and herders to new cultigens, new technology and new institutionalized production relationships. This meant a shift of decision-making from the domestic unit to another level as represented by the inspectorate system.

2. To develop new social communities often creating new social alliances and new local institutions of decision-making.

3. To create new dependencies such as an increased reliance on market forces and on cash for transactions. This monetarization of a subsistence economy gradually has become a major factor. Project crops such as cotton and groundnuts have also created new labor relations between tenants and sources of labor.

The shift from subsistance cultivator to tenant has involved a series of major adjustments by both the Corporation and Project residents, a number of which are described in the following section.

III. RESETTLEMENT AND ANNEXING SETTLEMENTS

A. Land Tenure

As mentioned above, nationalization of land in 1970 permitted the Corporation to obtain the Project land required without purchase. Rights were recognized, recorded and compensation was made by exchanging 22 fed tenancies for traditional rights invested in land. In the case of individual claims to land in excess of 22 fed, the Corporation gave several tenancies with the condition that each 22 fed tenancy had to be registered under a separate name.

As a first step, the Committee for Resettlement with the help of local leadership drew up a list of names of eligible families based upon the following criteria listed in order of importance:

1. Land owners in the Project area;
2. Residents of the Project area who practice agricultural activities;
3. Any other residents of the Project area;
4. Any qualified Sudanese related to the Project area; and
5. Any other qualified Sudanese national.

The second and most critical step was the assignment of individual families, groups of families constituting residential units, and on occasion entire village populations to new villages. The notion was to create new settlements which reflected original social groupings.

Those who had established rights in land were generally given tenancies if they met additional criteria--they had to show evidence that they were economically "fit" to handle a tenancy. Those who were landless such as nomads and laborers were given stipends of LSd 50 to build a straw hut like all other settlers but were not given a tenancy. In theory, each new village was to assign one-half of the 600 residential plots available to non-tenants.

SELECTED INFORMATION ON RAHAD AREA VILLAGES PRIOR TO PROJECT IMPLEMENTATION

	Southern Area			Northern Area				
Sub-Areas	West	East	Fau Hills	Sharif Yacoub	Barnousa	Wad El Obeid	Abu Shara	Abu Harza
Total Population	3,320	5,853	3,894	3,959	4,471	10,986	18,417	21,340
No. of Villages	16	18	14	7	15	19	23	30
No. of Villages over 1,000	0	1	0	1 (1 over 2,000)	1	4	7	5 (1 over 3,000)
Average Household Size	5.4	5.3	5.6	5.9	5.3	5.4	5.2	5.7
No. of Mosques and Koranic Schools	4	3	3	?	?	1	5	2
No. of Elementary Schools (No. of classes unknown)	2	2	1	3 (1 for girls)	3 (1 for mixed)	6 (3 for boys 2 for girls, 1 mixed)	10 (1 for mixed)	14 (1 for girls)
No. of Secondary Schools	0	0	0	1	0	0	2	6
No. of Health Dispensaries	0	1	1	1	2	2	5	10

Source: El Din, 1975

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Elsewhere, villages slightly outside the Project area were not shifted since tenants could reach Project tenancies located within five km of the village. In a few cases it was necessary to group a few existing small villages into a single new village to rationalize the delivery of services. In the North, particularly villages 41-46, old villages were annexed into the Project area without any major resettlement.

The ideal model of settling villagers by (a) proximity to the old village, (b) by offering an identical array of services and (c) by preferred social (tribal) composition broke down as villagers who refused to move or who moved only to leave and return to their old village were replaced by others. Replacement from the waiting list introduced tenants into new communities who had no prior relation with village inhabitants: eg., northerners within southern villages, nomads without any established residence in the area, and seasonal laborers from other provinces.

In terms of the relative difficulties inherent in such a complex resettlement process the operations of tenant selection, village siting with respect to the irrigation system, and tenant/non-tenant location should be judged a success. The three to four year resettlement and annexation experience, however, is affected by growing discontent related to attitudes and behavior concerning unfulfilled expectations and a declining commitment toward the production relationship.

B. Social Structure as a Context for Decision-making

The process of resettlement and of the incorporation of existing communities into the organizational sphere of influence of the Rahad Corporation created new social distinctions. Not too dissimilar to Gezira, the Rahad Project area can be distinguished by the gradual emergence of four to five levels of social distinction.*

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* Tony Barnett. The Gezira Scheme: An Illusion of Development. London: Frank Cass, 1977 (See pp. 177 ff).

1. Rahad Corporation and provincial government management personnel and sectoral civil servants

A relatively large number of functionaries, technicians and administrators are located at the Project headquarters at El Fau and the Group and Block levels of organization. As employees of the state, either directly or through the Corporation, this small group of managers represents a social category distinct from cultivators and laborers. Well educated, non-local urban oriented, monied and located at the apex of authority, this management class is beginning to have an impact on the structure of decision- making at El Fau. Within this group, as one approaches the level of daily contact with tenants and laborers, individuals can be found who nominally should represent both the interests of management and those of the tenant, eg., the field inspectors, actual field operators of equipment, service providers such as teachers and health facility personnel. For the majority of tenants and laborers who form the indigenous population of this area, this close proximity to managers and technicians has both positive and negative impacts.

Many villagers interviewed indicated that the presence of service personnel, albeit inadequate for existing needs, has influenced the beliefs, attitudes, and behavior of village populations. Shortfalls in budget funds expressed in inadequately staffed and supplied services often, however, are attributed to service providers--the first line of access that villagers have to management.

2. Rural Entrepreneurs (nas tayyibin)

This is a diverse social category, indeterminate but small in size, bound together only by their entrepreneurial roles as merchants, money lenders, transporters, marketeers, artisans, etc. In some cases, there are tenants who use their tenancy as a base from which they seek out alternative income from these types of activities. These activities play a critical role in the extension of credit to facilitate household cash flow, in bulking crops and in seeking out markets external to the Project. Their profit margins are high and the Corporation is interested in how to replicate some of these functions at a lower cost. In the case of Rahad, household self sufficiency is rather limited, since the growing of sorghum is not permitted, and most tenants are more highly reliant on markets where cash is the medium for transactions. Under such circumstances merchants have capitalized on these ties of dependency on market goods and services through cash transactions.

3. Tenants

The term itself suggests a relationship to resources and to decisions about resource use which differs from that of a farmer (mezari). To be a tenant seems to connote the following:

-- a production relationship in which the wider organizational context determines the material/machine/water labor input strategy;

-- a production relationship in which the outcome of efforts is linked not only to individual performance but also to a wider rationality which determines the price of outputs, eg., cotton; and

-- a production relationship which does not permit much maximizing of gains within the latitude of tenant decision-making.

Barnett's characterization of the Gezira tenant equally applies to Rahad with a few major differences. Briefly (Barnett, 1977, p. 169):

-- The tenant's normal sphere of decision-making revolves around (a) minor equipment inputs, (b) whether he or she should personally work or act as an agent of the Corporation to provide hired hand labor, and (c) what quality of work will actually be accomplished;

-- At Rahad the labor input strategy is more a decision of the Corporation in those areas where full mechanization has been achieved;

-- Where the tenancy normally provides flexibility of growing a subsistence crop, eg., sorghum, the tenant can, to an extent, minimize loss through the security of a needed food crop;

-- At Rahad sorghum has yet to be introduced into the rotation and the current rotation provides little predictability and security; and

-- A tenancy can provide a minimal cushion from which alternative income gaining strategies can be employed. It also need not be worked beyond a level of gain exceeding the consumption demands of the family--a situation which determines incentives.

In some respects, a tenant functions at times as an employee or agent of the Corporation within a tightly controlled management environment.

4. Laborers

There are a number of categories of laborers in the Project area, eg., seasonal migrant laborers (obtained by the Corporation and/or by the tenant), resident non-tenants who derive most of their income from hand labor operations both on and off the Scheme, and tenants who also serve as laborers to other tenants or who continue a tradition of going to the Gezira for harvesting. The supply of seasonal labor is well organized both in terms of recruitment by the Corporation and in terms of setting wage rates through informal labor organizers. An issue exists over to what degree is there a labor deficit during particular times and whether or not

laborers in the Project have a major place in the life of those communities. Resident laborers are an integral part of almost all communities in an economic, social and political sense. Many of these individuals are awaiting a tenancy in the event that evictions occur. Rural entrepreneurs in the Project area depend upon laborers for a major part of their income. Mechanization will undoubtedly interrupt the flow of cash from tenant to laborer to merchant. Increasing mechanization and a lack of off-farm employment will affect the supply and value of rural labor (See Appendix E).

IV. DEVELOPMENT OF LOCAL INSTITUTIONS FOR DECISION-MAKING

A. General

The Corporation recognizes the need to encourage the formation of local institutions. For indigenous villages, of course, local leadership in the form of tribal village sheikhs, councils of elders, mutual aid relations (nafir), sub-village social groupings and a host of other relationships already constitute institutionalized means of handling competition and cooperation. As the Project dramatically impacted on traditional land tenure, on local authority and on household economics, traditional leadership and local institutions have had to cope with new variables. In the case of new villages, settlers have began to transplant and reconstitute local institutions around new and old leaders. In this process, the Corporation, through the efforts of a Commissioner seconded from local government, sees itself as responsible for establishing village councils which reach upward through two systems, (a) the Corporation vis-a-vis its relation to scheme residents and (b) provincial government in relation to villages within a wider regional entity.

B. Village Councils

The Rahad village councils* will eventually number 46, one per village, of which 22 will be a part of Kassala province and 24 of Gezira Province. Each village council is related to other elements of local government as follows using Kassala Province as an example:

Kassala Province People's Council

District Council (Town of El Fau plus Rural Council)

(24 members of which 18** are elected and six appointed)

Rural Council (located in El Fau responsible for 22 Scheme villages and five outside villages)

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* Provincial councils at all levels are empowered by the People's Local Government Act of 1971.

** Six places are reserved for women.

Village Council
(open membership**).

The general functions of the Village Council include:

-- eliciting self help resources for village services;

-- ideally making recommendations on the performance of village services (education, health, security, cleanliness, water supply);

-- monitoring rationed commodities;

-- helping most-disadvantaged families, etc.; and

-- sending Village Council chairmen to the Rural Council.

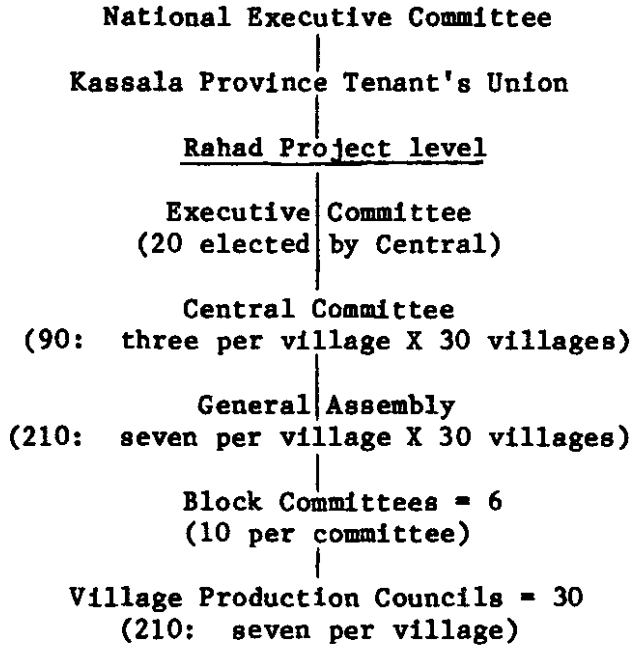
The means for effective representation exist from villagers, to Assistant Commissioner to Provincial Commissioner. The blueprint for local government including structure, functions and ideology has been worked out by experience elsewhere in Sudan. The system, however, in practice has yet to take effective hold as a decision-making process within the Rahad Scheme. There are a number of limitations placed on the development of effective local government. First, during these formative years of establishing village services and of working the problems out of the production system, the Corporation has retained much of the decision-making authority for planning and implementation. The Commissioner of the Rahad area retains exclusive control over the village councils for the first year or so before turning the councils over to the regional government. Second, the village councils do not have a budget. Only in the area of self-help do the councils manage money assessed from villagers and implement projects. Village council leaders complain of having little voice and only nominal authority when it comes to relations with the Corporation. Expectations by provincial government that the Corporation should be responsible for community affairs also places the village council in a difficult situation.

C. Production Councils

In many respects the need to associate for purposes of resolving problems related to the production system is more critical than many other areas. There exists a potentially effective structure consisting of village production councils reaching up to an executive committee at the national level.

The ideal structure is as follows:

** Six places are reserved for women.



This hierarchy of decision units is slowly taking shape alongside of the village councils and the Sudanese Socialist Union. Where production councils exist, they attempt to function along the following lines:

-- transmit tenant complaints to management regarding problems related to the delivery of agricultural inputs;

-- work together to resolve problems related to farm allocation of irrigation water in conjunction with field inspectors;

-- facilitate cash advances from management to tenant for selected farm operations;

-- mediate between tenant and management to reduce fines levied by inspectors and/or in cases where eviction proceedings are underway; and

-- to encourage audits of Corporation-provided inputs to assure that such services are equitable, efficient and accountable.

Village production councils differ from one to another in terms of actual functions performed. Tenants complain that communication is poor between the different levels of authority. Often tenant/inspector relations are characterized by inadequate information, ambiguity of the role of the inspector and a lack of the means of enforcement of Corporation

procedures and rules. Tension also exists between local levels of decision-making and the executive committee level. Similar to the village councils, the authority of local leadership is, at best, nominal outside of the local community. The lack of budgets for local institutions also limits their sphere of influence.

The development of local institutions for decision-making is clearly underway. The Corporation is committed to a policy of encouraging local councils to form around issues of social services and of the economics of the tenancy. The goal is to nurture experiments in local government and, once established through one to two years of operation, to turn them over to provincial control. In some ways this process suffers from (a) Corporation ambiguity of how much decentralization can be attempted within a context of central command over the factors of production and (b) the need to do so much community building with so few financial resources.

Many classic problems exist:

-- communication support activities are negligible. Villagers are little aware of Corporation planning objectives, do not participate in policy setting, and generally possess little relevant information;

-- lines of authority are only dimly perceived by tenants and lower level management personnel. Tenants are often unclear about who makes what decisions concerning resource allocation; and

-- expectations are largely unmet leading to declining levels of individual and family commitment.

The Corporation is aware of many of these generic problems. A recent plan will establish a Social Development Unit with a budget that will support research, improved project monitoring, educational activities related to home economics, childcare, youth activities, literacy, consumer cooperatives, etc. In short, more attention will be paid to the quality of community life and to the needs of tenants as villagers rather than of tenants as Project employees.

Management of Technical Resources At The Micro-Level

I. BACKGROUND

Sudan is a sparsely populated country with a population of 17 million and a land area slightly less than one million square miles. There are vast areas of the Central Clay Plain which are ideally suited for mechanized agricultural development. Large mechanized schemes in this area have been developed. The development had its beginning as a result of the shortage of sorghum (dura) during World War II for feeding troops of the Sudan Defense Forces. The British Colonial government at the request of the British Army agreed to mechanize the production of dura in order to meet the need. Dura was produced using only a tractor and a disk plow with attached seeder box for land preparation and seeding. Weeding and harvesting were done by hand. An area near Gedaref, Kassala Province, was selected for production. This was so successful that when the war was over the idea was expanded. By 1960 there were 1.5 million fed mechanized.

The mechanized crop production schemes were originally under the supervision of the Ministry of Agriculture. Demarcated areas were divided into 1000 fed farms which later were increased to 1500 fed each. Interested farmers pay a nominal rent and are supposed to follow a rotation of 1000 fed of dura and 500 fed in fallow or in sesame. Originally, prospective farmers were left to their own financial resources to provide the tractor and machinery. After independence in 1956, the Government made available credit through government credit institutions.

The schemes grew and became a popular means for Sudanese to gain financial independence. A surplus of dura was produced with the excess being sold to neighboring countries. Today there is in excess of six million fed devoted to rainfed mechanized crop production of dura, cotton and sesame. This is about 22 percent of the total cultivated area of the Sudan. The total irrigated area, which either partially or totally mechanized, is four million fed or approximately 15 percent of the cultivated area. The Rahad Irrigation Project is the first irrigated project which is to be 100 percent mechanized.

During the development of mechanization, as more and more cultural practices were mechanized, the training of tractor drivers, farm managers, and agricultural fitters did not keep pace with the demand. Furthermore, there were limited opportunities for practical experience. The cost of mechanized crop production has escalated at a faster rate than the prices of the agricultural crops produced. The margin of profit has decreased. For the crop year of 1981/82 the estimated cost for mechanized production in the Rahad Scheme for cotton and groundnuts is in excess of LSd 200 and LSd 60 per feddan respectively. The economics of a tenant farmer's costs and net returns are discussed in Appendix D.

It is believed that the cost per feddan can be lowered, and the quality, timeliness, and effectiveness can be improved. A suggested plan for improvement will be covered in a separate section of this appendix.

II. ORGANIZATION AND IMPLEMENTATION OF THE AGRICULTURAL MECHANIZATION INPUT

The Rahad Scheme is divided into nine Blocks and three Groups. The Southern Group is composed of Blocks I, II, and III with Group headquarters at Village 10. The Middle Group is made up of Blocks IV, V and VI and has its headquarters at Village 23. Blocks VII, VIII and IX make up the Northern Group with headquarters at Village 40. The number of staff positions needed and available for the agricultural engineering department are shown in Table I.

The Blocks have between 30 and 35 thousand feddans with half in cotton and half in groundnuts each year. Block agricultural engineering staff consists of one each of the following: agricultural engineer, senior mechanic, mechanic, fitter (agricultural machinery mechanic), assistant mechanic, assistant fitter, welder, electrician, and timekeeper. There are 45 tractor drivers, 45 greasers (assistant drivers) and three head drivers. There are 45 tractors for each Block with appropriate equipment, if available. Table II shows the total number and present condition of the tractors and implements. The staff required for the heavy machinery, the number and condition of each unit are shown in Tables I and II also.

The amount of work to be done for each crop for each year is determined in a joint effort of the Head Drivers, Field Inspectors, Block Inspector and Block Agricultural Engineer. The Field Inspector in cooperation with the Head Drivers and Block Agricultural Engineer will determine the number of feddans for each crop, the operation to be performed for each during the crop year and the optimum time for performing these operations. The Block Agricultural Engineer reports to the Group Agricultural Engineer on the data developed. The Group Agricultural Engineer submits this to the Agricultural Engineering Headquarters. After receiving the reports from all Groups, the Headquarters office prepares the scheme wide requirements in a composite master plan. From this, the number of tractors and implements required in each area and for any given operation are prepared. The result of this exercise is called the "Rahad Standard Practice." From this overall plan the Chief Agricultural Engineer projects his spare parts and P.O.L requirements, number of tractors and implements required and additional staff requirements if any.

Tables III and IV show a revised program based on changes made in regard to amount required to carry over from last season and last minute additions that could be made as newly repaired machines were put back to work. Table V and VI show the amount of cropland planned and actually achieved for each operation for cotton and groundnuts. Table VII shows the Rahad Standard Practice for the crop year of 1981/82.

III. PROBLEMS OF MECHANIZATION

From the outset the Rahad project management decided that groundnut production would be 100 percent mechanized and that cotton production would be mechanized except for picking. This decision was based on the supposition that the majority of the tenants would be from the so called nomadic tribes who earn their livelihood from raising livestock and would be adverse to doing manual labor on the farm. The Rahad Project was viewed as a settlement scheme for semi nomadic and nomadic peoples. As the scheme developed, it was found that there were more and more difficulties in getting laborers to pick cotton. The explanation given was that the profit margin in producing cotton is so low that it is not profitable to pay a high enough wage to entice workers to come from other areas to pick cotton. The pickers that are recruited are from Central and Western Sudan. Before agreeing to come to Rahad, the potential laborer first harvests his own crop. The optimum time for marriage is considered to be immediately following harvest. Therefore, those pickers who do come arrive late. Last year it was estimated that up to two kantars of cotton per feddan were lost due to the unavailability of pickers and the resulting untimeliness of the operation. One hundred percent mechanization of cotton was not adopted as a policy until two years ago. It was considered to be the only obvious solution to the labor problem.

Some Rahad officials question the feasibility and profitability of continuing to grow medium staple cotton. Should other alternative cash crops be considered? All schemes, Kashm el Girba, Suki, and Gezira, need pickers at the same time. Harvest of dura and sesame comes at the same time. It has been suggested that perhaps agronomic investigation of improved higher yielding varieties of cotton is needed, thereby, increasing the incentive of the tenant to produce cotton. The cost of production would remain approximately the same.

The present rotation is for 11 fed of cotton followed by 11 fed of groundnuts, i.e., 100 percent utilization of the land area. It was originally intended that the tenant would have 11 fed of cotton followed by eight fed of groundnuts and three fed of fodder. If he were allowed to grow dura in lieu of the fodder, this would be hand harvested which would partially relieve the Agricultural Engineering Department of part of their harvesting burden by reducing the requirement for the harvest of groundnuts. The machinery requirements for mechanization were originally calculated on the basis of 80 percent mechanization for cotton and with three fed of fodder in the rotation.

The practice of 11 fed each of cotton and groundnuts has decreased the the ability of the Agricultural Engineering Department to cope with the mechanization requirement. The problem of providing mechanical equipment on a timely basis and in an effective manner is difficult and complicated in Sudan. Perhaps one could fault the planning and management organization, but in most instances planning and management at the Headquarters

level is adequate but frequently too optimistic. The problems occur when the orders of management are carried out at the Block level. These orders are further delayed by logistical and financial problems in the purchase of spare parts and P.O.L. supplies; young inexperienced staff, lacking in practical experience, not fully realizing the importance of timeliness, effectiveness, or quality of work on crop yields; by drivers not being adequately trained in the use of equipment or in the importance of quality work and timeliness of the operation; by purchase and delivery of equipment on an untimely basis; and by purchase of equipment on the basis of lowest bid and not on a basis of its adequacy to do a job or, in fact, whether or not it meets specifications.

IV. SUGGESTED PLAN FOR IMPROVEMENT OF MECHANIZATION INPUT

Corporation management is not entirely blameless for the inadequacies of the mechanization input, but a good share of the blame lies in inadequate budgets; disapproval of requested increases in technical staffs; and lack of adequate hard currency budgets for purchase of spare parts. The management of the scheme, particularly in regard to projected output of the mechanization equipment, has not been realistic. World Bank reports have faulted the Agricultural Engineering Department for not allowing enough down time in estimating machine requirements for a crop season. On the other hand, if there were enough spare parts, which are limited due to lack of hard currency, down time would be less. The World Bank reports also state that more maintenance equipment is required; that more mechanics need to be recruited; and that longer working hours are needed. These requirements are needed for the short term but the long term problems need to be solved. The principal long term problem is inadequate practical training of staff.

New graduates of the University of Khartoum in agricultural engineering or agricultural mechanization are assigned as Block Agricultural Engineers with little practical experience. They are in charge of 30 to 35 thousand fed of crop land that is expected to be completely mechanized. Mechanics, fitters, head drivers, tractor drivers and assistant drivers all need additional training. Corporation management urgently needs to take action to initiate a training program for technical staff as well as mechanics, fitters and drivers. This organization would probably need, at the start, technical assistance from outside the Sudan but all training staff would need to be Sudanese. There are experienced Sudanese available that could do this work.

An all out effort in the form of local currency budget support, recruitment of additional staff, allocation of an adequate hard currency budget and the initiation of a scheme wide training program for the mechanization staff is needed if the Rahad Irrigation Project is to be salvaged.

V. OPERATION AND MAINTENANCE OF THE IRRIGATION SYSTEM

There was not sufficient time to make other than a cursory survey of the irrigation system, and to review the operation and maintenance of the system and the organization for performing that important function nor was there any extensive amount of irrigation going on at the time. Some problems developed with the discharge basin at the pump site in Meina last year which resulted in a failure to deliver sufficient water for a period of two months. Some farmers lost their groundnut crop as a result of this failure. Notwithstanding the pump discharge basin failure, tenant farmers complained that water was not delivered on time or was not delivered at all. In the Northern Group, Village 33, tenants complained that water was not delivered on time or was not delivered at all. In the Northern Group, Village 33, tenants complained that water was two months late in getting to them and the crop was two months late as a result. This is fairly obviously a problem that can be classified as "growing pains."

The World Bank reports indicate that problems with the system were minor difficulties with the design of the drainage system which caused poor drainage on less than five percent of the total area. Several drains had inadequate gradients; additional drain culverts need to be installed or replaced; and a general improvement made to the drainage system before it is considered to be adequate. The major problems were not with the overall system but improvement of the on-farm application. The long furrow irrigation system, where there is proper gradient in the row, is proving to be superior to the angaya or level basin system. Certainly the long furrow system will improve the efficiency of the mechanization input by cutting down on idle time at the end of the field for turning. The World Bank has proposed actions that will bring the existing 50,000 fed of long furrow irrigation to necessary standards for proper operation; rectify defects in the angaya system in the balance of the system in the project area; establish trials of the long furrow and angaya systems to demonstrate and assess the relative benefits of each system; complete the rest of the project on the basis of the angaya system so that, if needed or desired, it can be converted to the long furrow system later; complete the topographic survey of the entire project area as soon as possible; and finalize a work program for converting from the angaya system into the preferred system, either the level basin or the long furrow system, within a five year period after project completion.

The organizational structure for the operation and maintenance of the irrigation appears to be adequate for efficient management after the "bugs" of the system are worked out. The data for the daily water requirement is submitted, starting in the Northern Group, by the Field and Block inspectors and passed to the sub-division engineer. He in turn passes this requirement to the sub-division engineer to the south of him who in turn takes his requirement and passes the cumulative amount to the sub-division south of him. The last sub-division engineer in the south passes the requirement to the resident engineer at the barrage who determines how much

will be needed to be supplied from the Rahad river and how much by the Meina pump station. There is a 10 hour delay in acquiring the total requirement and if all goes well only a 24 hour delay in delivery of the water. Each sub-division engineer is required to allocate all water to those sub-divisions north of him before diversion for the use of the area for which he is responsible.

The problems with the irrigation system and on-farm water application are not considered to be too severe. Given time, it is felt that the deficiencies will be corrected.

TABLE I **AGRICULTURAL ENGINEERING DEPARTMENT STAFFING**

For the Whole Scheme (9 Blocks - 3 Groups)

Needed	Post	Available
1	Director	1
1	Deputy Director	1
3	Group Agricultural Engineers	2
9	Block Agricultural Engineers	9
9	Senior Mechanics	9
9	Mechanics	9
9	Fitters	9
9	Assistant Mechanics	9
9	Assistant Fitters	9
9	Welders	9
9	Electricians	9
9	Timekeepers	9
(45 x 9)	Tractor Drivers	(45 x 9)
(45 x 9)	Greasers	(45 x 9)
(3 x 9)	Head Drivers	(3 x 9)

Remarks : Block Nine is included in staffing and all the posts are being secured and recruitment is just underway.

HEAVY MACHINERY UNIT

Needed	Post	Available
1	Senior Mechanic	1
1	Engineer	-
4	Mechanics	3
40	Tractor Drivers	22
1	Welder	1
1	Electrician	1
9	Motor Grader Drivers	3
1	Crane Driver	1
40	Greaser	20
1	Timekeeper	1

TABLE II PRESENT CONDITION OF AGRICULTURAL MACHINERY

(February 1981)

ITEM	Total Number	PRESENT CONDITION Good Condition	Fair Condition	Major Repair	Operable
Wheeled Tractors					
Massey Ferguson	387	241	55	91	296
Ford 6600	10	10	-	-	10
Ford 5000	30	-	3	27	3
Implements					
Disc Harrow P.M.	130	10	28	92	38
Disc Allis Chalmers	20	-	-	20	-
Disc Bush Hog	10	-	-	10	-
Ridgers	297	100	56	141	156
Land Planes (Eversman)	60	-	41	19	41
Planters	200	5	78	117	83
4-Row Cultivators	50	50		-	50
Fertilizer Attachment	168	-	30	158	30
Abu VI Ditchers	15	-		-	-
Trailor Mounted (sprayers)	20	-	17	3	17
Harvesting Machinery					
Groundnut Digger/Shakers	165	67	41	57	116
Groundnut Combines	120	48	25	47	48
Pickup Balers - Bamford	50	50		-	50
Heavy Machinery					
Fiat Allis 16-B (Crawler Tractors)	12	-	6	6	3
Ford 9700 W-Tractors	8	3	4	1	3
Motor Grader-WABCO 444	9	-	3	6	3
Heavy Duty ROME (Disc Harrows)	6	5	1	-	6
Heavy Duty Disc Harrows (TAYLOR-WAY)	6	3	1	2	4
Abu XX Ditcher (EVERSMAN)	4	2	1	1	3

TABLE III REVISED PROGRAMME FOR AGRICULTURAL OPERATIONS SEASON 81/1982

Crop: Groundnuts Area: 95,000

Operation	Total Area	Area Carried Over	No. of Units	Unit Output/ Day	Total Output/ Day	Effective Working Days	Total Area Achieved	Starting Date*	Completion Date*
Cotton Stalk Cutting	90,000	-----	30	12	360	20	7,200	01/03	20/03
Cotton Stalk Cutting	-----	82,800	150	12	1800	46	82,800	21/03	10/05
Disc Harrowing	30,000	-----	35	22	7700	40	6	10/04	20/05
Re-Ridging	90,000	-----	60	33	2000	45	90,000	10/04	30/05
Ridging	40,000	-----	30	33	1000	40	40,000	10/03	25/04
Heavy Disking	10,000	-----	4	40	160	63	10,000	01/02	05/05
Herbicide Application	20,000	-----	17	50	850	25	20,000	15/05	10/06
Green Ridging Row Cultivation	95,000	-----	97	33	3200	30	95,000	15/06	20/07
Harvesting:									
Digging	95,000	-----	173	11	2000	50	95,000	20/10	01/12
Stripping	95,000	-----	173	11	2000	50	95,000	22/10	03/12

* Date is given as Month/Day.

TABLE IV

REVISED PROGRAMME FOR AGRICULTURAL OPERATIONS SEASON 81/1982

Crop: Cotton Area: 130,000 Feddans

Operation	Total	Carried Over	No. of Units	Unit Output/ Day	Total Output	Effective Days	Total	Starting Date*	Finish Date**
Disc Harrowing	120,000	110,000	35	22	770	50	38,000	15/02	09/04
9.5 ft. Disc	-----	71,500	65	22	1430	50	71,500	10/04	30/05
Heavy Disking	10,000	-----	6	40	240	40	10,000	06/05	20/06
Ridging, 4 Row	100,000	-----	100	33	3500	30	100,000	01/06	10/07
Ridging-Fertilized Application	30,000	-----	30	22	660	45	30,000	15/05	25/06
Split Ridging	100,000	-----	114	22	2500	40	100,000	26/06	10/08
Herbicides Application	30,000	-----	17	50	850	35	30,000	30/06	10/08
Planting	130,000	-----	108	30	3250	40	130,000	01/07	20/08
Green Ridging	130,000	-----	100	33	3300	40	130,000	01/08	20/09
Cotton Picking - Mechanical Pickers	30,000	-----	45	9	405	75	30,000	01/01	15/03

* Includes a nightshift as well. ** Date is given as Month/Day.

TABLE V PROPOSED VERSUS ACTUAL MECHANICAL OPERATIONS ACHIEVED 1980/81

Crop: Cotton

Operation	Area		Remarks
	Proposed	Achieved	
Disc Harrowing	30,000	21,798	Part of the area in groundnuts was received very late in June
Heavy Disking	20,000	27,284	
Ridging	57,500	49,949	As above
Ridging and Fertilizer Application	68,500	50,120	Unfavorable conditions (Heavy rains)
Split Ridging	111,081	96,548	Unfavorable conditions (Heavy rains)
Planting	111,081	94,801	Unfavorable conditions (Heavy rains)
Green Ridging*	111,081	17,775	Unfavorable conditions (Heavy rains)

* Green Ridging consists of "running the middles" for purposes of obtaining more efficient application of irrigation water. This operation also eradicates weeds in the furrow between the rows.

TABLE VI PROPOSED VERSUS ACTUAL MECHANICAL OPERATIONS ACHIEVED 1980/81

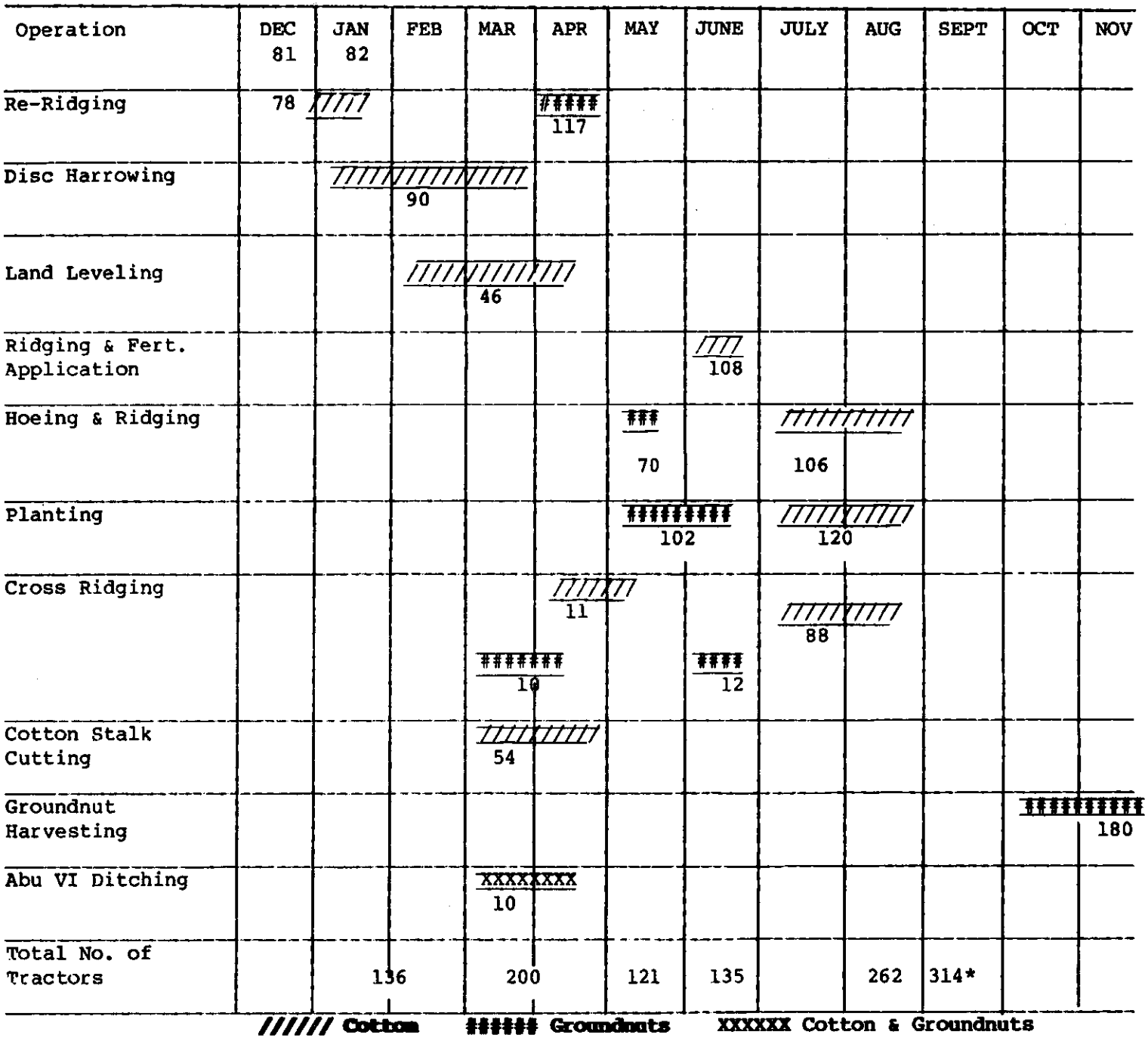
Crop: Groundnuts

Operation	Area		Remarks
	Proposed	Achieved	
Cotton Root Cutting	88,400	88,400	
Ridging (Northern Block)	17,500	14,314	Areas received late from Northern Block
Ridging	75,500	86,496	
Planting	17,500	14,314	
Green Ridging*	17,500	------	Unfavorable conditions
Harvesting:			
- Digging	90,000	63,000	The production area was 63900.
- Stripping	31,500	31,740	Fifty percent of the production area was done due to lack of spare parts.

* Green Ridging consists of "running the middles" for purposes of obtaining more efficient application of irrigation water. This operation also eradicates weeds in the furrow between the rows.

TABLE VII

RAHAD STANDARD PRACTICE - AGR. MECHANIZATION INPUT



* No. of tractors actually used is approximately 400 due to downtime.

APPENDIX D

ECONOMIC ANALYSIS OF AGRICULTURAL ENTERPRISES

by

Rollo Ehrich

Economic Analysis of Agricultural Enterprises[1]

Summary and Conclusions

1. Production decisions are virtually all made by corporation management, with only partial discretion over family labor falling to the tenant. Lack of decision-making ability is undoubtedly a major cause of low yields and production inefficiencies.

2. Costs of production are higher than gross returns from crop sales, leaving both the corporation and its tenants in poor financial condition. Tenant's deficits are eased somewhat by forgiving some cost items, effectively subsidizing the tenant.

3. Seasonal cash flow problems exist owing to the Corporation's failure to advance sufficient funds for weeding and harvesting labor. High interest loans (shail system)[2] were therefore obtained from local merchants.

4. Introducing dura into the rotation would greatly relieve the squeeze on food prices, but may only be a short term solution. A study of the economics of dura production under irrigation is needed.

5. Employment is lower than optimal and wage rates are kept artificially low. Improved labor markets, competition for labor, and reduced subsidies for machinery would do much to alleviate this problem.

6. Village-level markets appear to be thriving, providing efficient service to tenants. Rural capitalists, many being tenants themselves, have seized full market opportunities to develop an apparent efficiently operating local market system.

7. The size of the tenancy should probably be reduced to 11 fed enabling employment of the landless laborers already settled on the scheme, and reducing the need for foreign-exchange for draining machinery imports.

Production Relationships

The purpose of the Rahad Scheme is to produce cotton and groundnuts for export, primarily to generate foreign exchange earnings. The scheme is managed by a public enterprise, the Rahad Corporation, a tightly managed

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1 The author is indebted to Dr. Ahmed Humeida Ahmed for his substantial contribution to this Appendix.

2 Shail also refers to the practice of advance sale of the crop for a price less than that of the harvest price.

and highly structured parastatal organization. Corporate lands are managed by an elaborate system which groups farmer/tenants according to village Block, and Group, each level having an inspector responsible for carrying out agricultural activities according to the policy set by central Corporation management. The tenancy relationship is the key managerial device for organizing production activities.

Conditions of Tenancy

The relationship between tenants and the Rahad Agricultural Corporation is specified in the Rahad Corporation Act of 1971 and detailed in the agricultural agreements between the Corporation (RC) and individual tenants. Tenants are provided with 22 fed of land, water, machine services, seeds, fertilizer and other agricultural inputs. A fixed land and water charge is levied against the tenant and expenses of agricultural operations performed by the Corporation are charged against gross proceeds from crop sales. The current land and water charge is LSd 1.5/irrigation/feddan which is about LSd 85 per year less than full capital and operating costs. The rate will be increased gradually toward the full cost recovery level at project maturity (14th year). The fixed rate charge has the advantage of giving the tenant incentive to apply labor efficiently as proceeds above costs are his to keep, but the tenant thereby takes most of the price and yield risk as a lower than breakeven crop would result in increased indebtedness to the Corporation.

The tenant is responsible for cultivating crops in a rotation specified by the Corporation. Cotton is handed over to the Corporation for marketing. Groundnuts are either marketed by the Corporation or sold on the open market. Proceeds are adjusted for costs and the net amount remaining is returned to the farmer/tenant. Cotton and groundnuts are grown on the "regular" tenancies, with provision for including three fed of fodder on the groundnut half of the 22 feddan rotation. All decisions regarding cultivation and marketing of these principal cash crops are tightly controlled by the Corporation through their elaborate system of field inspectors. Scope exists for the tenant to choose how intensely to apply his own labor and to vary hired labor inputs somewhat. Virtually all other decisions are pre-programmed by the Corporation.

The village production councils ostensibly participate in production decisions but in reality they are at present nothing more than agents for carrying out Corporation orders. Very little feedback from tenants to Corporation management is realized in practice. It is clear, however, that the village councils are pressuring the Corporation for increased decision-making power with regard to choice of crops, timing and intensity of cultivation, marketing, and other fundamental production activities.

Transferring tenancies in the case of death and eviction proceedings are two very live issues between the tenant councils and the Corporation.

Corporation officials categorically refuse to allow the production council to participate in eviction proceedings although the councils are making it quite clear that this has top priority. A tenancy can be transferred to a family member if a tenant dies and if the family member meets the rather stiff eligibility criteria. The production council can nominate another village resident to cultivate the vacant tenancy but the nomination must be approved by the Corporation.

Costs of Production

Production costs exceeded gross revenues from cotton and groundnuts during the last two crop years. On the average, returns to tenants were LSd 30 per feddan for cotton and LSd 32 per feddan for groundnuts. According to the Opeations Appraisal Report developed by the IBRD, low yields and artificially low cotton prices were primarily responsible for the unfavorable economic results. Yields had been projected at six kantars/feddan for cotton but are estimated to be almost half that amount (3.5 kantars/feddan) for the 1980/81 season.

Low yields may be attributed in part to weeds which went uncontrolled owing to heavy rains and somewhat to the untimely delivery of critical machine services. However, it would appear that low and declining yields must be attributed largely to lack of sufficient incentives for tenants. Low prices owing to the artificially low exchange rate were a significant factor. Lack of decision-making authority over choice of crops and cropping practices is another, perhaps critical, factor.

Over 80 percent of the total cost of producing crops is paid directly by the Corporation without passing under the discretion of the tenant. This is a significant index of the lack of decision-making power on the part of the tenant/farmer. For example, while the tenant is billed after harvest for tractor services for plowing, he does not have control over the amount of machine services received, or the timing of application of services. He also does not control the technical operation to any significant degree. Village and Block inspectors determine the nature and timing of machine operations, interacting only minimally with the tenant on assessing possible alternative practices.

Labor inputs are somewhat more controlled by the tenant. However, in reality, hired labor inputs are effectively programmed by the Corporation. The tenant's failure to hire labor and carry out a specific task perceived as necessary by the Corporation is remedied by the Corporation which can hire labor crews on its own account, perform the programmed tasks and bill the tenant for the cost. Thus, virtually no discretion over any inputs except his labor and that of his family is available to the tenant. There is a margin for manuevering the intensity of family labor input although even this is circumscribed by the eviction threat which is a control mechanism both available and used. Nonetheless, interviews with tenants,

inspectors and top management reveal that use of family labor is, in fact, varied significantly in direct response to expected economic and social returns.

This is manifest in the comparative statistics on family labor input for cotton for Village Four and Thirteen. The latter farmers applied all their family labor to cotton and groundnuts, hired labor to undertake some of the tasks, had the lowest level of mechanized operations of any tenant group, yet experienced declining yields and fluctuating income in cotton. They did not reallocate labor to alternative crops or livestock enterprises because their opportunities were virtually nil. Prior to settling on the scheme they had produced dura (sorghum) under rainfed conditions and lacked livestock to provide an income source. Thus, they could not readily divert labor from cultivating cotton in the face of low expected returns. Village Four farmers, in contrast, had livestock enterprises, were more involved in off-farm tasks such as marketing, and were more aggessive about marketing their groundnut crop outside of official channels. They, in effect, neglected the cotton crop because price/cost policies followed by the Corporation made the profit outlook very poor relative to both groundnuts and livestock enterprises from the point of view of the tenant.

The latter problem, coupled with certain inefficiencies in machine use, poor timing of machine operations and failure to recover groundnut costs from tenants, is also the primary cause of the low net income results for the Corporation. These are discussed below.

TABLE 1 COSTS OF PRODUCTION: COTTON AND GROUNDNUTS (1979/80)
(LSd/Feddan)

	Cotton	Groundnuts
Land and Water Charges	18.00	12.00
Materials and Services	86.38	15.04
Machine Operations	18.49	12.88
Labor	54.59	34.00
Total	177.46	73.92

Table 1 summarizes costs of production per feddan for cotton and groundnuts. Several items are noteworthy in addition to the observations made above. First, materials account for virtually half of total cotton costs, with aerial spraying accounting for half of that category. Note

also that labor costs are three times machine costs, indicating that mechanization is not nearly as important as Corporation policy and rhetoric would have one believe. Moreover, labor is relatively more important in producing groundnuts than in producing cotton.

Income

Total - Gross returns to cotton per feddan equalled LSd 147.71 in 1979/80 and returns to groundnuts were LSd 41.75, giving average losses of about LSd 30/feddan for both crops. These losses reflected in the Corporation accounts as increased indebtedness between crop years 1978/79 and 1979/80, amount to LSd 15.8 million. This indebtedness was covered by grace periods written into the foreign donor loans.

IBRD economists, however, estimated that the net cash position of tenants was somewhat better than indicated in these costs and returns data, because the Corporation placed certain charges in a suspense account and forgave cash advances made for labor tasks. Furthermore, tenants for the most part refused to pay costs of operations or groundnuts and sold them on the open market. Thus, gross returns were in effect pocketed by the tenants. No accurate data are available on actual cash returns although the IBRD estimated total returns of around LSd 200 per tenant. Such returns are, of course, not sustainable without continued subsidy. The fundamental problem of low yields must be overcome in order that the scheme would be viable in the longer run.

Another interesting piece of information relates to net returns on horticultural plots. Net returns for 1979/80 exceeded LSd 900 on a "typical" vegetable tenancy according to IBRD estimates, compared to net losses of over LSd 400 on the "regular" cotton and groundnuts tenancies. Several factors combined to produce this rather startling contrast in income results. First, vegetable prices were unusually high during 1979/80. However, second and more important, tenants on horticultural farms have a wide scope for choosing cultivation practices and selecting crops according to potential returns. Relatively unrestricted by the Corporation, they were apparently motivated to apply their own labor intensively and thus reaped larger benefits relative to outcomes on the regular cotton and groundnuts tenancies.

Source and Seasonal Flows of Income - Compiling case histories of tenants through personal interviews, a profile of the income flow situations was constructed and is summarized in Appendix Table 1, which forms the basis for summary Tables 2, 3 and 4.

Table 2 summarizes a typical cash flow situation for a "regular" cotton and groundnut producing tenant. Table 3 summarizes the tenant's major cash labor expenses for cotton and groundnuts production. These are primarily weeding and harvest costs. Weeding is done three times during the months of July and August. Harvest labor is contracted as early as

October, requiring advances to provide incentive payments to migrant workers and to pay costs of transport and a maintenance ration. As machine costs and land and water charges are carried by the Corporation, the tenant's cash expenditures are solely for hired labor and for family food and other supplies. Family food consumption is estimated to be about two sacks of dura per month, two sheep per month, and a kilo of vegetables or beans per week. Given current prices, these essential monthly family maintenance costs are estimated to be about LSd 50/month. Table 4 summarizes the estimated cash surplus/deficit situation by month for the typical cotton/groundnut tenant.

Comparing Tables 2-4, a number of important generalizations regarding income/expenditure patterns, credit and "advances" requirements, and the need for off-farm sources of income to meet critical cash needs during the planting and weeding season can be made. These are:

1) Forward sales of groundnuts and oftentimes, sales of animals are required to meet the heavy cash expenses of weeding during the July-September period. Advances for weeding from the Corporation did not cover the costs of cotton weeding. Compounding this difficulty, the Corporation, in a move to punish tenants for not paying groundnut production costs, suspended advances for weeding for the 1980/81 crop-year. Furthermore, advances are made after the task, not before, exacerbating an already tight cash situation and forcing tenants to obtain credit or sell assets to acquire laborers for critical weeding tasks.

2) Advance sales of groundnuts, using the shail system of credit practiced by local merchants, is highly detrimental to the tenants' income condition. The pre-harvest "shail" price tends to be less than half the actual price realized at harvest time. Pre-task advances and larger advances by the Corporation are recommended to ease this difficult situation.

3) Cooperative buying of food should be considered as a means of pooling "operating" capital resources to spread available cash and credit over the critical expenditure months.

4) Allowing tenants to divert up to three feddans of the groundnut-rotation to production of dura would obviously alleviate some of the constraints on cash availability. Less cash is, of course, required if the basic staple food, dura, is produced on the farm and stored for consumption throughout the year. The primary difficulty with this alternative is the low value per feddan of dura and dura's detrimental effect on soil fertility. A solid study of agronomic and economic alternatives is required to sort out this question.

5) Tenants claim that they received no profits from cotton during 1979/80.

TABLE 2 **CASH INCOME FLOW TO TENANTS: COTTON AND GROUNDNUTS TENANCY***

(LSd/Tenancy)

Factor	MONTH June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
1. Land Preparation	11											
2. Weeding		66	55	33								
3. Harvest Labor Acquisition Costs					66	22				22		
4. Labor Payments for Delivery of Cotton[1]/							44	29	29	29		
5. Cotton Stalk Pulling										18	18	19
6. Profits[5]/												
7. Advances for Food[2]/			25		14			10	10			
8. Sales of Animals	100	100					45	45		30	30	30
9. Off Farm Work[3]/	16									16	16	16
10. Groundnuts[4]/		320					400	400				
11. Total	127	486	80	33	80	22	495	484	39	115	64	65

* Composite of data gathered from Blocks #1, #5, and #7, 1979/80 crop year.

1/ Assumes a yield of three kantars/feddan.

2/ This advance is given for the first three years on new tenancy and is viewed as emergency rations owing to high dura prices.

3/ To earn some food cost. Assuming two sacks/mo/family at LSd 16/sack, and ability to earn one half of needs by working off-farm.

4/ Assume yield of 30 sacks/feddan, 11 feddan. One half of the crop is sold on shail system at LSd 2/sack in July for weeding cash. Remaining half sold at LSd 5/sack in December and January.

5/ Tenants claim that they received no profits from cotton during 1979/80.

TABLE 3 ESTIMATED CASH EXPENDITURES FOR HIRED LABOR: A COMPOSITE OF DATA FROM BLOCKS ONE, FIVE AND SEVEN, 1980/81

(LSd/Tenancy)

	Cotton	Groundnuts[1]	Total
Weeding			
July	15	50-150	50-300
August	150	50-150	50-300
September	150	50-150	50-300
Harvest			
October	35		35
November	30	45	75
December	34	45	79
January	30	45	75
February	30		30

1 Groundnut harvest costs estimated from official sources. Groundnut weeding-cost estimates were highly variable, depending on whether family labor was plentiful. Also, one suspects, production council members may have inflated the estimate to make a case for the unprofitability of groundnuts. This amounted to roughly LSd 200/month during July through September. Harvest labor costs are estimated at about LSd 75/month during November through January.

TABLE 4 **ESTIMATED NET CASH FLOW PER MONTH COTTON AND GROUNDNUTS TENANT 1980/81**

(LSd/Tenancy)

Month	Income	Hired Labor Costs	Family Maintenance Costs	Cash Flow	
				Income Less Costs	Accumulated Net Flow
June	127	---	50	+ 77	----
July	486	200	50	+236	+313
August	80	200	50	-170	+143
September	33	200	50	-217	- 74
October	80	35	50	- 5	- 79
November	22	75	50	-103	-182
December	495	79	50	+366	+184
January	484	75	50	+359	+543
February	39	30	50	- 81	+462
March	115	---	50	+ 65	+527
April	64	---	50	+ 14	+541
May	65	---	50	+ 15	+556

Trends in Yields, Wages and Net Income

Wage Labor Costs - Costs of seeding 11 fed of cotton three times (i.e. wage labor costs) increased from LSd 75-90 in 1977/78 to LSd 310-370 in 1980/81. Advances to tenants for weeding labor costs were less than one-half of the latter figure during 1980/81. Other evidence of bureaucratic lag in meeting rapid inflation in wage costs is manifest in the piece rate for manual cotton picking. The proportion required to be paid by the tenant rose from 25 percent to 40 percent and the absolute piece rate rose from 20PT to 50PT per guffa. Thus, the tenants out-of-pocket cash costs increased four-fold in four years while Corporation cash advances made to the tenant only doubled. Clearly, financial difficulties have caused the Corporation to squeeze tenants. The squeeze in turn probably contributes significantly to the trend toward lower yields reported below, as tenants experience difficulty in hiring weeding and harvesting labor.

The tabulation below summarizes weeding and harvest labor costs trends since 1977/78 for cotton (LSd/Tenancy):

(in LSd)

Cost Item	Year 1977/78	Year 1978/79	Year 1979/80	Year 1980/81
Weeding	75-90	180-210	270-330	310-370
Harvesting[1]	57	74	100	130

Tenant's Net Income - Data are spotty on trends in profit margins for cotton and groundnuts. Interviews with tenants indicated that less than 10 percent of the tenants had profits in 1977/78, 30 percent profited in 1978/79 and 60 percent lost in 1979/80. Although no estimates of the amount of losses are available, it is abundantly evident that cotton farming has become highly unprofitable in the last year or two.

Tenants who were formerly nomads reported that their incomes were higher than previously earned before taking up a tenancy in the Rahad Scheme. However, they qualified their remarks by indicating that net income from the tenancy was lower than income earned in prior years from dryland farming and livestock sales. Combined livestock and cotton/groundnuts proceeds totalled higher than previous incomes indicating that tenants are better off than before but only because they tend livestock herds off the tenancy. Lower than anticipated incomes from cotton and groundnuts results from artificially low prices and low yields.

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1 Assume yield of three kantars (936 lbs. or 26 guffas).

Trends in Yields - All tenants interviewed were convinced that cotton yields declined steadily since the first year of production (1977/78). This is corroborated by official statistics. Tenant interviews and indications from various published materials support the following conclusions on yields of cotton:

1) Average yield dropped from about six to eight kantars/feddan in 1977/78 to four to five kantars/feddan in 1979/80. Expected yield for 1980/81 was 3.5 kantars/feddan.

2) Rising labor costs increased the breakeven yield, so the profit situation has been deteriorating even more rapidly than yield levels.

3) Low yields are attributable to a combination of factors which may be categorized as either inefficiency in corporate service delivery or disincentives to tenants. Inefficiencies include late tractor operations in plowing, seeding and weeding (green-ridging), inappropriate timing of pest control operations, and excessive weeds owing in part to heavy rainfall. Tenant inefficiencies, according to field inspectors interviewed, include unfamiliarity with long furrow irrigation, lack of skills in supervising weeding tasks, absenteeism to care for off-scheme livestock and crop enterprises, and unfamiliarity with critical indicators of pest infestation. Disincentives are lack of say-so in choosing crops and cultivation practices, low expected cotton profits, and failure of the Corporation to recognize tenant security requirements vis-a-vis their staple food grain, dura.

Notes on Employment - Rahad officials insisted that there is a critical shortage of labor for weeding and harvesting of cotton and groundnuts. Moreover, the Corporation's chief concern regarding labor seems to be minimizing costs of production rather than promoting employment and well-being for the resident landless laborers or seasonal migrant laborers from other regions.

Although firm statistical evidence is not available, interviews with laborers, tenants, and Corporation inspectors strongly indicate that employment and income from labor is lower than it could be, given the employment policies of the Corporation. Three policies combine to reduce employment below the socially optimum level. First, the goverment-operated farm enterprises do not compete for labor. Wages are fixed at artificially low rates, and labor supplies are arbitrarily allocated among shemes, ostensibly to avoid "chaotic" competition for labor among state-owned enterprises. Second, the scheme was deliberately "over-settled" with laboring families to provide a pool of laborers and to provide a ready supply of new tenants to replace those who are evicted or choose to leave. The existence of a larger than required, resident labor pool necessarily reduces wage rates because the laborers have diminished opportunities for employment off the scheme. Third, the government's policy is to mechanize as many operations as possible, thereby reducing employment opportunities

and causing downward pressure on wage rates. It is not clear that the degree mechanization is practiced is economically or socially efficient, given the apparent surplus of labor resident on the scheme.

Two actions should be taken to clarify the labor/machine problem. First, an analysis of employment, wages, and capital relationships should be undertaken to determine optimal employment levels. Second, improvement in the labor market could potentially increase both wages and employment. Improved information dissemination, improved transportation schemes for mobilizing seasonal migrant labor, and training programs should be implemented to increase the efficiency of the farm labor market.

Perhaps the action required with most urgency regarding employment issues is a re-examination of the policy of importing cotton picking machines. These machines may or may not be efficient in the longer run. However, in the short run, importing sophisticated cotton harvesters clearly impacts negatively on the well-being of resident landless laborers who were in fact settled on the scheme permanently for the express purpose of providing a reliable labor pool. Cotton harvesters thus directly reduce employment of laborers whose residence on the scheme limits their opportunity to find other employment.

-- Macro-Economic Environment of the Tenant - Marketing, credit institutions, extension services, government price policy are the important factors outside the scheme that affect tenant income and employment levels. The current status, of each factor is described below and tentative recommendations for improvement are made.

Marketing - Prior to the scheme, traditional markets existed in a few scattered villages. As stated in the IBRD Appraisal Report, 1972:

> "There are weekly markets in a few major villages and many merchants provide high interest credit against the security of crops, resulting in poor prices to the farmers. All the facilities and institutions are scaled to a very low level of rainfed farming and agricultural services are almost totally lacking."

At present, village markets operate daily in the Block headquarters villages (one for every five villages) and each village has a small periodic market for food, household goods and livestock. Construction and maintenance of these market places is the responsibility of the villages and their councils, as no provision was made for construction of buildings and stalls by the Rahad Corporation. Despite official Corporation neglect of this important service institution, village markets are apparently flourishing, owing largely to council efforts to promote such facilities and tenant-family entrepreneurship. A high percentage of merchants dealing

in staple grains, animals, household goods, vegetables and groundnuts are also tenants on the scheme. Backgrounds of other merchants include agents of merchants in larger towns and cities, independent merchants having no farm connections, and part-time laborers engaging in petty trade.

Markets in the "scheme" villages appear to be patterned closely on the traditional village market systems found throughout Sudan, as described in the latest sector assessment published by the IBRD (May 18, 1979, Annex 7). As reported by the IBRD sector survey, markets for some food crops such as millet and cassava are handled entirely by private marketing arrangements with virtually no state participation. At the other extreme are several major crops such as sorghum (dura), groundnuts, gum arabic, and sesame, the marketing of which involve the private trading sector, the provincial governments and government export monopolies at various stages. The latter type of exporter/monoply is typified by the Sudan Oilseeds company. This parastatal corporation deals in all oilseeds and implements floor prices set by the Ministry of Finance. The company is obligated to purchase oilseeds if the price offered by wholesale merchants falls below their floor and wholesalers are obliged to sell to the company at no more than a predetermined maximum price. A major problem with this price stabilization scheme is that the official range in price is often established too late into the harvests or funds are insufficient to implement the required purchases.

The major food grain, sorghum, has a minimum price set by government policy. However, prices in recent years have tended to be above the official floor level owing to export demand by Near East neighbors. Price policy will be explored in greater depth, below. Institutional market forces are described in the following profile of a village food market drawn from an interview with one marketer in Village 10.

-- A local food Market (The "Welfare Shop", Village 10) - Ahd Alla Mohamed, proprietor is a merchant selling sorghum, dried foods, household goods, and a few luxury items from a corrugated iron structure in a prime location in the Village-10 market. He is the first son of a tenant on the scheme and is one of 11 family members. He dropped out of secondary school to support the education of his younger siblings. Seven of the family work the tenancy and four work in the shop.

The merchant buys locally produced farm commodities including groundnuts, onions, dried tomatoes, peppers, and okra, as well as retailing these commodities. Most of his retail and wholesale customers come from Villages Six through Ten, which make up Block 2. Six shops compete with the merchant interviewed in selling . Credit is given "in kind" (sugar, salt, dry goods, etc.) to tenants during slack seasons.

Merchants pay LSd 25/year for rental fees to the village council. Capital investment in the "typical" shop included: LSd 1000 for a zinc covered building, LSd 35 for a display table, LSd 120 for a scale, LSd 15

for display tins and LSd 12 for measuring tins. Measuring tins included:

1--1/2 kala (2 malwa) (1/4 kala is 7 lbs. of dura

1--mala

1--1//2 malwa

1--1/4 malwa.

-- Profit from trade in dura - A typical sack (110 lbs.) of dura is purchased from one of the mechanized rainfed schemes. It is purchased at about LSd 15/sack, transport costs of LSD 1 are added, plus a local market tax of 80PT and 25PT for the sack, bringing the retail sale price to LSd 17.05. Adding a profit of LSd 1/sack, the final retail price equals LSd 18.05. It can be ground next door to the retailer for an additional LSd 1.50/sack. The particular dura sold by the Welfare Shop is purchased directly from a private, rainfed, mechanized scheme in northeastern Sudan (gadaraif) at the rate of 180 sacks per month. Most of the commodity is sold at retail but a significant amount is sold to "dealers" from other villages in the Block (6, 7, 8, and 9). The dealers were not merchants but rather representatives of groups of families of the same village.

If dura were to be grown on the scheme the merchant felt that he would lose a significant amount of his trade. He seemed sanguine about the prospect, indicating that expansion of other lines of trade such as household essentials, other grains, and dealing in groundnuts, onions, and fodder would sustain him.

-- The groundnut trade - This merchant's second most important item of trade was dealing in groundnuts produced by tenants in the Block. Purchases were largely direct from the farmer for cash but a significant amount was purchased under the shail system, (contracting at a relatively low price prior to harvest and receiving delivery at this fixed price when harvested). The merchant refused to discuss the terms of purchase under the shail arrangement as others were within listening distance of the interview.

The merchant markets the groundnuts by selling about 75 percent to agents from the Sudan Oilseed company and about 25 percent to private, independent merchants. About 4,000 sacks were marketed during the 1979/80 season but none were traded this year (1980/81). The reason given for this was that the price is too high and other lines of trade are expanding, requiring more of his management attention. (Perhaps the merchant was not being completely truthful at this point because the "parallel" market in groundnuts is a volatile issue throughout Sudan, with recent attempts at controlling the illicit trade outside of official markets ending in failure). The 1979/80 price paid was about LSd 9.00/sack compared to LSd

8.5 on the official market.

-- Prices - Table 5 summarizes prices paid for farm produce on the day of the interviews. It is noteworthy that the major farm products of the zone found a regular market with sufficient demand to establish firm prices on a daily basis. There were at least two or three merchants competing for the farmer's goods in the market place.

TABLE 5 PURCHASE PRICES OF COMMODITIES

Commodity	Unit Measure	(in LSd) Price/Unit
groundnuts	sack (kantar)	9.00
peppers	sack (10 lbs.)	6.00
tomatoes (dried)	sack (kantar)	60.00
onions	sack (180 lbs.)	18.00
okra	sack (90 lbs.)	25.00
goat and kid (breeding)	one + kid	40.00
cattle		
calves		60.00
medium size cows and bulls		75.80
large, thin cows and bulls		130.--
large, fat cows and bulls		175.--
sheep		
small		25-30
medium		35-40
large		50-70

-- A profile of livestock marketing - The cattle merchants interviewed in the Village-10 market places were from the town of Kassala. They have a regular 10-15 day turnaround in purchasing cattle in the large Kassala market where over 300-400 head are sold per day during the dry season and even larger numbers during the wet season. Merchants usually buy and sell only locally in Kassala during the wet season as travel is difficult, prices are low, and money is not flowing from the tenants on the scheme. Thus, livestock have a regular market only during the dry season.

Cattle are "guaranteed" regarding ownership by a certification process in Kassala province. The local village council also issues a certificate at 25PT per certificate, paid by both buyer and seller. Other marketing costs include LSd 60 for 18 days of labor to tend the animals, and LSd 60 paid to local tenants for 10-15 days grazing. The merchants pool their livestock (about 65 head over the two-week period) and contract with the

local farmers for fodder and grazing. About LSd 5-10 per animal is gained in profit by the cattle merchant. Eight percent of the cattle are sold for meat and 20 percent for breeding stock. Cattle are purchased in the town of Kassala on an individual sale basis, there being no public auction system at that location.

-- Conclusions on local marketing systems - There is a thriving, apparently efficient private trade in food grains, groundnuts, vegetables, and livestock. Dura is a staple commodity forming the basis for a large number of competitive small traders in the Block headquarters on the scheme. Indigenous farmer traders called "rural capitalists" by one Gezira Scheme official interviewed, seem to gain reasonable profits and provide an essential service to Rahad tenant farmers. Private capital, provided largely out of personal savings, is the primary source for construction of market places, working capital requirements and credit for farmers. Village level market services including space, certification of goods and settlement of disputes are financed through a tax levied on each item sold.

Indigenous trade apparently provides a significant level of non-farm employment for families settled on the scheme. Participation in marketing ranges from permanent shop-management to casual selling of animals to gain cash needed for essentials. Despite (or perhaps because of) official neglect by the Rahad Croporation, adequate trade in essentials needed by scheme residents appears to be thriving.

Credit and Extension - The shail system of credit practiced by private merchants is a means of acquiring working capital to pay production costs such as weeding labor while crops are still in the field. In the absence of official development credit the tenant appears to be at the mercy of the merchant in that the preharvest "shail" price is often less than 1/2 the harvest time price. Given that credit is only used for about four months during the growing season, the implied interest rate is over 300 percent per year. The net income of tenants could be greatly enhanced by introducing an official credit system that would enable the producer to finance his production costs at reasonable rates.

Extension services, while in the plans for development of the Rahad Scheme, are virtually non-existent. At present, the village inspector doubles as a carrier of technical information and as a manager of farm production activities. It is apparent that management tasks take priority and that little time is left for extending new production techniques and practices to the tenants. In a very real sense, extension broadly defined would not be required because the tenant has virtually no decision-making power. If tenants were to be given more scope to make production decisions then a functioning extension service would be imperative.

Key Policy Issues - The welfare of the tenant is adversely affected by certain key government policies. The exchange rate structure subsidizes machinery imports thereby reducing employment and wage rates. Further, the

price of cotton is kept artificially low by applying the official exchange rate which is virtually one-half the market rate. This squeeze plus rapidly inflating sorghum prices owing to the policy of exporting sorghum to oil producing Arab countries, has greatly reduced the tenant's real income position during the last few years. The impact of rising sorghum prices could be eased somewhat by allowing tenants to include sorghum in their rotation, although the efficacy of so doing must await a study of alternatives. For example, would it be more rational to reduce exports, making food supplies for cash-crop producing corporations higher priority, extending guaranties to tenants, and growing sorghum only under rainfed conditions?

The large size of tenancy (22 fed) and the implied need for mechanization is a policy much in dispute by diverse analysts of the scheme. The Hunting report of 1965, Dr. Ali Zaki (Michigan State University Thesis), and officials of the Corporation interviewed, support the thesis that an ideal tenancy size for cotton and groundnuts is 11 fed. A family with two adolescent children could easily carryout most of the tasks without using machinery except for heavy land preparation. Employment would be increased and yields would ostensibly increase, as greater labor intensity plus increased decision-making authority should stimulate productivity.

APPENDIX TABLE

methods used to compute hired labor costs of producing cotton: tasks performed by machine, and family labor (1981) [1]

(in LSd/Tenancy)

Task	Block #1	Block #5[2]	Block #7[5]
land preparation	M	M	M
weeding	N.A.[3]	495-990[3]	210-366
distribution	N.A.	F	F
resowing	N.A.	F	F
water course repair	N.A.	F	LSd 14-21
irrigation	F	F	F[5]
reridging	M	M	M
spraying for insects	M	M	M
harvesting[4]		LSd 110 advance	LSd 110
advance		+ 50 PT/guffa	+ 50 PT/guffa

1 F indicates family labor, M indicates machine use.

2 About fifty percent of weeding and harvesting labor is provided by the family and fifty percent is hired labor. Machines were used for land preparation and seeding.

3 Machine for "green ridging."

4 Machine picking was practiced in Block #1, although some labor was hired to pick ends. It was not clear whether it would pay to send laborers over the field after the machine harvester had pased. Standard practice is to advance the tenant LSd 110 (LSd 10/feddan) to acquire outside labor. This advance is distributed approximately as follows for an 11-feddan holding:

a) LSd 5 per picker is paid as incentive prior to moving. Approximately one picker or adult family member is required per feddan.) (LSd 55 maximum) The average for Block #5 was seven pickers, so we calculate LSd 35 for this element.

b) One sack of dura plus LSd 10 cash to purchase food for a group of five to six pickers (LSd 52). (Maximum of LSd 55 per tenancy) Average of seven pickers gives about LSd 30 total.

c) Fifty PT/guffa is paid as cotton is picked and weighed. The Corporation pays LSd 30/guffa and the tenant must provide the remaining LSd 20/guffa. Assuming an average

yield of four kantars/feddan, harvesting costs would equal LSd 17/feddan or LSd 187/tenancy. If family labor is 1/2 of the total, then total cash costs are LSd 94.

d) Summarizing hired labor costs for harvesting cotton approximate LSd 159 per tenancy (11 fed of cotton) under conditions found in Block #5.

5 a) Harvest. As these villagers were historically cotton pickers on other schemes, they did almost all operations by hand, hiring local labor from the approximately 200 landless families which settled in the village. An average of seven pickers were hired. Tenant family labor averaged three persons. Assuming a low yield of two kantars/feddan (first full year of production), the total harvest labor "bill" would be LSd 93.5 x 7/12 = LSd 54.5.

b) Weeding. Three weedings are required costing LSd 7-12/feddan/weeding for hired labor. Family labor was mostly used in Block #7.

c) Other. As this village was experiencing its first crop, some irrigation tasks that normally are done by family labor were performed by hired, skilled laborers. Preparing the water course and irrigating required two laborers for a "few" days.

APPENDIX E

LABOUR/TENANT RELATIONS IN THE RAHAD IRRIGATION PROJECT

by

Mohamed Abdel Rahim Mohamed Salih

Labour/Tenant Relations in the Rahad Irrigation Project

One of the objectives of the Rahad scheme is the provision of 90,000 employment opportunities for seasonal and permanent labour. The maximum number of tenants was projected to be about 14,000 consisting of tenants to cultivate medium staple cotton, groundnuts and fodder and a second category to cultivate vegetables and fruits. The primary objective of the project is to bring under modern utilization part of the Sudan share of Nile waters to cultivate 300,000 fed of the Rahad area. This area had been traditionally used for subsistance rainfed agriculture and/or as pasture by the nomadic tribes of the Kawakla, Shukriya, Rufa'een, Araki'een, Muslamiya and Gal'ain. An intensive two course rotation for medium cotton, groundnuts and fodder is being applied in 22 fed tenancies and five fed tenancies of vegetables and fruits per family. The Rahad Corporation was aware of the great need for casual and permanent labour and anticipated competition with other mechanized rainfed and irrigation schemes. The labour issue is reflected in its selection of medium staple cotton which can be picked early October instead of the long staple cotton which can be picked in December, theoretically reducing competition over cotton pickers. In practice this was not realized because of both the late handling of land preparation and irrigation problems delaying cotton planting until September and subsequently picking until December or early January (the same time for cotton picking in the Gezira).

The second approach for avoiding competition over cotton pickers with other schemes is the introduction of mechanical pickers which was envisaged as a way to reduce dependency on casual labour. In 1977/78 the Rahad Scheme was to start production with 50,392 fed of cotton, vegetables and fruits. About 20 new villages were established and about 6,000 tenants were moved inside the scheme. Some permanent labour moved along with the tenants from their old villages to the new ones. In other villages tenants moved as individuals leaving behind their families whom they expected would follow after the rainy season. Nonetheless, the early arriving tenants largely missed the first agricultural season because of the delay of land preparation and the supply of water for irrigation until late September. The total labour requirement forecasted for that season was 57,000 people for cotton picking alone. With little experience in labour recruitment, the special Corporation recruitment committee could only recruit about 35,000 people who began to arrive at the scheme in early January 1978. The labour shortage of 22,000 was due to the fact that the new scheme was still little known for casual labour opportunities and because the areas of labour sources were dominated by specialized recruitment committees from other schemes, such as the Gezira Board which alone employs more than 1/2 million casual labourers. A second problem with recruiting cotton pickers in that first agricultural season was the shortage of trucks and gasoline which contributed very much to the shortage of labour.

In the 1980/81 agricultural season, the committee for labour recruitment was able to recruit about 14,000 seasonal labourers from Western Sudan (including about 221 from the Red Sea and Kassala provinces). Individual tenants recruited about 35,300 labourers (60 percent) to make a total of 49,400 labourers. At this level of demand, the Rahad Scheme has entered into serious competition over casual labour with the already established mechanized rainfed and irrigated schemes in Gezira, Kassala and the Blue Nile provinces. It is not surprising to know, however, that even in its first year of production the Rahad Scheme had absorbed more than the 30,000 annual demand rate for seasonal labour (ILO Report: 1976, p. 103).

The need for such a high amount of labour in the Rahad Scheme can be justified by the lack of experience of those Rahad tenants who were mostly nomads or semi-nomads with little experience in irrigated agriculture. In such a case, casual labour may have two roles to play: first, to supplement the tenants labour input in carrying out labour-intensive agricultural operations and second, to transfer experience in irrigated agriculture gained from involvement in similar field operations on other irrigated schemes. This experience is invaluable for inexperienced tenants to obtain the basics of irrigated agriculture in a tenancy size exceeding family labour capacity. The need of labour to supplement tenant labour in the Rahad Scheme is inevitable because 22 feddan tenancies are distributed regardless of family size. In short, the need for casual labour will continue if the Rahad project is to survive with the present size of tenancies per family. An agricultural labour policy also needs to be developed within the context of an effective labour recruitment office.

Sources and Recruitment of Labour

The total number of agricultural labourers who move in response to geographic disparities in employment opportunities in the Sudan is estimated to be about seven million. Of this amount two million find their way to Gezira, Kassala, and the Blue Nile provinces where most of the rainfed and large irrigation schemes are located (ILO Report: 1976, p. 91). The majority come from the western regions of Kordofan and Darfur, the Southern Region, foreigners from Chad, Central West Africa, and Northern Nigeria. Few recruits are from the villages surrounding the rainfed schemes in Kassala or the Red Sea province. These areas of vast mechanized schemes are hosts for large numbers of labourers because the schemes are located in low density population areas benefitting from access to Nile waters and/or annual rainfall suitable for crop production at an economic cost.

The labourers who work in these schemes including the Rahad project are of two kinds. First, there are permanent labourers who are settled in Project communities. Second, there are seasonal labourers who are recruited annually to participate in labour-intensive agricultural operations, such as weeding and cotton picking, cotton stalk clearing and groundnut harvesting. Seasonal labour migration is generated by many

factors. The most important factor is the need of labourers to increase their low incomes from subsistance agriculture or nomadism. Secondly, it is generated by displacements due to climatic disasters, such as rain fluctuation, decline of land fertility due to the absence of a rotation system or the lack of any means of pest and disease control. These negative factors shaping crop production together with the rudimentary techniques used in traditional agriculture constitute the main reasons for seasonal movement for employment enabling farmers and herdsmen to bridge the gap in their still poor incomes. These seasonal labourers normally become permanent residents in rainfed or irrigation schemes in central Sudan.

Unlike the Gezira Scheme, some of the permanent labourers moved from old villages were given tenancies in the Rahad Scheme. These tenancies were not distributed according to ethnic or tribal origin. As a result of their long association with the original inhabitants of the Project area, some of the landless moved their families onto the Scheme.

The recruitment of seasonal labourers depends on techniques similar to those developed by the Gezira Scheme. The official recruitment of labourers in the Rahad Scheme is achieved by a special committee known as Seasonal Labour Recruitment Committee. This committee is responsible for forecasting labour requirements for cotton picking, identifying labour sources, contracting village sheikhs and tribal headmen to assist in labour recruitment and to facilitate transport. The committee is also responsible for estimating the financial requirements for increased labour. Rahad Scheme officials estimate that the total money paid for labour recruitment in the present agricultural season will be about LSd 1,000,000. Although there is no written contract between the Rahad Scheme and seasonal labourers, the LSd 1 paid as an advance per adult picker, food supplies and other benefits provided by the tenants to encourage labourers to stay until they finish picking and clearing the stalks of their tenancies is a type of informal contract.

A good deal of seasonal labour is recruited through direct tenant/labour contact where a group of tenants may delegate three to four tenants to travel to labour sources visiting labourers in their villages and recruiting labourers on their behalf. Normally they collect the advances from all the interested tenants and hire a truck for this purpose. When these labourers arrive at the scheme they are given some grass to build a "rakuba" shelter for their settlement. Some sorghum, onion, sugar, cooking oil, okra, salt and tea are also given to them to maintain themselves until they begin their work. It is worth mentioning that these payments, though not considered by the tenants as advances, usually affect their income since labourers normally accept less payments than those who did not receive such advances. It is not unusual to find a whole family recruited for cotton picking. Also it is not unusual to find a group of 250-300 labourers from the same village recruited to work in one Block. Such a large group of people have better a chance to bargain for more than the 35 PT per gufa (35 lbs.) of picked cotton.

The demand for seasonal labour increases during the eight months December-July. During these months most of the labour intensive agricultural operations occur. These labour-intensive operations are cotton picking, groundnut digging and cotton stalk clearing. These seasonal labourers can move from one Block of the Scheme to another after they finish picking the tenancies of those who recruited them and who offered them return transport to their villages. Seasonal labourers are usually contacted by the same tenants each year, and they sometimes come with a promise to work for them for another agricultural season. They may also change their destination for a better employment opportunity.

Income and Working Conditions

It is difficult to calculate exact income for seasonal or permanent labour because incomes vary considerably from person to person and according to agricultural operation performed. An estimate* of average incomes from labour-intensive agricultural operations follows:

A. The average daily income for one cotton picker is about LSd 1.4 (picking 140 lbs. per day). For three months of continuous work an individual can earn about LSd 126. Additional income can be earned from clearing cotton stalks. Total income from the period of three to five months of work may amount to about LSd 198. With a daily expenditure of around 95 PT savings can amount to about LSd 75 for the whole period of work.

B. Whereas the sesonal labourer may confine himself to cotton picking and cotton stalks clearing, the permanent labourer has a variety of farm and non-farm employment opportunities to choose from. The following are etimates of the annual income of an average family of five persons (husband, wife and their two to three children), from the most labour-intensive labour operations.

Cotton	LSd
Weeding	250
Picking	210
Cotton Stalk Clearing	90
Packing	75
Groundnuts	
Weeding	280
Digging and Threshing	180
Total	1085

* Estimate is based upon field interviews conducted in February 1981.

The average earnings given here are for a husband and his wife. These earnings also exclude off-farm activities which are available for very few people.

Average monthly expenditures for such a couple together with their one to two children are as follows:

Expenditures	lbs.		LSd	Total LSd
sorghum flour	210	x	.10	21.00
sugar	30	x	.50	15.00
tea	2 - 5	x	1.40	3.50
coffee	2 - 5	x	2.00	5.50
cooking oil	6	x	.70	4.20
salt	3	x	.10	.30
okra	2	x	2.00	4.00
onions	30	x	.15	4.50
vegetables				3.00
lubia (beans)	8	x	.30	2.40
kerosene	2 bottles	x	.20	0.40
firewood				7.50
charcoal	2 sacks	x	4.00	8.00
matches	7 packs	x	.05	0.35

Items computed from annual expenditures to fit monthly expenditures

clothes and shoes	10.00
social obligations	2.50
medicines	1.50
self-help	2.50
building	10.00
transport	5.00
utensils	2.00
GRAND TOTAL =	89.65

The average monthly expenditures for a medium size family of four to five persons is about LSd 89.65. Such a family may get an average saving of about 49 pt. per month excluding all off-farm income possibilities which may be available for them. It also excludes income from livestock which can augment their family budget.

To place these figures in their national context one has to compare them with the minimum wage of LSd 28 per month in an organized urban sector. It is obvious that the minimum average daily income for a seasonal labourer is about LSd 1.4 and for the permanent labourer LSd 3.0 per day. In other words both seasonal and permanent labourers are better than those who work for the urban sector for LSd .93 per day.

However, one should give equal weight to the bad working conditions in which seasonal and permanent labourers gain their relatively high incomes. The seasonal labourer comes to the Project with high hopes to obtain enough money to support himself during his work period and to save enough for his family. They reside in very bad housing conditions where one may find more than six to eight persons living in one small reed hut at the fringes of the tenancies close to irrigation canals. They are also exposed to malaria and schistosomiasis and no precautions are taken to protect them. Shortage of medicine to treat infected people is common not only for the labourers but also for all those who live in the Scheme.

The absence of any institutional body to organize tenant/labourer relations and to secure the payment of the required wage to the labourer after completion imposes psychological and material uncertainity on the labourer. Labourers complain about tenant failure to pay labour wages and/or to meet promises to provide free advances.

The now classic labour versus machine dispute represents itself in a very different shape in the Rahad Project. Here one encounters a situation where hand labour is more desirable and machine labour is under attack by different parties. For the tenant, it is far better to depend on hand labour for cotton picking because it is both more efficient and to their satisfaction. Also, hand picking is said to be about LSd 20 cheaper than mechanical picking (calculations are based upon 11 fed tenancies).

It was stated earlier that the Rahad Project has targetted 100 percent mechanization for groundnuts and 80 percent mechanization for cotton in order to reduce dependency on wage labour for labour-intensive agricultural operations. It is also suggested that the introduction of mechanization has yet to create major confrontation and competition between labourers and mechanization. The labourer's attitude, however, should be reconsidered. In the state of affairs where manual labour is in shortage one has to make a balance between labour/machine requirements and to determine the suitability of each more selectively.

Tenant/Labour Relations

Three types of relations exist between tenants and labourers in the Rahad Project. First, there is a brief relationship between a tenant and a seasonal labourer which is based on the principle of buyer/seller. This first group of labourers are highly mobile males who come to the project especially for cotton picking and cotton stalk clearing. After obtaining

enough money they return to their villages.

The second group consists of some semi-permanent labourers who settle in a single place but keep moving from one Block to another searching for employment. Others may spend the dry season in an off-farm activity in the towns and villages adjacent to the Rahad river. They usually collect firewood, manufacture charcoal, or seek employment in urban centers. This second category has more intimate relations with other labourers rather than tenants whose relationship with them is not different from that of the first group.

The third group is the permanent labourers who live continuously in the villages. They may secure a partnership with one of the tenants, obtain a permanent occupation outside the Scheme in one of the small market places, or shift from one agricultural activity to another throughout the year. This last group of permanent labourers has very close relations with the tenants wherein they equally participate in the payment of self-help contributions, and in collective labour through the nafir system.

These different types of labourers are found in most villages in the Scheme and tenants deal with each group according to status as a seasonal, a semi-permanent or a permanent labourer. The need of any labourer to do certain agricultural operations depends on the tenant's family size, the availability of cash or any other asset which can be transformed into cash and whether the tenant and his family commit themselves to their tenancy or split for other off-farm activities, such as livestock herding. Farmers normally supplement wage labour with another kind of traditional mobilization of labour, the nafir system. The nafir is a system of reciprocal labor whereby tenants and permanent labourers help each other to weed a tenancy, to build a school, a mosque or a house for an individual who requires assistance. As an obigatory institution to organize labor, the nafir provider offers food and drinks to the participants and is expected to participate in other nafirs.

In some villages both permanent labourers and tenants participate in self-help activities by volunteering to build dressing-stations, schools or mosques with local material (mostly built of grass). In contrast with seasonal labourers who just disappear after they obtain some money, the permanent labourers consider themselves part of the new community despite their different tribal and ethnic origin.

It is not unusual, though, to find some of the seasonal labourers being discriminated against by tenants , especially when the former try to share the inadequate educational and health services available. However, most of the tenants and labourers depend on their own incomes to purchase medicine from urban centres instead of depending on poorly equipped dressing-stations and the few medicines available in them.

Since labourers are non-tenants they have no right to be represented in the village production committee. As a link between the tenants, and

the Rahad Corporation, the village production committee has nothing to do with labour recruitment or the settlement of disputes between labourers and tenants. In the event of problems over payment which sometimes occur between the labourers and tenants, tenants normally refer to traditional shaikhs or tribal headmen in the village before they take the dispute to the formal courts. Seasonal labourers, on the other hand, refer to the inspectors and not to the influencial leaders at the community level to solve problems over payment.

In short, there is no formal institutional body to organize the relationship between tenants and seasonal labourers. Permanent labourers may become members of the village councils, yet these councils have little to do with the production relations in the Scheme. Seasonal labourers are also excluded from the membership of village councils because they have no right to become members of more than one village council (village of origin and village of orientation in the Scheme). Multiple membership would make the national distribution of supplies under the rationing system more complex. These supplies include sugar, soap, wheat flour, rice and cheap cloth "Damoriya." Sorghum is also distributed under a rationing system in the Rahad Scheme. The seasonal labourers have no option but to buy these items from the black market for high prices.

As far as the shortage of sorghum is concerned, it can be explained by two factors. First, sorghum is not included in the present rotation system which means that the majority of the population in the Scheme area has been transformed from food producers to food consumers. Second, the existence of about 50,000 seasonal labourers in the Project area who consume almost 80,000 sacks of sorghum during the period from December to July is another contributing factor to the steady increase in sorghum prices (from LSd 7.5 to LSd 18.1 in four years). The increasing demand for sorghum, is the major cause of rising prices despite the fact that sorghum is produced in export quantities and at a very economic cost in the rainfed mechanized farms only aabout 100 km from Kassala province. However, seasonal labourers have no access to sorghum distributed under the rationing system since they are not registered members of the village councils.

Conclusions

Seasonal and permanent labourers make major inputs to the Rahad project. First, they bring their experiences gained from their involvement in similar activities in other irrigation schemes and second, they contribute to the scheme by supplying the labour force needed to carry out labour-intensive agricultural operations. Despite the lack of any institutional body to help organize the tenant/labour relationship, labourers participate in nafir and self-help activities which reflect a growing sense of "community."

The Scheme may have some negative health impacts on seasonal labourers since they live inside the tenancies exposing themselves to malaria and schistosomiasis by bathing and drinking in the canals. It is also obvious that these seasonal labourers have very slim (if any) access to the slim educational and health services available in the Scheme.

The existence of such a large demand for basic food crops in a scheme which lacks sorghum in its two course rotation system means that sorghum prices are inevitably going to rise. Both tenants and labourers suffer from a sorghum shortage. The situation for seasonal labourers is the worst since they depend on the black market to obtain their food.

Finally, the Rahad Scheme has created some employment opportunities for seasonal labourers who get higher earnings than that of better organized labour in urban centres. By involving people from different regions, the Rahad Scheme has contributed to a wider inter-regional distribution of incomes. The quest for future development of the scheme is to create an integrated community life between the labourers and tenants.

The discrepancy between the forecasted amount of labour required and the actual number recruited indicates that competition between these labourers and mechanized operations is not at a climax. This is because most of the tenants believe that mechanical picking is not to their satisfaction and that manual picking is both efficient, cleaner and cheaper.

ANNEX F

ENVIRONMENT AND NATURAL RESOURCES

by Stephen F. Lintner[1/]

I. INTRODUCTION

Implementation of the Rahad Irrigation Project (Project) resulted in the transformation of an approximately 300,000 feddan tract of nearly level black clay land covered in brush, scrub and open savannah into an irrigated agricultural tract for the production of cotton, groundnuts, fodder and horticultural crops. The Project is supplied with irrigation water from the Blue Nile at Meina utilizing a major electrically powered pumping station and an 80 kilometer (km) supply canal. The Rahad River, which flows seasonally from July to November, serves as a supplementary water source. All discharges into the Project Area are controlled by the Rahad Barrage which serves to regulate the flow levels.

Within the Project Area, water is distributed through a 90 km main irrigation canal which connects to approximately 5,700 km of smaller canals. The canalization is designed to operate on a night storage system. The drainage systems collect surface runoff from fields and minor drains into the main collector drains. Drains run parallel and adjacent to the main irrigation canal to protect it from runoff from higher land to the east. Drainage canals empty into uncultivated lands adjacent to the Project and do not transfer waste waters to adjacent seasonal stream channels.

Agriculturalists resident on the Project come from villages directly incorporated into the Project or from adjacent agricultural and nomadic populations. In addition to cultivation of crops under the supervision of the Rahad Agricultural Corporation (Corporation), the local population maintains large numbers of livestock on the Project and in non-irrigated

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[1/]The author wishes to acknowledge the assistance of the following persons in preparation of this Annex: Carroll Collier, Pesticides Management Specialist, Office of Agriculture, Bureau for Science and Technology, A.I.D. (Washington, D.C.); John J. Gaudet, Regional Environmental Officer, A.I.D., Regional Economic Development Office Services Offices, East Africa (Nairobi, Kenya); Brian Johnson, Senior Fellow, International Institute for Environment and Development (London, England); Frederick W. Whittemore, Pesticides Management Specialist, Office of Agriculture, Bureau for Science and Technology, A.I.D. (Washington, D.C.).

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areas adjacent to the Project.[2/] Sorghum is cultivated under traditional rain-fed methods at the margins of the Project Area and adjacent to the supply canal. Constructional wood, fuelwood and charcoal are imported into the Project Area from traditional sources, the riparian floodplains of the Rahad and Dinder Rivers, and more recently from the vicinity of El Gedaref to the northeast of the Project Area.

The Project provides an early example of a large-scale international development project which was subjected to ecological/environmental examination by the donors prior to finalization of project design and implementation. Environmental aspects of the Project were examined by the World Bank; these findings were later reviewed and incorporated into the Project Paper prepared by A.I.D.[3/] [4/] The following environmental issues were identified as of potential concern at the time: (a) creation of vector habitat for water-borne diseases (malaria, schistosomiasis, etc.); (b) management of agricultural chemicals (insecticides, herbicides, etc.) for crop protection; (c) health aspects of Aflatoxin (a fungus-related substance) on groundnuts; and (d) disruption of migratory routes of native game to and from the Dinder National Park.[5/] These concerns were reviewed by the Government of Sudan prior to the signing of the Project agreements, which included a condition requiring the Government of Sudan to develop a program for the control and treatment of schistosomiasis and malaria in the Project Area acceptable to the donors.

[2/] Survey data provided by Dr. Idris Ali Ibrahim, Director, Division of Animal Production, Rahad Agricultural Corporation, indicated that Project residents owned the following livestock:

Animal Type	Inside Scheme	Outside Scheme	Total
Cattle	23,000	47,000	70,000
Goats and Sheep	200,000	300,000	500,000
Camels	-	7,000	7,000

[3/] It should be noted that the ecological/environmental examination was prepared prior to the development of formal procedures for the environmental review of projects by the World Bank and A.I.D.

[4/] Annex VIII, "Analysis of the Project's Ecological Impact," 1973, pp. 22-24.

[5/] Potential impacts to native game were reviewed by the Game Department, Government of Sudan, and technical experts provided by the United Nations Food and Agriculture Organization (UN/FAO); see Holsworth (1968) and Dasmann (1972).

II. EVALUATION CONCERNS

This Annex reviews the environmental and natural resource aspect of the Project, placing emphasis on:

-- Examination of the scope of the advance ecological/environmental examination and its utilization in project design, project decision making and project implementation.

-- Examination of the primary and secondary impacts of the Project, placing emphasis on the success of advance ecological/environmental examination to identify and propose mitigations for these impacts.

-- Examination of the methods employed and level of success achieved for the mitigation of environmental impacts identified in advance.

-- Identification of impact areas and provision of realistic and implementable mitigation activities.

-- Examination of methods to improve the environmental planning of future development projects of this type.

The Annex is based upon field studies conducted in the Sudan during February 1, 1981 to February 27, 1981, supplemented with literature review and discussions with individuals expert on the Sudan or specific technical aspects of the evaluation. It should be noted that the majority of the information is qualitative in nature and should be understood to suggest only trends rather than the more firm findings of a quantitatively based analysis. Execution of the study was complicated by the tendency on the part of both management and senior technical experts to report the findings and recommendations of feasibility and planning studies as implemented programs.

III. REVIEW OF ADVANCE ECOLOGICAL/ENVIRONMENTAL STUDIES

Project implementation resulted, as anticipated in the advance study, in the creation of significant environmental management problems with regard to the prevention of water-borne diseases and agricultural chemicals. Aflatoxin[6/] on groundnuts, as predicted in the advance study, did not develop into a problem due to the local techniques utilized in groundnut harvesting. Direct impacts to Dinder National Park were significantly reduced by adoption of the option of supplying irrigation water by construction of a pumping station at Meina rather than by a gravity flow from Roseires Dam. This design change, made on the basis of economic evaluation, resulted in shifting the water supply canal to the north, which greatly reduced disruption of native game migratory routes.

[6/] Aflatoxin is a substance produced by the common fungus Aspergillus flavus.

Secondary impacts received little attention in Project planning or analysis. In many ways, Project management chose to restrict their concerns to the irrigation water supply system, irrigation tract and internal transport system. Previously unidentified secondary impacts, predominantly outside the area under jurisdiction of the Corporation, include: (a) displacement of traditional nomadic herdsmen and their livestock, resulting in displacement of native game and overgrazing in areas adjacent to the water supply canal and irrigated area; (b) creation of a market for wood (for structural and fuel use) and charcoal with resulting localized degradation of available resources adjacent to the development area; and (c) creation of an incremental increase in development pressure on Dinder National Park through items (a) and (b) above. Unanticipated environmental benefits of the Project include (a) creation of extensive bird habitat in the irrigated area, (b) creation of fish habitat in the irrigation canal system, and (c) a reduction of grazing pressure from traditional nomadic herdsmen within the Es Soki Irrigation Scheme and adjacent non-irrigated lands.

The Project represents a case where, despite the identification and recognition of the major environmental problems in advance by the donors and host country, the Project design and implementation plan was unsuccessful in addressing these problems through effective mitigation measures. Notable success has been achieved in the reduction in the incidence of malaria and in the prevention of the spread of schistosomiasis within the Project Area; however, this has been principally the result of timely external intervention of the Blue Nile Health Project (World Health Organization/Government of Sudan) rather than as the result of Project design. The limited development of an institutional capability within the Project Area to control water-borne diseases, provide for environmental sanitation and assure the safe supply of potable water has been most noteworthy. The failure of the initial environmental analysis to systematically review crop protection techniques and alternatives resulted in a long-term commitment to large-scale chemical control in the Project Area.

IV. PLANNING ISSUES

A comprehensive understanding of the environmental and natural resource aspect of the Project requires review of the following basic planning issues.

A. Water Rights

At the time of the Project design, the Sudan had entered into a water rights agreement with Egypt[7]; however, no water rights agreement existed, nor currently exists, with the upstream riparian on the Blue Nile, Ethiopia.[8] It should be noted that at the time Ethiopia was under the traditional monarch, Haile Selassie, and was considered to be a politically stable pro-Western country. Sudanese development strategy has

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[7] Agreement for the Full Utilization of the Nile Waters, November 8, 1959.

[8] Waterbury, 1979, p. 75.

focused on the conservation of White Nile water through such projects as the Jongeli Canal to allow for the increased use of Blue Nile Waters for irrigation while still meeting the water supply levels agreed to under terms of the 1959 agreement with Egypt. Hence, it is critical that Blue Nile flows be reliable for maintenance of the existing areas under irrigation and the development of additional areas, such as the proposed Rahad Stage II expansion of 400,000 feddans.

International cooperation between Ethiopia and Sudan is also desirable in terms of limiting the rates of siltation in the Roseires Dam in order to maintain storage capacity and hence capacity to both generate power and irrigate. Rates of siltation at Roseires have significantly exceeded initial estimates with the result that the reservoir of the dam would be filled 10 to 20 years earlier than planned without the intervention of improved watershed management techniques or dredging of the reservoir. In order to maintain existing power generation and irrigation and to create a capacity for expansion or intensification of cropping in completed projects, the heightening of the Roseires Dam is currently being investigated by international donors.

B. Analysis of Technical Alternatives[9/]

Studies conducted by donors examined two technical alternatives for conveyance of irrigation water to the Rahad Project: (a) gravity flow from Roseires Dam and (b) pumping with electrically powered equipment from a station at Meina. Selection of the pumping option resulted from an evaluation of the internal rate of return which utilized an energy cost of "0", assumed a fixed investment in power generation capacity at Sennar and Roseires Dams, and assumed that the project could be implemented one year earlier due to reduced construction time.

It is suggested that had the environmental review been broader in its topical concerns and scope that this issue would have been more rigorously reviewed from both short- and long-term aspects. The analysis neglected evaluation of long-term demand growth and opportunity cost on power. It should be noted that the additional production year benefit from the selection of the pumping option was not realized, while the opportunity cost and demand for power has increased significantly. In addition, the Ministry of Irrigation has been forced to assume significantly higher operation and maintenance costs with the pumping alternative.

C. Sudanese Retrospection

In reviewing programmatic alternatives, some Government of Sudan officials questioned retrospectively the wisdom of investing in irrigated agriculture rather than rain-fed agriculture and livestock production in

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9/ See A.I.D., 1973, Annex II, "Alternative Technical Approaches Considered for the Rahad Irrigation Project."

terms of both financial return and national/regional development priorities. A senior official stated that at the time it cost $1,900/feddan to develop irrigated land in comparison to $100/feddan to develop rain-fed land and questioned the distribution of benefits from different investment options. It was also noted that up to a 100 percent increase in yields from areas under traditional agriculture could be obtained with improved seed, weed control and assistance in marketing.

Sudanese officials noted that overexpansion of capital infrastructure during the 1970s, especially in the irrigation sector, simultaneously with the massive increase in international employment opportunities in professional, technical and skilled labor areas, has resulted in delays in project implementation, operational problems and poor maintenance. Several senior experts felt that the original concept of supplying water to the Project through a gravity flow canal from Roseires Dam was better than the pumping alternative which was adopted. They cited the dramatic changes in the cost of energy and rapid expansion in demand for electricity (especially in Khartoum) in support of their position. It was argued that the future focus of Government of Sudan and foreign donor activity should be in the rehabilitation of existing irrigation systems rather than their expansion. The recent World Bank project for rehabilitation of the Gezira Scheme represents an action in this direction.

V. ENVIRONMENTAL IMPACTS

A. Introduction

Environmental management within the Project Area is highly fragmented, without clear lines of authority. Administrative and technical responsibilities are assigned to numerous organizations which operate at a variety of structural levels and derive their capital and operational funds from different sources of varying reliability. These organizations are characterized internally by excessive compartmentalization of operating divisions and have limited (often informal) coordinating mechanisms with external organizations. In addition, poor linkage exists between the research activities of international and national organizations such as the Agricultural Research Corporation and organizations responsible for project design, implementation and operation. The inability to mobilize sufficient manpower and resources to address key issues in a timely manner has resulted in "crisis planning."

The inadequacy of financial and human resources available to organizations greatly restricts their ability to implement program responsibilities. The Corporation and the Government of Sudan have difficulty in retaining professional/technical staff with advanced degrees (M.S., M.P.H., Ph.D.) due to competition from employment opportunities in both the internal private sector (crop protection contractors, for example) and the Arabian Gulf.[10/] Many of the technical specialists are assigned to the Corporation on a consultancy basis or are on secondment from other Government of Sudan organizations. The resulting shortage and

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[10/] Democratic Republic of Sudan, Rahad Irrigation Project, 1980, p. 111.

instability of staff has affected successful implementation of crop protection, public health and water supply activities within the Project Area. The lack of professional staff is compounded by an inadequate supply of mechanics and technicians, again due to pressure from foreign labor markets. In many instances, management and operational problems result from the inability of the responsible organization to deploy personnel in the field due to an insufficient number of field vehicles and inadequate vehicle maintenance.

B. Primary Impacts

Primary environmental impacts are those which are directly related to the project under evaluation. Principal primary impacts associated with the Project were in the areas of (a) water-borne diseases/public health and (b) management of agricultural chemicals.

1. Public Health/Water-Borne Diseases

a. Institutional Aspects

The provision of public health services, control of disease and provision of domestic water supply is highly fractionalized between a number of Government of Sudan authorities. This fragmentation is compounded by the interventions of the Blue Nile Health Project which is jointly sponsored by the World Health Organization and the Government of Sudan. The limited development of an indigenous institutional capability within the Project Area to: (a) control water-borne diseases, (b) provide for environmental sanitation, (c) assure the safe supply of potable water and (d) implement a health education program, has been most noteworthy and problematic.

(1) Government of Sudan

Preventative health activities within the Project Area have been designed to address the widely recognized risks of the transmission of malaria and schistosomiasis due to the creation of extensive vector habitat through the construction of the irrigation system. A secondary area of emphasis has been the control of diarrheal and eye diseases. An integrated strategy has been adopted for the control of water-borne diseases in the Project Area which focuses on: (a) disease control, (b) a public health program to improve health through the provision of a treated domestic water supply and proper sanitation and (c) a health education program. Implementation of this control program has been greatly delayed by insufficient staff, capital funds, operation and maintenance budgets, medical supplies and organizational problems. The socioeconomic implications of malaria, schistosomiasis and diarrheal diseases are reflected in the general poor health of the population, low worker productivity and the expenditures for disease control and health care. It has been estimated by health authorities that in 1974 an average of 33 work days per tenant were lost due to malaria in the Gezira Scheme.[11/]

[11/] World Health Organization, 1980, Plan of Activities, p. 29.

Health services in general are under the authority of the provincial governments and are divided between public health and curative health services. Public health services are under the direction of a Senior Health Inspector and include divisions headed by Public Health Officers to address malaria, schistosomiasis and environmental health/sanitation. Curative health services are under the direction of a Senior Medical Assistant who is responsible for management of health facilities. Health facilities in the Project Area (see Map 6) include:

-- One hospital at el Fau;

-- One health center at Village 10;

-- Eleven dispensaries;

-- Twelve permanent dressing stations; and

-- Thirteen temporary dressing stations.

Services provided at these facilities are hampered by shortages of staff (especially laboratory technicians) and medicines. Salaries and inadequate housing are critical constraints to the recruitment and retention of professional and technical staff. Outreach programs for sanitation and health education as well as health services to migrant workers are almost non-existent due to an inadequate number of vehicles and fuel shortages. Facilities and services are at a low level of development in the North Group due to delays in Project implementation. The buildings which house health facilities are experiencing serious structural damage due to shrinking and swelling clays.

Villagers generally reported that health in the Project Area was better than in their original villages or as nomadic herdsmen. There was a constant complaint from villagers and health staff about the inadequacy or absence of medical supplies, especially common drugs.

(2) Blue Nile Health Project

The Blue Nile Health Project is a comprehensive multidisciplinary program directed at the preventative control and curative activities for the control of major water-borne diseases, especially schistosomiasis and malaria, in the Project and in the Gezira Scheme. The program places emphasis on examination of new methods for the integrated control of these diseases and the reduction of costs through the introduction of new techniques. The Project is jointly sponsored by the World Health Organization and Government of Sudan through the Ministry of Health; the Project has received financial support from a number of international donors including the World Bank and A.I.D. The total budget for the Project over its planned ten years (1979-1989) is $159.6 million, however, delays in donor subscription to date have slowed down implementation considerably. The Blue Nile Health Project has also suffered from delays in staffing and the acquisition of materials.

It is an applied research project with the objective of developing a long-term strategy to considerably reduce the incidence of malaria, schistosomiasis and diarrheal diseases in irrigated schemes. The Project emphasizes the testing of cost effective control techniques; emphasizing environmental management, biological control, community participation and health education with an objective of reducing foreign exchange costs. In addition to the research focus, the Project also plans to improve basic health services, water supply and sanitation and train designers of water resource projects in methods of preventing and controlling water-borne diseases.

In the context of the problem of fragmented jurisdiction combined with inadequate staff and budgets discussed above, the Blue Nile Health Project introduces an additional level of activity which due to its external source of funding provides a convenient target for actual or theoretical transfer of responsibilities. Underfunded local organizations have been all too willing to "transfer" their responsibilities to this Project, frequently without any formal procedures; hence, informants stated that the Blue Nile Health Project was responsible for activities within the Project Area to include:

-- Monitoring for malaria and schistosomiasis;

-- Procurement and application of chemicals for control of malaria and schistosomiasis;

-- Technical assistance and spare parts for domestic water supply systems; and

-- Health education.

The lack of clarity concerning delimitation of areas of responsibility between the Government of Sudan, particularly the Corporation and the Blue Nile Health Project, are best exemplified by statements such as:

-- "A programme to combat water-borne disease is to be provided by the World Health Organization during 1980."[12/]

-- In January 1980 a continuous programme to control and eradicate the snails is to commence. In addition a mission from the World Health Organization is to spend time at the project. It is envisaged that they will carry out a programme of education of the tenants as well as surveys, and treatment of the disease."[13/]

b. Disease Control

A program of preventative control of water-borne diseases jointly implemented by the Corporation and the Blue Nile Health Project has been successful in reducing the incidence of malaria in the Project Area and

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12/ Democratic Republic of Sudan, 1980, Director's Report, p. 20.

13/ Ibid., p. 21.

controlling the transmission of schistosomiasis. This program has been successful due to the timely intervention of the Blue Nile Health Project, which has provided critical technical advice, chemicals, drugs and logistical support. Blue Nile Health Project serves to technically and financially supplement the activities of the Corporation and other Government of Sudan organizations. It has been especially important in the rapid procurement of materials from the international market which require payment in foreign exchange.

Migrant laborers and their families are an important element in the introduction and transmission of disease in the Project Area, especially malaria, schistosomiasis, relapsing fever and lischmanaisis. They are annually recruited to pick cotton (December-March) and come predominantly from Korodofan and Darfur Provinces in Western Sudan. Trucks transporting migratory laborers are required to stop at checkpoints as they enter the scheme where all laborers are dusted with DDT and given a dose of an anti-malarial drug (most commonly Chloroquine and Pyremethemine). They live in temporary camps without basic facilities. Therefore, defecation is indiscriminate; domestic water is taken from canals and drains, while bathing by both sexes is conducted in the canals.

The provision of health and social services is sporadic and inadequate. It includes annual vaccinations against immunitable diseases and distribution of anti-malaria drugs at crossroads and population collection points. The people have no access to safe water supplies nor do they have facilities for waste disposal.

An additional disease control problem is posed by the large-scale movement of individuals between the Project Area and landholdings in areas occupied before joining the Project. This is most common where land has been retained for the production of dura or where grazing rights exist.

(1) Schistosomiasis

There are two forms of human schistosomiasis in the resident and migratory population of the Project Area. They are (a) Schistomsoma haematobium, which causes disease of the urinary system, and (b) Schistosoma mansoni, which is responsible for a chronic disabling disease affecting the liver and intestines. Both forms depend on certain small species as intermediate hosts in their life cycle. These snails inhabit fresh water sources throughout Africa and the Near East. Man-made water impoundments and irrigation schemes have created an extensive new habitat for the intermediate hosts and the disease.

Within the Project Area, schistosomiasis control activities have focused on prevention of the introduction and establishment of transmission in the Project Area. Control techniques include the following types of interventions: (a) environmental management (to eliminate or decrease potential habitats), (b) biological control (snail competitors and predators), (c) domestic water supply and sanitation, (d) chemotherapy and (e) health education.

There was no schistosomiasis transmission in the Project Area prior to construction of the canal system and current transmission has been controlled through a monitoring and mollusciciding program overseen by the Blue Nile Health Project. Until the end of 1979, the Project Area was free of the snail intermediate hosts of schistosomiasis; however, in January, 1980, two snail species (Bimphalaria pfeifferi and Bulinus truncatus[14/]) were found in the canals. Following a rapid field survey, all canals infested with snails are sprayed with Bayluscide (25 percent emulsifiable concentrate) along their edges. The molluscicide was applied at an average dose of 0.2 milligrams (mg)/cubic meter.

Following a survey to identify infected individuals conducted by the Blue Nile Health Project, a program of schistosomiasis chemotherapy was initiated which involved the administration of Oxamniquine (Vansil) for the intestinal variety and Metrifonate for the urinary variety. Discussions with experts from the Blue Nile Health Project emphasized the view that changes in the unit cost of drugs utilized in chemotherapy could greatly alter the recommended disease control strategy in the Project Area. It was noted that current costs are $4.50 per dose, while those of newly developed drugs are anticipated to be $1.00.

According to studies conducted by the Blue Nile Health Project[15/], the incidence of schistosoma mansoni was 9 percent and schistosoma haematobium was less than 1 percent. There was an insufficient incidence of schistosoma haematobium to show any trends in prevalence or geographical distribution. It was found that schistosoma mansoni had a general tendency of higher prevalence in the North Group, where many of the residents are from the Gezira Scheme. Prevalence of infection was low in young children, increasing to a maximum of 15 percent at 20 years of age, then declining in an irregular pattern.

(2) Malaria

The Project Area is within the major endemic zone in which malaria was traditionally hyper-epidemic with seasonal transmission during the rainy season (July to October). Project implementation which allows for the provision of a permanent water supply has transformed the disease incidence pattern to an annual transmission with peak occurrence in the rainy season. The principal mosquito vector is Anopheles gambiae, with Anopheles pharoensis also prevalent in the Project Area. Primary breeding areas include the smaller canals and drains, pond water adjacent to fields and wastewater pools in the vicinity of villages. As the result of long exposure to low-level dosages from drifting residues of agricultural chemicals, mosquitoes in the Sudan have developed a high level of resistance to most common pesticides. Studies indicate that Anopheles gambiae has developed resistance to DDT but remains susceptible to malathien.

[14/] It has recently been documented that molluscicide resistance in Bulinus truncatus has developed in the Gezira Scheme following several years of utilizing trifenmorph (World Health Organization, 1980, Report 643, p. 16).

[15/] World Health Organization, Draft Report, 1981.

Malaria control focuses on larvae and pupae control, control of adults, protective doses of anti-malarial drugs to residents, together with passive and active surveys for the disease. Larvae and pupae control is carried out by Corporation staff which spray larvicide (Abate at 10 cubic centimeters [cc]/10 liters of water) into the minors, subminors, drains and stagnant pools between November and June. Adult control consists of spraying buildings and dwellings with DDT [2 grams (gm) active ingredient/square meter], a residual insecticide. As a protective measure and in an attempt to reduce the number of parasite carriers, the Corporation has developed a program of giving doses of chloroquine and paramathraine to migrant laborers. In 1979, the Corporation gave doses to 18,305 migrant workers.16/

According to survey data, supported by laboratory analyses, the incidence of malaria is less than 1 percent of the permanent population. This indicates the generally successful implementation of the mosquito control operation and chemo-prophylaxis activities. However, it should be noted that on the basis of clinical diagnosis approximately 25 percent of the outpatients at the hospital in el Fau and approximately 50 percent of the patients visiting the health clinics suffered from "malaria." These cases are believed by the staff of the Blue Nile Health Project to represent fevers of non-malarial origin. Residents in the Project Area take large amounts of anti-malarial drugs on an irregular basis, which is also felt to be a contributing factor to the low number of cases.

(3) Diarrheal and Eye Diseases

Residents of the Project Area experience a high incidence of diarrheal and eye diseases, predominantly conjunctivitis. A review of the daily patient register at el Fau Hospital indicated that approximately 12 percent of the patients suffered from diarrheal diseases and 10 percent from eye diseases. The incidence of diarrhea is highest during the summer season due to the intensive breeding of flies associated with unsanitary fecal and solid waste disposal at the village level. Children have the highest incidence of diarrheal and eye disease with numerous infant deaths being attributed by health workers to diarrhea. The Government of Sudan has started an oral rehydration program to combat diarrheal diseases, while eye diseases are treated with irregularly available drugs. Locations favorable to fly breeding are treated by removal and/or burning solid waste and by locally dusting with DDT 75 percent powder. The prevalence of both disease types is the highest in the North Group, which can be attributed to the inadequate development of social infrastructure and poor provision of services to this area.

The incidence of these diseases cannot be reduced until there is an improvement in basic sanitary practices within the Project Area; particularly necessary is a significant improvement in the control of flies. Health education programs are necessary to improve personal sanitation habits, including the washing of hands after defecation and improved food preparation especially with regard to children's and

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16/ Democratic Republic of Sudan, 1980, Director's Report, p. 20.

purchased foods. Community sanitation services also require improvements: excreta and solid waste disposal need to be improved and domestic water supply systems need to be more reliable.

C. Domestic Water Supply

The construction of domestic water supplies at both el Fau and the villages is the responsibility of the Division of Civil Engineering of the Corporation; continuing operation and maintenance is the responsibility of the Governorate, and inspection of water quality and hygiene is that of the Ministry of Health of the Governorate. All villages in the Project Area are provided with a piped water supply delivered at standpipes (see Map 7) with a design per capita consumption of 80 liter/day. The siting of standpipes is done by the engineering staff without consultation with village authorities or health/social science personnel. It is not anticipated that house connections will be made other than at Corporation headquarters in el Fau. At the time of the evaluation, the following levels of service had been attained:

-- El Fau was provided with water from a moderate water treatment plant.

-- Twenty-four villages receive surface water which is drawn from canals and treated through sedimentation and use of a slow-sand filter.

-- Ten villages have slow-sand filter systems under construction with water being presently supplied from canals.

-- Twelve villages utilized groundwater as a source of supply. In most cases, the systems employ drilled wells equipped with a deep well pump driven by a diesel engine.

All systems involved the pumping of water to elevated storage tanks from which it flows by gravity to the standposts by distribution pipes. When improved supply systems have problems, attempts are made to have tanker trucks supply treated water to the villagers. However, in most instances villagers are forced to draw untreated water from the canal for domestic purposes.

A variety of problems occur with the water supply systems which force or encourage villagers to utilize water directly from the canal. They include the following:

-- Residents frequently draw domestic water from the canals as it is more convenient than going to the standpipe. Due to the lack of an active health education program, they are unaware of the health risks associated with the use of untreated water.

-- Water levels in the canals are frequently below the level necessary for flow into the intakes of the slow-sand filter

systems. Failure of the system to be supplied with water forces villagers to obtain water supplies from the canal with both a reduction in health standards and loss of time devoted to drawing water.

-- Inadequate maintenance of the slow-sand filters results in blockage of the filter with sediment and forces the water treatment system to be either bypassed or closed down.

-- Current designs do not provide adequately for the safe watering of livestock with wastewater from the standpipes. This has resulted in villagers blocking the sinks and the water taps in order to utilize them as water troughs. This creates unsanitary conditions at the standpipe and restricts human access.

-- Standpipes are currently poorly maintained, frequently resulting in the contamination of the water supply at the tap and unsanitary conditions in the vicinity of the standpipe. Pooled wastewater and mud often characterize conditions in the vicinity of standpipes. The pooled water provides breeding habitat for disease vectors, while the mud obstructs access to the standpipe and serves to trap garbage and animal wastes.

-- Shortages of fuel on an occasional basis and the inaccessability by road to villages to deliver fuel during the rainy season result in the groundwater well pumps and storage tower pumps not being used.

Resolution of the problems identified above would require strengthening of the operation and maintenance program, system design modifications and the development of improved backup systems. A health education program would be required to improve resident understanding between health/ sanitation and the source of domestic water supplies.

D. Sanitation

Public sanitation standards in the Project Area are extremely low and are best characterized as follows:

> The results of this [survey] have thrown light on the appalling conditions of latrine accommodations, which are grossly defective and primitive as well as the most unsatisfactory situation of the community, which is very short in summer and very polluted. The general standard of cleanliness in houses in the villages is very bad. The result is that diarrheal diseases are rife in those areas . . . Co-habitation with animals is almost a universal habit and this adds to the filthy conditions in the environment.[17/]

In el Fau and Division Headquarters, there are public and private water carriage latrines and toilets which are connected to septic tanks.

[17/] Satti, 1974, Preface.

The tanks are emptied by corporate vacuum pump trucks and the septage is dumped into uncultivated lands adjacent to the Project Area. Although the public latrines and toilets are poorly maintained and poorly cleaned, they are utilized. Due to poor vehicle maintenance, the vacuum pump trucks are frequently out of service (4 out of 12 trucks were operational in February 1981), which results in septic tank overflows adjacent to public buildings and private homes. Solid waste is collected in el Fau and taken to the desert for disposal; some residents burn waste in their yards.

A program to build public latrines for the use of villagers proved to be a failure and has been discontinued. The Corporation has provided villages with four sets of four latrines which were not used for cultural (especially by previously nomadic people) and aesthetic reasons (due to poor maintenance and cleaning) by the local population. Fecal wastes are most commonly deposited at the edges of villages, boundaries of fields and immediately adjacent to spoil banks which parallel canals. Solid wastes are deposited at the edges of villages, where they are periodically burned to reduce odors and to control flies and rodents.

Improvement of public sanitation standards in the Project Area would require the initiation of a large-scale health education program which would focus at the school and community level. It is also necessary to implement a socially acceptable latrine program and to improve solid waste collection and disposal methods.

E. Health Education

Little has been done in the Project Area with regard to health education at either the school, health facility or adult education/ extension level due to the limited resources available and the low priority it has been given by Project management. High priority should be given to the development of a program directed toward the mothers of infants and small children. Current plans of the Government of Sudan and the Blue Nile Health Project call for development of a program similar to that in the Gezira Scheme which engages in the following activities:

-- Training of health workers and teachers on different health education activities;

-- Conducting informational meetings with different school and community groups;

-- Arranging for television and radio broadcasts on important local health problems;

-- Showing films in villages related to health activities;

-- Participation in health center activities, especially in the areas of nutrition and child care; and

-- Distributing posters and pamphlets to school and community groups.

F. Management of Agricultural Chemicals

1. Institutional Aspects

The Division of Plant Protection is responsible for the selection, management and application of pesticides, herbicides, fungicides, defoliants and rodenticides in field areas. It supplies DDT and rodenticides to the Division of Public Health for use in villages and houses. It provides equipment, chemicals and limited technical advice to residents of horticultural tenancies. Control of pests occurring at the national level--locusts, grasshoppers, migratory birds, etc.--is the responsibility of the Division of Plant Protection, Ministry of Agriculture. The Irrigation Works Corporation, Ministry of Irrigation, is responsible for management and control of aquatic weeds in the primary and secondary canals.

2. Principal Pests and Their Control

Crop protection activities on the Project involve the intensive and extensive use of a variety of agricultural chemicals, including insecticides (Tables F-1, F-2), herbicides (Table F-3), defoliants, fungicides and rodenticides (Table F-4). These chemicals are predominantly used for the production of cotton, especially for control of the whitefly (Bemissia tabaci), which secretes a sticky substance on the cotton lint deteriorating its quality and sales value. Other common cotton insect pests include Jassid (Empoasca lybica), Aphid (Aphid Aphis) and American bollworm (Heliothis armigera).

Crop protection activities presently form about 30 percent of the cost of cotton production. Chemicals are obtained through international tenders and spot market purchases from France, Italy, Netherlands, Switzerland, United Kingdom, United States and West Germany. Presently, 99 different pesticides have been approved for use on cotton crops in the Sudan[18/], reflecting the high level of restivity developed by insect pests to these substances. In addition, substantial quantities of pesticides (principally DDT) are used for the control of malaria mosquitoes and molluscicides for control of snail species involved in the life cycles of two schistosome genera.

During the recent growing season, most cotton fields were treated 11 times with aerially applied insecticides; tractor-applied herbicides were used to control weeds, while areas to be mechanically harvested were treated two times with aerially applied defoliants. Horticultural plots are treated with insecticides and fungicides on an individual basis by tenants utilizing knapsack sprayers.

3. Current Management Issues

When the Project was appraised, crop protection techniques then in use in the Gezira Scheme were directly transferred with the assumption

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[18/] El Amin, et al., 1980.

Table F-1. Insecticides Applied to Cotton During 1980/1981 Growing Season (in Liters)

Chemical		South Group			Middle Group			North Group		TOTAL
Commercial Name	Technical Name	1	2	3	4	5	6	7*	8*	
Applied by the Crop Protection Division										
Roger 32	Dimethoate	18,768	21,828	7,752	21,420	25,704	23,052		17,136	135,660
Torbidan 10	Toxaphene + Methyl Parathion	11,424	16,932	19,584	23,460	20,604	26,724	24,276		143,004
Thimul 50	Endosulfan	11,016	16,728	5,100	19,380	19,992	24,684	-	-	96,900
Thimul/Roger	Endosulfan + Dimethoate	25,296	22,236	26,112	15,504	25,092	20,196	-	-	134,436
Vanval	Unknown	7,140	7,752	9,588	14,892	17,340	26,316	-	-	83,028
Torbidan ULV	Toxaphene + Methyl Parathion	13,668	12,240	13,872	-	6,324	6,528	-	-	52,362
Azodrin/DDT	Monocrotophos + DDT	23,868	17,340	22,440	19,380	15,912	59,364	-	-	158,304
Dursban ULV	Chlorpyrifos	-	12,852	17,136	16,728	-	-	-	-	46,716
Bidrin 24%	Dicrotophos	-	-	4,080	23,664	-	17,136	-	-	44,880
Heliotox	Toxaphene + DDT	25,704	14,484	-	19,788	11,220	15,708	-	-	86,904
Dursban 4 E.C.	Chlorpyrifos	-	-	204	-	2,244	-	-	-	2,448
Ekalux	Quinalphos	6,528	12,852		5,100	6,936	6,120	-	-	37,536
Hostathion	Triazophos	1,020	-	-	612	-	-	-	2,652	4,284
Applied by Ciba-Geigy Under "Package-Deal" Arrangement										
Curacron	Profenofos	-	-	-	-	-	-	21,301	4,740	26,041
Roger/Dysuate	Dimethoate +	-	-	-	-	-	-	19,678	17,864	37,542
Indosulfan	Endosulfan	-	-	-	-	-	-	26,359	23,922	50,281
Nuvacroh	Aysdrin	-	-	-	-	-	-	22,304	17,011	39,315
DDT	DDT	-	-	-	-	-	-	-	478	478

*Ciba-Geigy applied pesticides on Block 7-8 from August 26 to November 15, 1980; thereafter pesticides were applied by the Rahad Agricultural Corporation.

Source: Compiled by Stephen F. Lintner, Bureau for Near East, A.I.D., from data provided by Dr. Salah el Sheikh Bashir, Director, Crop Protection Division, Rahad Agricultural Corporation.

Table F-2. Insecticides Used for Other Than Cotton During 1980/1981 Growing Season

Chemical		Cotton Collecting Centers	Research	Public Health	Horticulture	TOTAL
Commercial Name	Chemical Name					
Sumicidine	Fenvalerate	-	204 L	612 L	-	816 L
Thimul/Roger	Endosulfan +	-	36 L	-	-	816 L
Heliotox	Toxaphene	-	816 L	-	-	816 L
Thimul 50	Endosulfan	294 L	-	102 L		396 L
Folimat	Omethoate, Dimethoateme +	-	-	-	204 L	204 L
Roger 32	Dimethoate	-	271 L	-	816 L	1087 L
Torbidan 10	Toxaphene + Methyl Parathion	-	612 L	-	-	612 L
Sevin	Carbaryl	-	36 cartons	-	-	36 cartons
Vantal	Dimethoate + DDT	-	204 L	204 L	-	408 L
Lannate	Methoniyl	-	1 carton	-	-	1 carton
Aldrex T	10% Aldrin + 10 % Parathion	-	204 L	-	-	204 L
Sofril	Sulfur	-	204 L	-	-	204 L

Source: Compiled by Stephen F. Lintner, Bureau for Near East, A.I.D., from data provided by Dr. Salah el Sheikh Bashir, Director, Crop Production, Rahad Agricultural Corporation.

Table F-3. Herbicides Applied During 1980/1981 Growing Season

Commercial Name	Chemical Name	South Group 1	2	3	Middle Group 4	5	6	North Group 7	8	TOTAL
Balan (liters)	Benefin, Benfluralins Bethrodine	25,246	-	-	-	-	-	-	-	25,246
Ronstar (liters)	Oxadiazon	3,225	3,110	-	-	4,690	5,880	530	1,360	18,795
Cotoran (kg)	Fluometuron	-	-	-	2,707	240	1,005	-	-	3,952
Zorial (kg)	Norflurazon	625	625	625	-	625	1,000	-	-	3,500
Treftan (liters)	Unknown	2,200	2,500	-	-	-	-	-	-	4,700
Stomp (liters)	Pendimethalin	4,700	-	-	-	490	3,590	-	-	8,780
Gramaxone (liters)	Paraquat	-	660	-	-	-	-	-	-	660

Source: Compiled by Stephen F. Lintner, Bureau for Near East, A.I.D., from data provided by Dr. Salah el Sheikh Bashir, Director, Crop Production, Rahad Agricultural Corporation.

Table F-4. Defoliants, Fungicides and Rodenticides Applied in the South Group During 1980/1981 Growing Season

	Commercial Name	Chemical Name	South Group			TOTAL
		Defoliants	Block 1	Block 2	Block 3	
1(a)	Def 6 and	5, 5, 5 - Tributylphosphorotrithioate	2949 L	4210 L	1105 L	8264 L
(b)	Grammoxone	Daraquat	1651 L	2358 L	619 L	4628 L
2(a)	Dropp and	Thidiazurone	295 kg	421 kg	110 kg	826 kg
(b)	Sunoil	Unknown	1474 L	2105 L	552 L	4131 L
		Fungicides				
	Sofril	Sulfur	150 kg			
		Rodenticides	8 tons of zinc phosphate, mixed with sorghum at a rate of 3% for application			

Source: Compiled by Stephen F. Lintner, Bureau for Near East, A.I.D., from data provided by Dr. Salah el Sheikh Bashir, Director, Crop Production, Rahad Agricultural Corporation

that the use of agricultural chemicals was the optimal solution. This resulted in the failure to initiate early efforts in the examination of alternative techniques of crop protection and has resulted in the Corporation being trapped in an ever-escalating need to obtain foreign exchange to finance the purchase of agricultural chemicals, aerial spraying services and application equipment. Physically and economically effective crop protection requires the continuous review of technical alternatives; in the case of Rahad, as in the Gezira, the failure to do this has led to an over-concentration on the large-scale application of chemical controls.

The heavy use of pesticides has given rise to some obvious problems. The major insect pest of cotton, the whitefly, has evolved genetic resistance to commonly used insecticides, creating economic havoc. Adding to the problem, DDT and malathion applied to cotton have drifted into mosquito habitats, giving rise to genetically resistant strains of malaria mosquitos. Extensive use of chemicals has also resulted in a radical decline in native parasites and predators of pest species. Environmental problems are aggravated through the poor operational standards utilized by both contract and government aerial spraying operations. These include overapplication of pesticides, excessive drift, poor formulation and poor field targeting.

Utilization of pesticides on cotton has rapidly accelerated in recent years, according to Dr. El Tigani Mohamed El Amin, Director of the Gezira Research Station. Use has risen from a single aerially applied spray in the late 1950s to five sprays in 1966, culminating with eleven in 1980. A broad Government of Sudan policy decision is to reduce the level of chemical use and listed chemicals in an attempt to lower the cost of production inputs and national imports. Sudanese experts frequently cited alternative crop protection methods such as cultural control and the introduction of predators, but felt that aerial spraying remained the most managerially efficient approach. It was emphasized by local technical experts that more labor intensive approaches to crop protection, most notably increased tractor spraying rather than aerial spraying, would both reduce crop protection costs and improve effectiveness. Tenants, it was noted, did not feel they received adequate benefits from the fees they are charged by the Corporation for crop protection.

4. Public Health Aspects

Public health data with regard to the use of these substances is minimal if not non-existent, and secondary impacts outside the jurisdiction of the Corporation have not been subjected to review. The large-scale and extensive use of agricultural chemicals presents a variety of public health risks, including: (a) direct exposure to individuals involved in their application and crop production/processing and (b) indirect exposure due to chemical residues on humanly consumed agricultural products, especially fruit and horticultural crops. In addition, it is hypothesized by Buck and Whittemore (1981) that in the Sudan, especially in the Gezira Project, there exists a synergistic relationship between the high level of pesticide use and the incidence of schistosomiasis.

There are no health statistics on the incidence of illness related to the utilization of agricultural chemicals in the Sudan; however, on the basis of observational evidence there must be a high occurrence. A major problem is that with the basic high level of illness in the population, especially among migratory laborers, people often do not recognize the cause of the problem. Public Health authorities interviewed all felt that the level must be high; however, only a limited number of cases had been identified where pesticides were directly related to illness. These included: (a) consumption of contaminated flour by a family and (b) consumption of contaminated fish which had been poisoned.

Within the Sudan there exist public health guidelines for the handling of pesticides and other toxic materials, but they are not enforced. All pesticide formulation, with the exception of Shell products, is done outside the country, while all dilution is done on landing strips without the utilization of protective equipment (no gloves, overalls, boots, etc.). The only reported use of protective clothing was by Corporation employees, at the insistence of supervisors, during the fumigation of seeds and the mixing of rodenticides, activities which involve exposure to highly toxic chemicals in enclosed work areas. Plant protection staff which mix and apply chemicals are not monitored for exposure; however, personnel with commercial firms such as Ciba-Geigy are regularly tested.

Tenants on horticultural plots are supplied with knapsack sprayers and chemicals by the Corporation; however, they are not provided with protective clothing. Chemicals are frequently purchased on the open market from private suppliers under preferred terms of credit or are diverted from use on cotton. Often chemicals are both improperly selected and applied with no economic benefit and with a risk to health. Tenants receive minimal assistance from the crop protection staff, principally in the form of pamphlets.

Agricultural chemicals are applied with inadequate attention given to their potential health effects to both human and animal populations. Prior to aerial spraying, the Plant Protection Division informally notifies the Block inspector to instruct local tenants to remove animals from target fields in advance of spraying and to keep them out for three to seven days thereafter. However, Corporate technical staff and tenants reported fields being routinely aerially sprayed while people and livestock were in them and regular incidents of livestock kills attributable to the utilization of agricultural chemicals. The use of rodenticides, in particular, has created a source of tension between the Corporation and residents as there are no procedures for compensation of livestock losses. Reports of problems associated with rodent control activities included: (a) the fatal poisoning of seven donkeys in Village 23 after eating dura-baited poison improperly spread on the ground and (b) the large-scale poisoning of nomadic livestock, up to 500 animals, in the vicinity of Village 5.

The aerial spraying of field crops frequently results in the direct spraying and drifting of agricultural chemicals into the supply and

drainage canals. In addition to the contribution to the residual chemical levels in the water supply, this often results in localized fish kills. These fish kills present a variety of problems: (a) they have resulted in documented cases of human poisoning when stunned dead fish have been collected and eaten, (b) they limit the potential for the development of a local food resource and (c) they greatly restrict the feasibility of introducing Chinese grass carp or other similar species for biological control of aquatic weeds. It can be anticipated that with the increased use of Endosulfin, an inexpensive and effective substitute for DDT, the problem, unless addressed, could become both more widespread and acute.

Health risk to exposure to agricultural chemicals is partially limited through the centralized control of these substances by the Corporation. It is, therefore, possible that improved chemical selection, application and safety techniques could be developed utilizing the resources of the Crop Protection Division in conjunction with the public health authorities and the research support of the Agricultural Research Corporation.

5. Agricultural Chemical Storage

Chemicals utilized by the Corporation in crop protection and malaria/schistosomiasis control programs are improperly stored in an open lot adjacent to the main canal. In addition to presenting a risk to public health, the lack of a proper storage facility results in the direct and indirect loss of these expensive imported materials. Observations at the present storage site indicated that approximately 5 percent of the drums were ruptured, physically disintegrating or damaged in another fashion with subsequent loss of materials, frequently from direct leakage or vaporization. Chemicals stored at the site (see Tables F-1 to F-4), especially carbamates and organophosphate compounds, are being subjected to an undetermined extent of compositional deterioration through continual exposure to direct sunlight and associated high air and ground temperatures. In addition, the present facility causes material management problems due to the difficulty in maintaining a proper inventory or locating chemicals in a timely fashion.

6. Reuse of Agricultural Chemical Storage Containers

Current Government of Sudan health laws require that pesticide drums be cut, pounded flat, burned with gasoline and then marketed as scrap metal or roofing material. The Corporation has adopted a policy of selling complete barrels through the use of competitive bids solicited by public advertisement. Complete drums bring 13.0 SL, while only .55 SL for cut barrels. These barrels are recycled following washing with gasoline for storage of fuel/oils, scaffolding and for water storage/transfer. Used drums varied in price in the Omdurman market from 18 to 25 SL according to demand. It was recognized by most marketers that pesticide drums were to be only used for fuel storage.

7. Fertilizers

The limited data on fertilizer application in the Project Area indicates that both simple and compound fertilizers are provided by the Corporation for use on field and horticultural crops. Field observations identified significant losses of fertilizer from improper storage and transfer, resulting in numerous broken bags and loss due to wind and water. The predominance of clay in the Project Area would tend to allow for excess nitrogen to be washed out in irrigation water from the Project Area. No signs of eutrophication, due to excess concentrations of nitrates and phosphates, were noted in the form of algal blooms or excessive water weeds. There were no reports of contamination of groundwater wells from fertilizers.

8. Aquatic Weeds/Ditch Bank Weeds

Management and control of aquatic and ditch bank weeds is the responsibility of the Ministry of Irrigation, which has extensive experience from control programs in the Gezira Scheme. Aquatic weeds reduce flow in canals and drains, reduce canal volume available for night storage, provide habitat for schistome-transmitting snails and often create slack water conditions favorable for the breeding of malaria-transmitting mosquitoes. Ditch bank weeds obstruct flow in canals and drains and cause bank seepage losses; however, they do control canal bank erosion.

Aquatic weeds do not presently present a major problem in the supply canals or drains in the Project Area due to the limited time the system has been in operation. Experience in the Gezira Scheme has shown an evolutionary trend for the development of infestation problems over time. It should be possible to minimize this problem in the Project Area through development and implementation of an active monitoring and control program. Aquatic weeds have been traditionally controlled through the application of herbicides (most common 2-4 D); however, the Agricultural Research Corporation and the Blue Nile Health Project are presently investigating alternative methods including mechanical cutting, drainage and the introduction of weed-consuming fish species.

Ditch bank weeds are becoming a problem along drains in the Project Area; several instances were observed where minor drains had significant levels of blockage. Ditch bank weeds have been spot-controlled by application of herbicides and cutting, but regular maintenance of drains is especially important to assure field and settlement drainage in the case of flash floods and heavy rains. It is possible that some of the heavy crop damage and extensive flooding of settlements which occurred during rainstorms in 1980 is attributable in part to the inability of the drains to function at design levels due to the presence of ditch bank weeds and other preventable types of blockages (informally constructed road crossings, trash disposal, etc.)

G. Secondary Impacts

Secondary environmental impacts are those which are indirectly related to the project under evaluation. Areas of secondary impact associated with the Project include: (a) wildlife, (b) vegetation/fuelwood, (c) impacts adjacent to supply canal, (d) nomadic livestock, (e) salinization, (f) shrinking and swelling clays and (g) archaeological and historical sites.

1. Wildlife

The impact of the Project on wildlife has been a reduction in habitat for native grazing species in the Project Area and, more significantly, the displacement of traditional nomadic herdsmen and their animals to more marginal areas. This creates increased competition for the limited range and brush tracts to the east and along the Dinder River. The Project has not directly had an impact on the Dinder National Park. It has, however, contributed to serious pressure on the Park through displacement of nomadic herdsmen and creation of a market for charcoal and meat.[19/] It is important to note that pressure on the Dinder Game Preserve must be seen as the result of collective developments adjacent to the Area, especially by the expansion of mechanized and traditional rain-fed agriculture, both publicly and privately financed. Should the Rahad Stage II Expansion be implemented, it should be subjected to a detailed study of potential impacts to wildlife and the identification of suitable mitigation activities to address: (a) the direct impact of the proposed irrigation main water supply system and (b) the intensified displacement of traditional nomadic herdsmen and native game from an additional 400,000 feddans projected for the development of the expansion project.

The development of the Project has created extensive habitat for bird species, both native and migratory, through the provision of year-round water supply. Presently, there is an abundance of birdlife on the Project Area, especially large predators. Field crops, crop stubbles and stored crops have created a food source for numerous rodents, especially the Nile rat (Ratus ratus), which have become troublesome within the Project Area. The large-scale utilization of agricultural chemicals could result in the introduction of a variety of toxic substances into the food chain with presently indeterminable consequences.

2. Natural Vegetation - Constructional Timber/Fuelwood/Charcoal

Traditionally, charcoal production was a source of supplementary income for agriculturalists and herdsmen resident along the Rahad and Dinder Rivers, especially the non-tenant members of these villages who have tended to be selected as tenants for the Project. Their partial incorporation into the Project has resulted in a decline in local charcoal production and an increase in charcoal imports into the Project Area from the vicinity of El Gedaref in Kassala Province. Prices have risen steeply due to this increase in demand which has been compounded by the development of an export trade in charcoal at the national level with Saudi Arabia.

[19/] Abu Shama, 1981, Sudanow, 1981.

Presently, within the Project Area charcoal costs 4 to 5 SL for a large sack; a donkey-load of fuelwood costs 5 SL, while a 2-meter pole costs .5 SL. It should be noted that the majority of this production along the rivers is illegal, with individuals and families operating without permits from the government which owns the resource. It should be noted that in response to high fuel prices residents are increasingly storing cotton stalks for use as fuel rather than burning them as required to control the spread of various plant diseases.

Present plans call for the development of 20,000 feddans of forestry plantations in the Project Area, with 6,000 feddans of Eucalyptus having been planted to date. The plantations are to serve as local sources of construction wood, fuelwood and charcoal and will be managed directly by the Corporation. It is planned to concentrate on fast-growing tree types such as Eucalyptus to comprise 90 percent of the plantings and slower-growing tree types such as Acacia to comprise 10 percent. It is also planned to develop additional wood supplies by the planting of trees, principally Acacia, on the interior sides of major and minor supply canals.

3. Impacts Adjacent to Supply Canal

Construction of the water supply canal from the Blue Nile at Meina to the Rahad Barrage has created a penetration corridor 80 km in length. The canal is bordered on both sides by semi-improved dirt tracks, and adjacent land has been cleared for approximately .5 km through grazing and fuel collection. Areas adjacent to the supply canal have been subjected to moderate to heavy overgrazing from livestock (camels, cattle, goats, sheep) being taken to the canal for watering. This has resulted in localized damage to the canal embankment, especially in the vicinity of bridge crossings where livestock are most commonly watered. Overgrazing in this area is the result of permanent water supplies being available in excess of the carrying capacity of the adjacent range.

There have been no settlements spontaneously developed adjacent to the supply canal of a large or small scale. The development of two government-authorized Eritrean refugee camps in the vicinity of the Rahad Barrage, each with a population of approximately 5,000 persons, has resulted in extreme environmental degradation in their vicinity. The nearly complete clearing of trees and brush for housing materials and fuel has occurred within a radius of approximately 2 to 4 km of these settlements. In addition, ground cover has been effectively eliminated through extensive overgrazing by livestock and burning for snake/rodent control. At many points around the periphery of the Project Area, fields have been cleared for the production of rain-fed dura by Rahad residents. Frequently, these are burned to utilize ash as a fertilizer.

4. Nomadic Livestock

There are four corridors in the Project Area to allow for the controlled passage of nomadic livestock; however, field observations

indicated that bank erosion caused by livestock watering is extensive in areas adjacent to crossing bridges and at selected locations along the supply canal. On occasions it has been necessary for the local Commissioner to request military assistance to prevent nomadic herdsmen from bringing their livestock into the Project Area to graze. The development of the Project has reduced grazing pressure on the Es Soki Irrigation Scheme; however, it has created much greater pressure for growing season/end-of-growing season pressure on the Rahad Irrigation Scheme. Due to the extensive livestock holdings of project agriculturalists and their non-resident relatives, it is difficult to determine the extent to which nomadic livestock contribute to the overgrazing of areas adjacent to the Project.

5. Salinization

Due to the nature of the soils in the Project Area and the initial installation of adequate drainage, it is not anticipated that salinization will become a problem in the Project Area. Field review did not indicate that this had evolved into a problem. The situation of extensive salinization in the Gezira Scheme has been attributed to an inadequacy of drainage and excessive application of irrigation water over a span of tens of years. The initial construction of adequate drains, the adoption of long furrow irrigation and the implementation of water distribution/application control measures by the Corporation should address this potential problem.

6. Shrinking and Swelling Clays

The Project has experienced, due to expansive soils, extensive structural damage to irrigation systems (especially concrete canal linings), Corporate buildings, staff housing and road fills located near canal crossings. Black cotton soils in the Project Area exhibit shrink/swell characteristics which are related to the proportion of the clay mineral montmorillonite. Damage occurs to structures which cannot accommodate movement or resist the soil expansion. Typical damage to the staff housing consists of uplifted and broken floors, wide cracks in the interior walls and displaced door and window frames. Heave of up to .5 m has been observed in kitchen and bathroom areas. Damage to both Corporate buildings and staff housing has been attributed to adoption of a standard foundation design rather than utilization of the pillar/piling technique used in the Gezira Scheme. Repairs of damage that has occurred during the last five years may exceed one million Sudanese pounds.[20/]

7. Archaeological and Historical Sites

The Project Area was not surveyed prior to development nor was the Antiquities Service consulted prior to implementation of the Project. It is considered by Sudanese authorities that some prehistoric sites of undetermined significance might have been disrupted in areas adjacent to the Rahad River and Jebel Fau.

[20/] Charlie, 1981.

VI. SUMMARY

The Rahad Irrigation Project represents an excellent opportunity to examine the rapidly evolving "state of the art" in the ecological/environmental assessment of large-scale development projects and provides for analysis of techniques for the implementation of environmental design and mitigation components. It presents a situation where Project donors identified in advance a series of environmental concerns, but failed to completely integrate them into their project design, implementation plan and programs of monitoring and evaluation. The Project clearly illustrates the existing gap between the ability to identify environmental problems and to successfully design solutions to them. It should be noted that the critical environmental problems of the Project have resulted from the inability of the Corporation and Government of Sudan to institutionally manage them and inadequate allocation of capital/operational funds to the responsible organizations. With the exception of schistosomiasis and malaria, the Government of Sudan did not perceive any areas of significant concern. One senior official noted that,"We have placed priority on the production of cotton and food; it is better to have sick people than starving ones."

Although a general environmental analysis was conducted in advance of the Project, it did not successfully influence the design of the Project or its implementation. The study identified basic problems; however, with the exception of a requirement for the development of a program for the control of malaria and schistosomiasis, no mitigations were required. The Project was not subjected to examination for technical alternatives. Failure to develop a program for integrated mitigation activities resulted in the failure to adequately develop institutional capabilities to manage problems. Failure to examine indirect impacts resulted in the development of a series of impacts to areas outside the jurisdiction of the Project which are not being addressed.

VII. PROPOSED MITIGATION ACTIVITIES

Mitigations are activities which are designed to eliminate or reduce identified negative impacts in advance of or in conjunction with project implementation. Proposed mitigation activities included in this Annex have been restricted to those relating to areas of primary impact or secondary impacts whose resolution is directly within the jurisdiction of the Corporation. Previously identified areas of secondary impact, especially with regard to pressure on wildlife species/habitat, nomadic livestock and fuel collection/charcoal production are extremely significant regional environmental problems. These problems warrant detailed independent studies prior to development of proposed mitigation activities.

A. Water-Borne Diseases/Public Health

-- It is recommended that the health services program as it concerns the Project be placed under a single unified jurisdiction

responsible for (a) curative health, (b) public health, (c) domestic water supply and sanitation and (d) health education. A coordination council should be set up between the integrated health services organization and (a) the Civil Engineering Division, which is responsible for the operation and maintenance of water supply systems, and (b) the Crop Protection Division, which is responsible for the selection, procurement and application of agricultural chemicals. There is a need for the formation of "agromedical" teams to address problems mutually affecting agriculture and human health.

-- It is recommended that a technical review be conducted of the basic structure of the primary health care program at the Project to examine its technical integration with health programs of regional governments, provincial governments and extension programs of the Corporation.

-- It is recommended that the activities of the Blue Nile Health Project within the Project be reviewed by a joint committee to assure that they are supporting the development of an institutional capability at the Project and community level rather than serving as a stop-gap organization assuming the responsibilities of regional government, provincial governments and the Corporation.

-- It is recommended that the Corporation review with the Ministry of Irrigation required water levels in canals which are used as sources of supply for potable water supply systems for villages. It was repeatedly identified during the course of field investigations and through interviews with technical experts that water levels in the canals were frequently below the level necessary for flow into the intakes of the slow-sand filters. Failure of the system to be supplied with water forces villagers to obtain water supplies from the canal with both a reduction in health standards and loss of time devoted to drawing water.

-- It is recommended that a review be conducted of the current program of operation and maintenance for village water standpipes. Standpipes are currently poorly maintained, frequently resulting in the contamination of water supply at the tap and unsanitary conditions in the vicinity of the standpipe. Consideration should be given to modification of standpipe design to improve drainage; it is recommended that the area in the immediate vicinity of the standpipe be covered with gravel or planted with vegetation. This design modification would serve to absorb excess water, thus preventing the creation of vector habitat for water-borne diseases and restricting access to the standpipe. Current designs should also be modified to provide for the installation of animal water troughs at the end of drains employed in current designs. This modification would serve to discourage the common practice of blocking sinks under water taps in current systems to serve for animal watering.

-- It is recommended that high priority be given to the development of a health education program following the pattern that has already been established in the Gezira Scheme.

B. Management of Agricultural Chemicals

-- It is recommended that the Corporation give priority to construction of proper facilities for the storage of chemicals used in crop protection and malaria/schistosomiasis control programs. In addition to presenting a risk to public health, the lack of a proper storage facility results in the direct and indirect loss of these expensive imported materials. Chemicals stored at the site, especially carbamates and organophosphate compounds, are being subjected to an undetermined extent of compositional deterioration through continual exposure to direct sunlight and associated high air and ground temperatures. In addition, the present facility causes material management problems due to the difficulty in maintaining a proper inventory or locating chemicals in a timely fashion.

An interim solution of utilizing excess storage capacity in the ginning complex should be reviewed by the Corporation. This could afford covered storage and provide for improved inventory control. Consideration will need to be given to the proper site selection of the new storage facility and cleaning of the area of the present storage facility when a proper facility is constructed. Remaining materials will require careful disposal, while the site itself will need to be excluded for agricultural or residential use due to the high levels of chemical compounds in the soil as a result of spills and leakage.

-- It is recommended that the Crop Protection Division of the Corporation actively seek assistance in the area of integrated pest management (biological control, crop hygiene, modification of crop rotation) from the Agricultural Research Corporation and through the current FAO/UNEP, Integrated Pest Control, Cotton (Sudan) Project based in Wad Medani. It is recommended that the Crop Protection Division in conjunction with the Agricultural Planning Unit examine cost effectiveness of selected integrated pest management techniques for potential application on an experimental basis.

Steps should be taken to improve application techniques and to more carefully select chemicals that are approved for utilization. An expanded capacity should be developed to test the "quality" of chemicals prior to their application to assure that they have not deteriorated during shipment or storage.

-- It is recommended that the Crop Protection Division of the Corporation should supply the local hospital, dispensaries and dressing stations with information on agricultural chemicals

(pesticides, herbicides, rodenticides, etc.) currently in use, descriptions of their clinical symptoms and recommended antidotes. It is recommended that this information transfer be further reinforced by institution of a formal joint committee of representative crop protection and public health authorities to meet on a regular basis.

A program should be instituted to monitor health of crop protection and public health personnel who regularly come into contact with agricultural and public health chemicals (including rodenticides). Changes in acetylchlinestarase activity, an indicator of the effects of organophosphorus insecticides, should be monitored on a regular basis.

-- It is recommended that the current practice of selling used agricultural and public health chemical storage drums should be immediately discontinued. These containers should be destroyed or modified to prevent their reuse as storage containers. The provisions of the existing Sudanese Law barring such sales practices should strictly be enforced by the Rahad Agricultural Corporation.

-- It is recommended that a general education program concerning agricultural chemicals should be developed for incorporation in extension and schools within the Project Area. A specialized public education program concerning the proper use of agricultural chemicals should be developed and given to tenants in the horticultural tenancies.

-- There is a need to determine the primary sources and level of human pesticide exposure in the Project Area (diet, drinking water, direct contact) and to establish a capability on a national level to monitor residue levels in marketed produce and groundnuts (this is especially important given the proposed introduction of chemicals such as Temrex).

C. Other Areas of Concern

-- It is recommended that the proposed program for the planting of trees for the production of timber and fuelwood on the interior banks of main and minor irrigation supply canals be reviewed. This program could result in the creation of significant access and operational problems for routine and major canal maintenance operations. In many cases, successful execution of these operations would require the removal of the trees. In addition, the development of such tree stands will result in water losses through both evapotranspiration and canal bank seepage.

-- It is recommended that the current monitoring and maintenance program for the control of ditch bank weeds in the drain system be reviewed. The introduction of exotic bank cover plants, such as

Impomoea carna, should be discouraged until such species can be shown to be easily controlled.

VIII. LESSONS LEARNED

-- There is a need to conduct and utilize comprehensive environmental analysis in the design and implementation of irrigation projects for the examination of both direct and indirect impacts. The analysis should be developed on the basis of field examination and literature review. The involvement of host country experts and institutions should be sought to the fullest extent reasonable. Analysis should examine programmatic and technical alternatives to the proposed project and identify realistic and implementable mitigation (corrective) activities. Institutional requirements and capital/operational costs should be critically reviewed when examining alternatives or proposing mitigations. Provisions and funding should be included in project design for environmental monitoring and evaluation.

-- In the case of multiple donor financed projects, a specific delegation of authority and responsibility for oversight for environmental concerns should be made to a specific host country technical organization/specific donor or to a joint technical committee. The responsible party should assure that environmental concerns are addressed in the course of project implementation, that monitoring is adequately conducted and that interim evaluations are utilized in fine tuning the project. Financial responsibility for environmental mitigation activities, in terms of capital and operational costs, should be clearly specified in project documentation. Technical assistance and training provided by donor organizations should be selected on the basis of appropriate organizational experience or predominate capability of international/national institutions.

-- Preventative programs for the control of water-borne diseases must be coordinated in the project design process and directly funded by the project for capital and operational costs. Programs must be carefully designed in coordination with authorities responsible for (a) public health, (b) irrigation system design, (c) settlement siting and development, (d) potable water supply, (e) crop protection and (f) aquatic weed control. Foreign exchange costs should be carefully reviewed to assure they are adequate for the provision of necessary inputs for project success. Critical inputs include the procurement of drugs, control chemicals, application equipment, support vehicles (including spare parts and maintenance), technical training and advisory services. Administrative capability and the provision of funding for interrelated activities should be recognized as the major constraint to successful implementation of control programs in the absence of a unified authority for the provision of public health services.

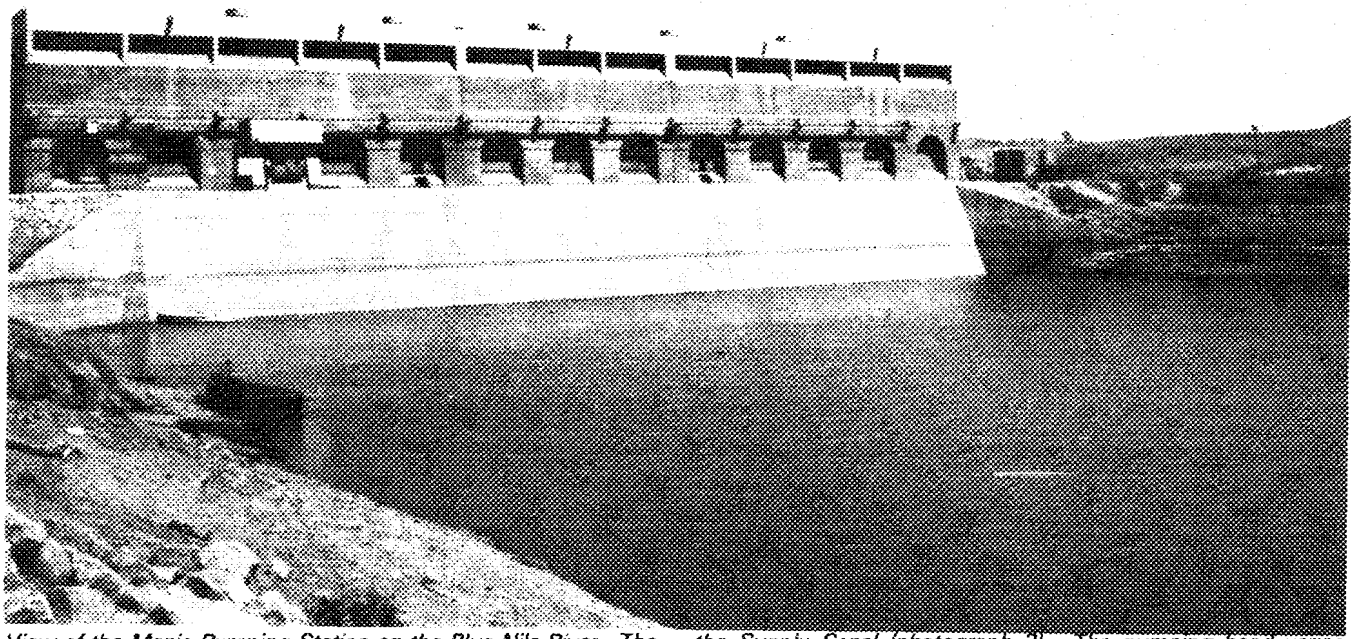
-- There is a need to systematically review crop protection techniques prior to the design and implementation of irrigation projects. Feasible alternatives to traditional chemical control techniques based upon an integrated pest management strategy (biological control, crop hygiene, crop rotation, etc.) should be critically examined for each pest/crop by a select technical committee composed of representatives of both host country and donor organizations. Specific crop protection/pest control research and experimentation programs to address both short- and long-term needs should be identified and prioritized. It is recommended that such programs be integrated directly into the project design and be funded either directly as a project component or as a complementary project/subproject. Crop protection authorities should coordinate closely with project economic research units to conduct evaluations of cost effectiveness of alternative techniques of crop protection.

-- Crop protection programs must be designed and implemented with the full coordination and assistance of public health and potable water supply authorities to assure the safety of specialist personnel, agricultural workers and human water supply. Public health authorities should be supplied, by the crop protection authority on a regular basis, information of agricultural chemicals currently in use, descriptions of their clinical symptoms and recommended antidotes. It is also necessary to design crop protection programs in coordination with the assistance of authorities responsible for animal protection, fisheries and aquatic weed control to minimize direct and indirect impacts on these biological systems. Coordination must be institutionally designed within the context of the project and, if necessary, required under conditions in the loan/grant agreement with the host country.

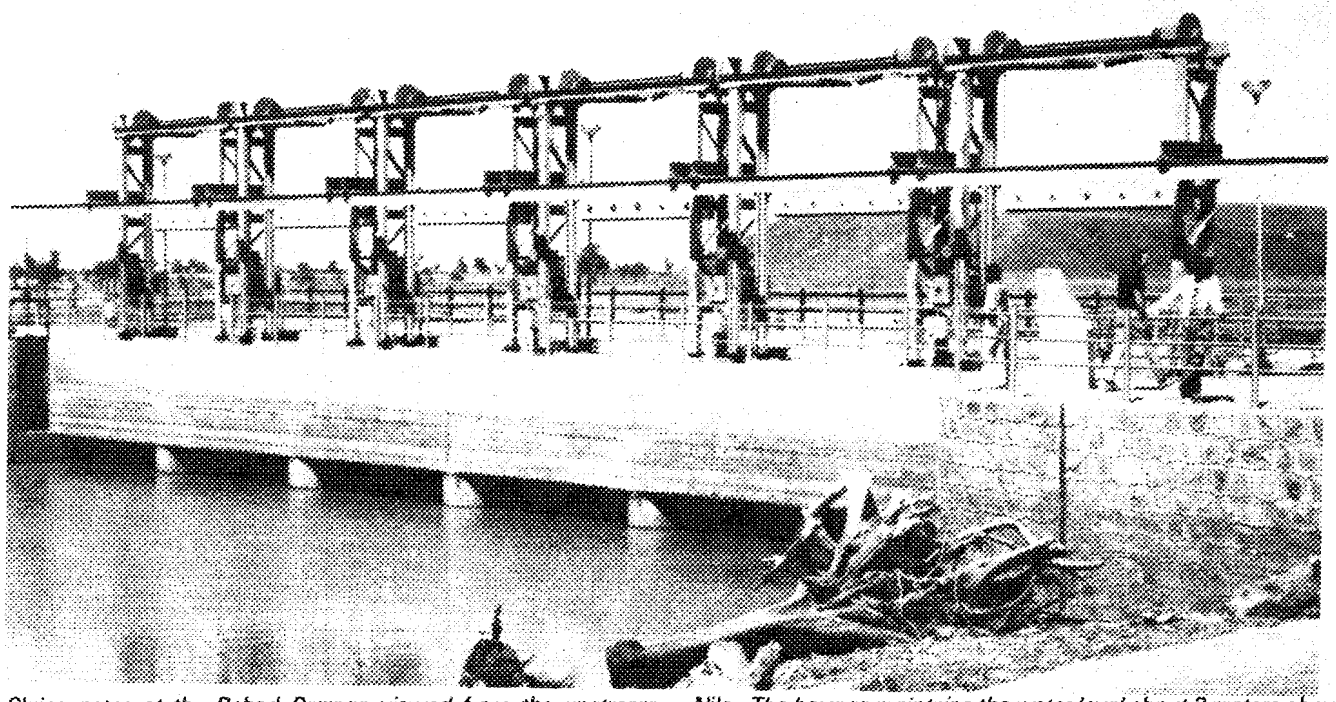
-- There is a need to accurately estimate and monitor the demographic composition of the project area for the design, provision and budgeting of social services, including schools, public health facilities and water supply. Social statistics sections should be included in the host country management organization as appropriate; it is essentially that these sections are provided with project capital and operational funds under terms of the intial loan/grant agreement. They should be responsible for both projection of population/demographic aspects of the project and direct field monitoring. It is essential that they have formalized coordination relationships with specialist organizations responsible for provision of services and financial organizations responsible for the management of development and operational budgets. Technical review of these units should be included in routine monitoring and evaluation activities of donor organizations.

PHOTOGRAPHS

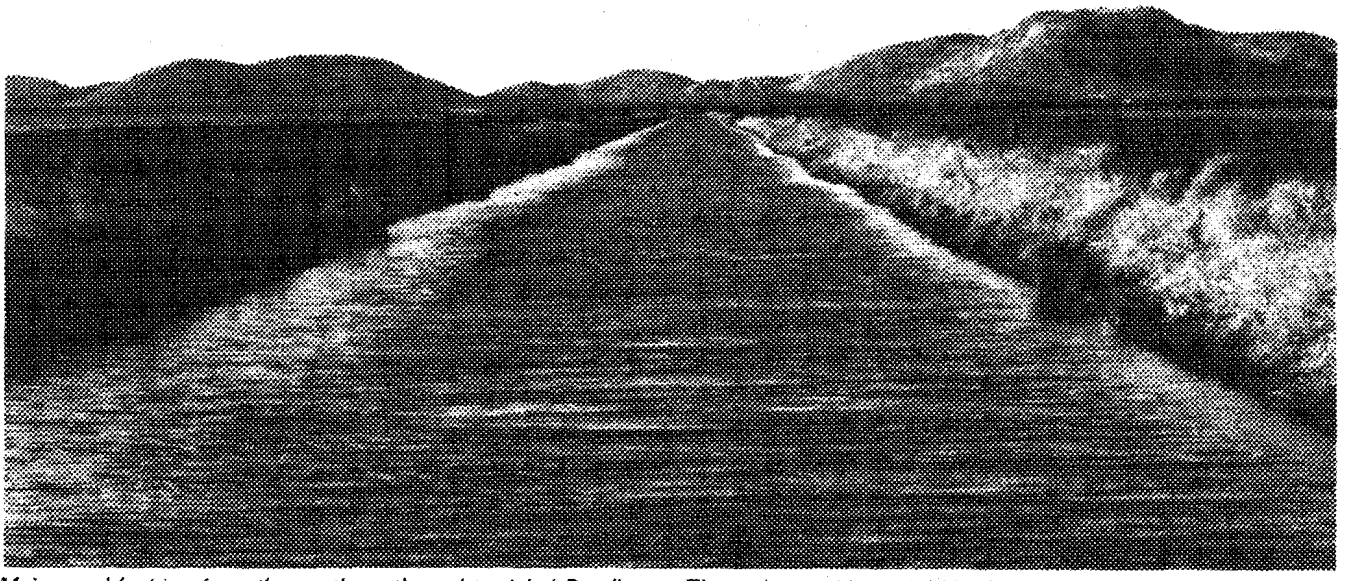
by
Stephen F. Lintner



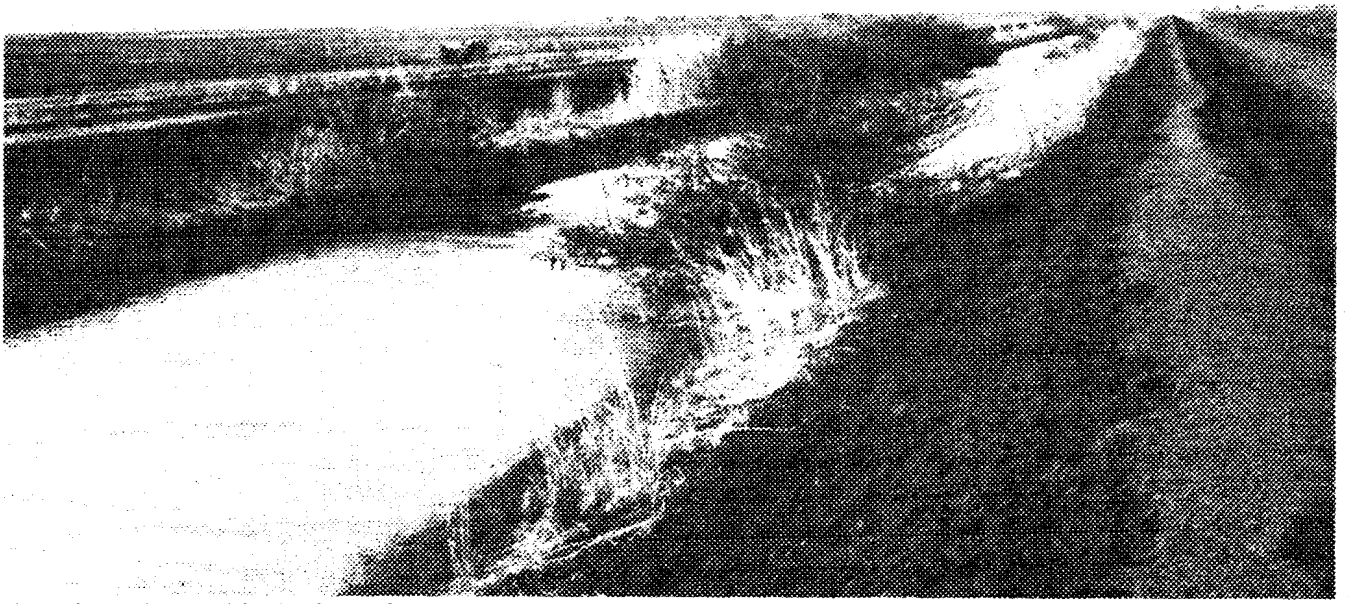
View of the Menia Pumping Station on the Blue Nile River. The superstructure of the station is 79 meters long and houses 11 pumps, each with a capacity of 9.55 cubic meters/second. Water is drawn from an embayment on the Blue Nile then pumped into the Supply Canal (photograph 3). The pumping head varies, according to the water levels in the Blue Nile and the Supply Canal from 6.7 meters to about 14.7 meters.



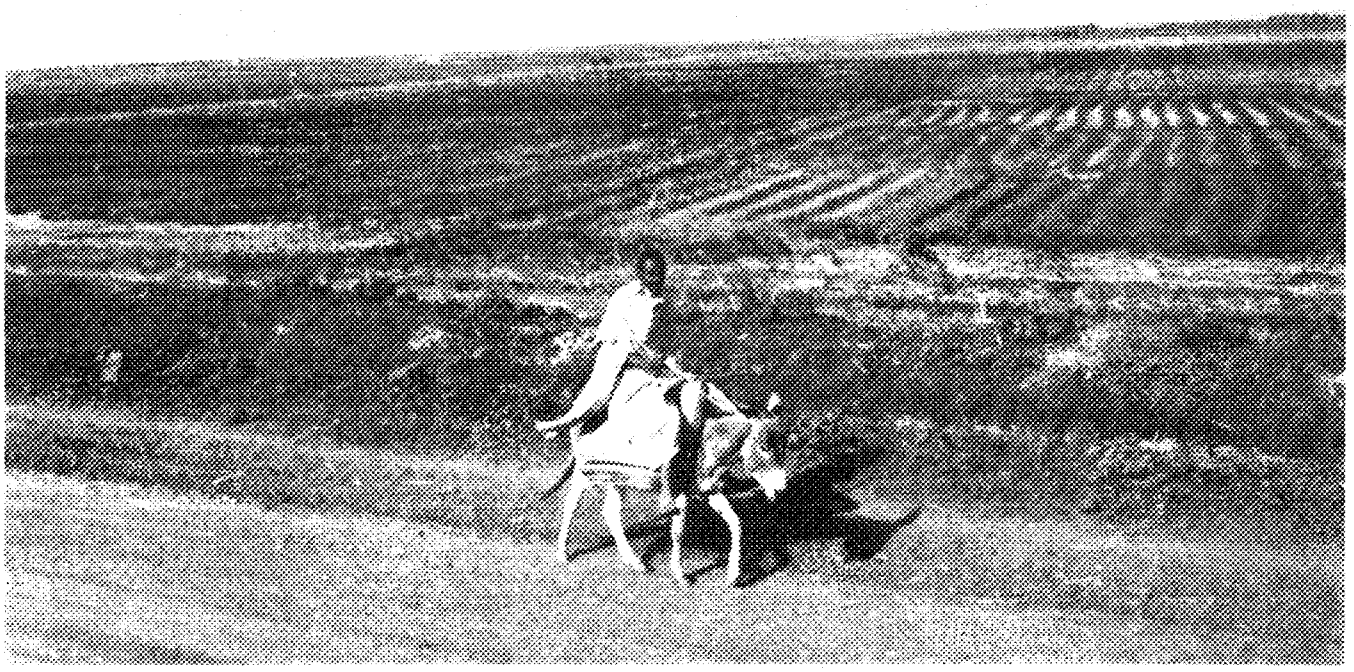
Sluice gates at the Rahad Barrage viewed from the upstream side. The barrage is the terminal point of the supply canal and serves to regulate flow into the main canal. The Rahad Barrage also serves to control seasonal discharges from the Rahad River which are used to supplement supplies pumped from the Blue Nile. The barrage maintains the water level about 2 meters above normal river flood level and a small reservoir is created upstream. The structure is of reinforced concrete construction with masonry facings to piers and abutments.



Main canal looking from the south northward to Jebel Fau (low hills in background). Note on left at base of hills major Corporation buildings at El Fau, including cotton ginning mill. The main canal has a width of 35 meters and an average design capacity of 100 cubic/meters/second. The canalization is designed to operate on a night storage system.



View of a major canal in the South Group area. The canal is paralleled by a paved road on the right leading to Village No. 10 with the Group Headquarters visible in the distance. On the left of the canal, is a dirt service road on which can be seen a horse-drawn wagon carrying large bags of cotton. Harvested cotton and groundnut fields are on the left. Temporary migrant workers homes can be seen in the distance, in the center of the photo. Note weeds and small trees encroaching on the canal channel.

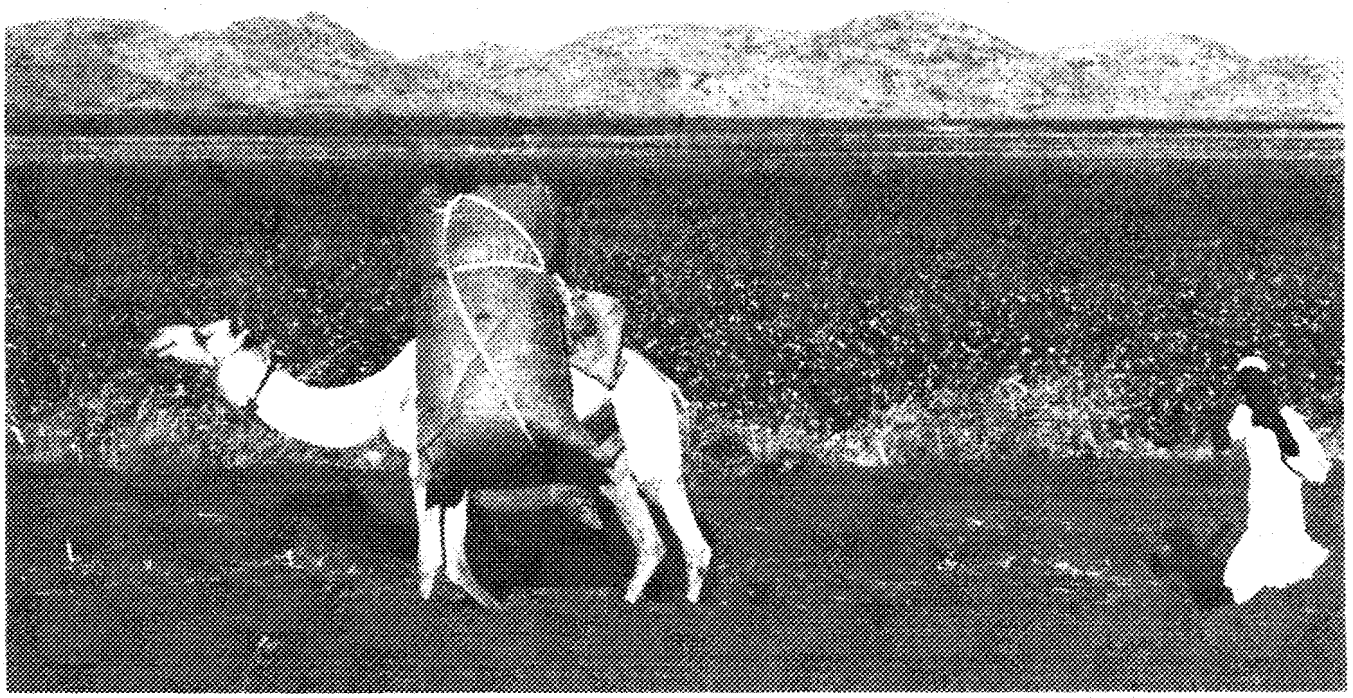


View along a major dirt service road of recently harvested irrigated fields, minor canal (parallel to road) and field level channels. Field stubble remaining in fields after harvesting is grazed by livestock which are maintained at the margins of the Project. The man on donkey is using dirt road to reach his fields.

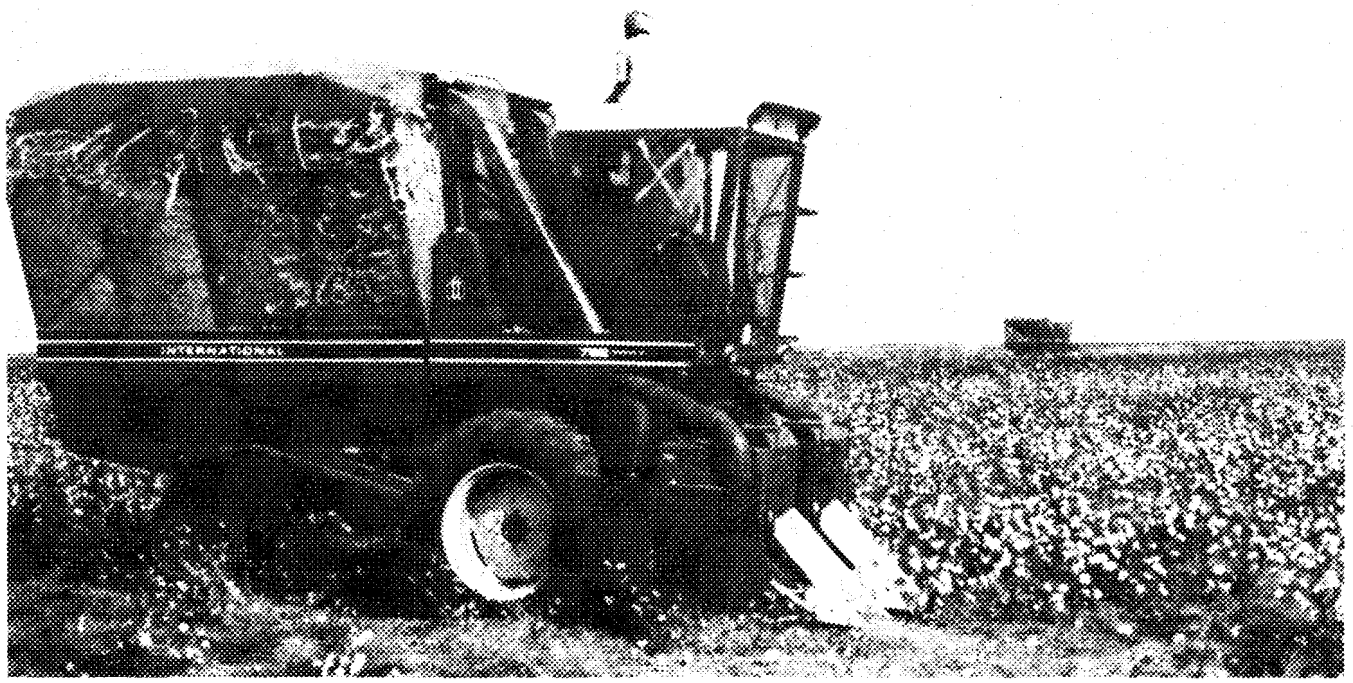
Horticultural tennancy producing a variety of vegetable crops for sale in regional markets such as Wad Medani. Common horticulture crops in the Project Area include: eggplant, okra, onions, peppers and tomatoes. Reed structure is used as housing by personnel tending the field. Note Abuishreen (watercourse) canal in the foreground.

Portrait of a typical tenant farmer. Population for resettlement within the Project was drawn from villages on both sides of the Rahad River, from selected villages near the Dinder River and from an area north of Wad Medani where the Rahad River joins the Blue Nile. Most tenants were previously involved in sedentary farming or semi-nomadic livestock herding.

Female migrant worker hand-picking cotton. Workers are predominantly from the provinces of Kordofan and Darfur in Western Sudan. On the average a worker can pick 140 pounds of cotton a day for which they are paid 1.4 Lsd and provided with food rations. Migrant workers live in temporary housing erected adjacent to fields and do not receive social and health services available to permanent residents of the Project.

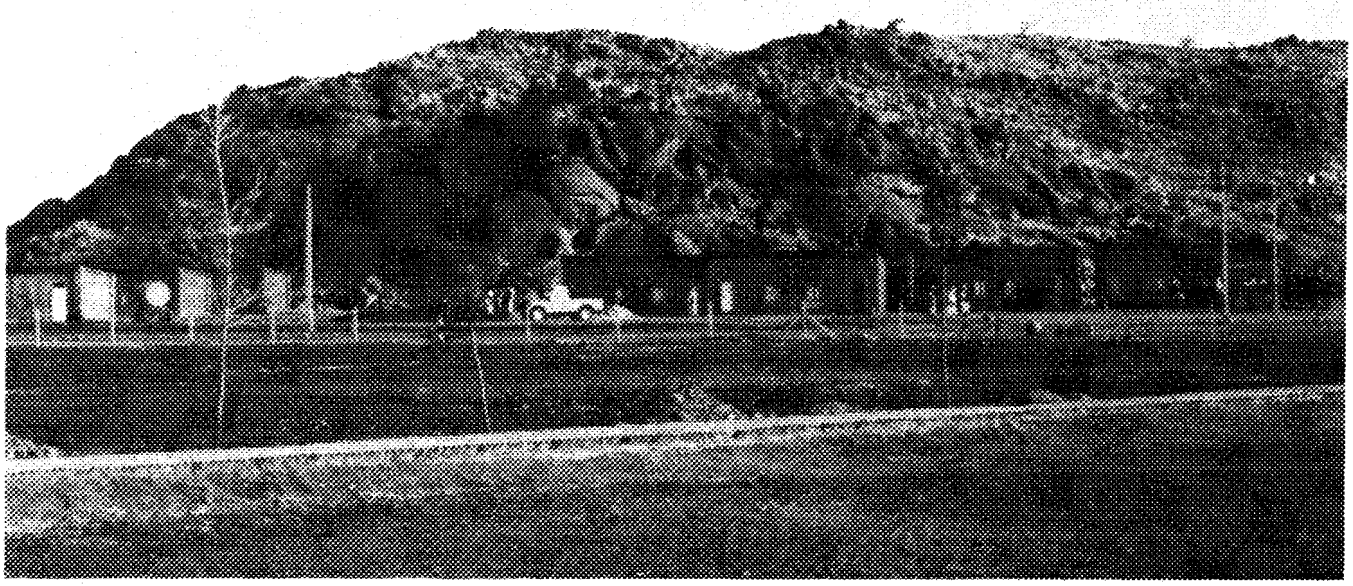


Man transporting cotton to collection center using camel. In the immediate background are fields of unharvested cotton while Jebel Fau is in the distance. All cotton produced on the Project is purchased by the Corporation and centrally processed at the cotton ginning mill in El Fau.



A.I.D. financed International Harvester cotton picker in use in fields which have been aerially defoliated in the vicinity of Village 10, South Group. These machines require highly sophisticated skills to operate and maintain. Their recent introduction has given rise to local social conflicts due to the displacement of both resident and migrant agricultural labor.

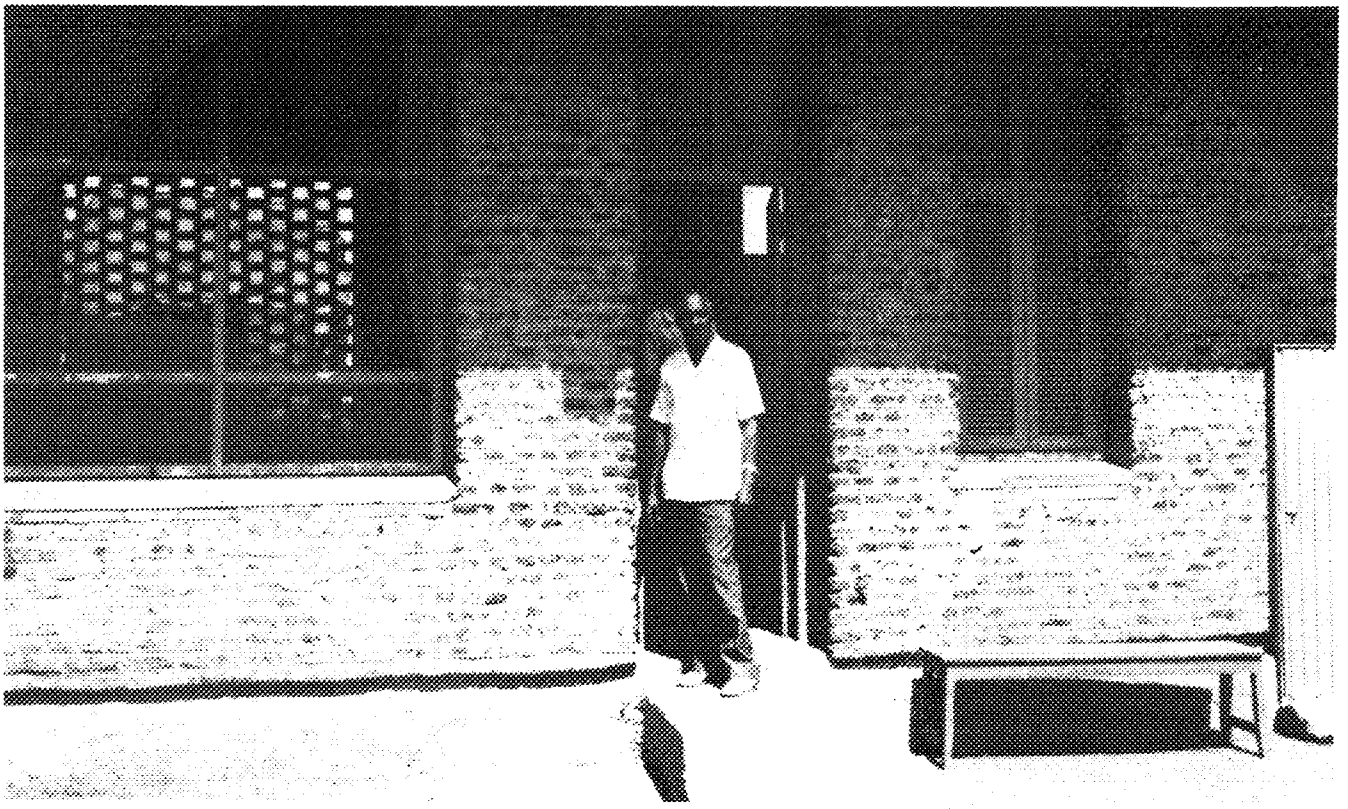
View of typical village occupied by resident tenant and non-tenant families. Livestock are kept in pens adjacent to and within the houses. They are constructed by semi-professional construction specialists utilizing rough timber framing covered with thatching. These houses cost 35 Lsd in materials and require 5 to 6 days labor by a specialist aided by an assistant.



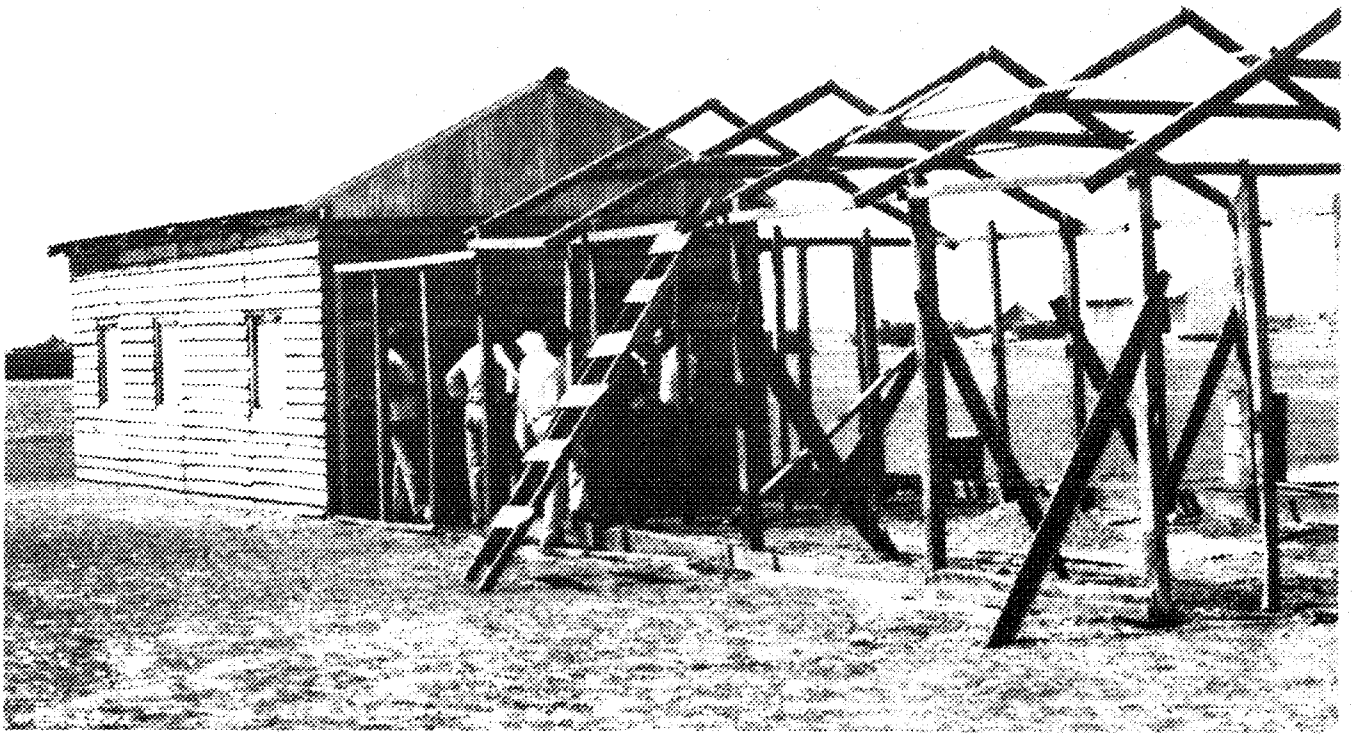
View of housing provided to skilled tradesman, such as mechanics, employed by the Corporation at Project Headquarters in El Fau. Provision of adequate housing remains a problem in attracting and retaining personnel at all professional and skilled levels. Shortfalls in the provision of local currency funds has resulted in an inadequate number of structures.

The Commissioner of the Rahad Irrigation Project, pictured in his Civil Servants uniform, is appointed by the Ministry of Interior and represents local governmental authority. He is responsible for overseeing governmental operations and controls the limited budget for local development. The picture was taken during the course of a meeting with representatives of village production councils.

Public standpipe in Village No. 19, Middle Group. Water is drawn from the canal, passed through a sedimentation tank and slow sand filter for purification, then pumped up into a storage tower for gravity supply to standpipes in the adjacent village. The Corporation selected extremely heavy guage pipe and fittings which has reduced maintenance problems. Water is drawn by women, girls and boys. Sanitation problems occur in the vicinity of the standpipes due to poor drainage and the absence of animal water troughs to utilize waste water.



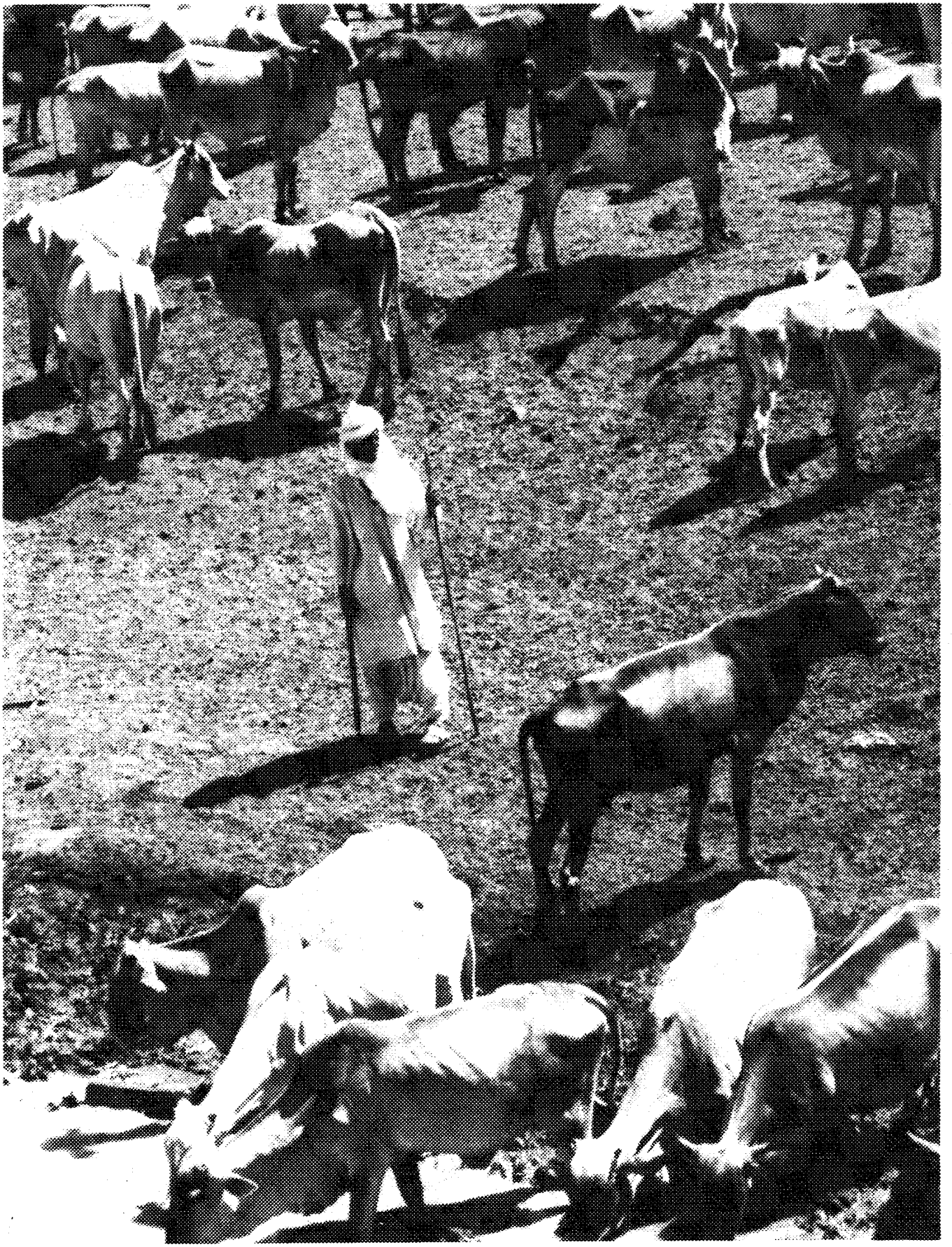
Health clinic in Village No. 23, Middle Group Headquarters, with the resident medical assistant standing in the doorway. This unit with a single staff member provides basic health services to six villages and to approximately 20,000 migrant laborers. The most common health problems are diarrhea, chest ailments, malarial type fevers, schistosomiasis and eye infections. Services are essentially limited to injections and the provision of drugs.



Self-help primary school constructed by villagers; note extension in progress. Villagers have provided materials and labor and the governorate will provide the teacher. Schools in the Project Area include both mixed sex and male or female students only at both the primary and secondary level.

New market place in Village No. 10, South Group Headquarters. The market is a public facility which is open on a daily basis. Store owners are predominantly holders of tenancies and obtain additional family income from these enterprises. Stores provide goods and services to both permanent residents of the project and migrant laborers. Enterprises include dry goods stores, food sellers, a butcher, clothing stores and several small restaurants.

Chemical storage depot near Project Headquarters at El Fau, drums contain insecticides, herbicides, molluscides and defoliants. These chemicals are improperly stored in an open lot adjacent to the main canal (in background). In addition to presenting a risk to public health, the lack of a proper storage facility results in the direct and indirect loss of these expensive imported chemicals. Observations indicated that approximatly 5% of the drums were ruptured, physically disintegrating or damaged in another fashion with subsequent loss of materials, frequently from direct leakage or vaporization. Chemicals stored at the site are being subjected to compositional deterioration through continual exposure to direct sunlight and high air and ground temperatures.



View of nomadic livestock being grazed along the main supply canal between the Menia pumping station and the Rahad Barrage. The supply canal is bordered on both sides by semi-improved dirt tracks and adjacent land has been cleared for approximately .5 km through grazing and fuel collection. Areas adjacent to the canal have been subjected to moderate-to-heavy overgrazing from livestock as the result of permanent water supplies being in excess of the carrying capacity of the adjacent range.

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